PARETO ENERGY

PGE Integrated Resource Plan

Comments Regarding Distributed Energy Resources

Submitted To:

Oregon Public Utility Commission
Docket Number LC 48

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9/1/2010

Contents

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I. INTRODUCTION

Pareto Energy is pleased to submit the following comments regarding the 2009 Portland General Electric ("PGE") Integrated Resource Plan ("IRP"). From our 20 years of work in developing IRP's, Pareto Energy concludes that PGE has followed a very sound methodology and proposed a superior and well-reasoned plan.

Pareto Energy generally supports the initial conclusions and recommendations of the IRP, but has some specific suggestions regarding distributed energy resources (i.e., demand-side customer actions to conserve or curtail energy and/or customer-owned distributed generation on the supply side). Our overall intent is to recommend some practical tools by which the IRP could have a contingency plan in case of large-scale adoption of distributed energy resources ("DERs") by PGE customers.

Chapter 7 of the IRP concludes that: "it is difficult to know how much cost effective DG may be available … the benefits [of distributed generation or DG] are difficult to quantify for IRP purposes … DG at this time is too distributed to make a practical difference in how substations are maintained and upgraded". If DER technology, laws, regulations and project financing remain static, Pareto Energy agrees wholeheartedly with these conclusions. However, the new innovations may portend a large-scale adoption of DERs and call for better measurement tools and new regulations to balance the interests of DER customers with those of gas and electric utility rate payers and shareholders. Some of these innovations are:

New Technology: non-synchronous interconnection, microgrids, and decentralized waste-to-energy.

New Laws and Regulations: Federal laws promoting grid independence for critical infrastructure, Federal smart-grid standards for cyber security, and climate actions at the Federal, State and local levels.

New Project Financing Options: economic stimulus and the emergence of public-private financing structures.

We conclude our comments by recommending several new tools by which the IRP could become more agile in responding to the needs of DG adopters and utility ratepayers and shareholders alike.

II. NEW DER TECHNOLOGIES

A. Non-Synchronous Interconnection

The inability of DERs to safely interconnect in parallel to the utility grid at low and medium voltages greatly impedes their adoption by customers. Because DG cannot match the reliability of the grid, the purported benefits of higher reliability can be achieved only if DG systems can interconnect to the utility grid for back-up power. A customer's ability to access both a DG system and the grid could reduce expected power outages to once every five years. However, distribution utilities have a legitimate concern about the fault current contribution of DG to their grid, especially the extent to which DER fault current could electrocute line workers during a grid outage or damage substations. Consequently, most states have prudently and correctly restricted the interconnection of a large amount of distributed generation to utility distribution grids, such that when the utility grid experiences an outage, the DER system must shut down also. This greatly reduces the reliability benefit of DERs for the customer and curtails DG market penetration.

In the more congested grids of the East Coast, DC-AC power inverters combined with new innovations in power electrics have emerged as solutions that utility companies will accept for interconnecting DG to their grids. Appendix A (attached) presents an overview of a DG architecture with non-synchronous interconnection using inverters. The ability of DG to always operate during grid outages would greatly increase the reliability value of DG to its adopters. Therefore, the emergence of inverter technologies may result a larger-than-expected increase in the adoption of distributed generation.

B. Microgrids

Some of the most cost effective DG systems employ combined heat and power ("CHP"), i.e. a generator located at or near its point of use can recapture the waste heat that would be exhausted in a central generating plant and use it to heat and cool buildings. Because CHP systems can reach over 80 percent efficiency in fuel use – far higher than the typical 30 to 40 percent rate grid generators – DG with CHP can offset some of the cost disadvantages due to lower economies of scale. As will be seen in the subsequent discussion of new laws, CHP benefits will also increase if the value of the heat they recapture can be monetized as a climate change benefit.

However, the IRP has correctly noted the difficulty of finding single-customer sites where DG produces precisely the amount of heating and cooling needed. For example, a typical office building will be able to use less than 40 percent of generator exhaust for heating and cooling services that are weather-driven. Occasionally, a DG system will be proximate to a light industrial, medical or data center facility that has a more constant non-weather related demand for steam, hot water or cooling, but there are not enough of these sites to imply a large-scale penetration of DG due to the benefits of CHP efficiency.

Microgrid technologies are emerging as a solution. A microgrid is a local peer-to-peer network by which some energy users that need more reliable electricity and less thermal energy can balance their needs with nearby buildings that have less of a need for reliable electricity but will welcome less expensive heating and cooling services.

Without a microgrid, an on-site CHP system is often sized to cover a facility's thermal load because there is no way to export the waste heat. This usually means that the on-site generators produce less electricity than what the facility needs to achieve its reliability objectives. On the other hand, if the system is sized to cover average or peak electric load, it will produce more thermal energy than the facility needs, thereby making DG less affordable. The innovation of the microgrid conceived by Pareto Energy is that this thermal energy from multiple distributed generators will be connected to a district energy piping system. Efficiencies can be achieved among the connected facilities by not only using modern boilers and absorption chillers, but also by trading thermal and electrical loads among different buildings according to need. For example, a hotel or conference center needs thermal energy at night, while a nearby office building or data center probably needs it during the day. To summarize, the district energy system supplied by multiple distributed generators can also sell the thermal energy to other customers who wish to be connected to the loop and do not have or intend to acquire on-site CHP systems.

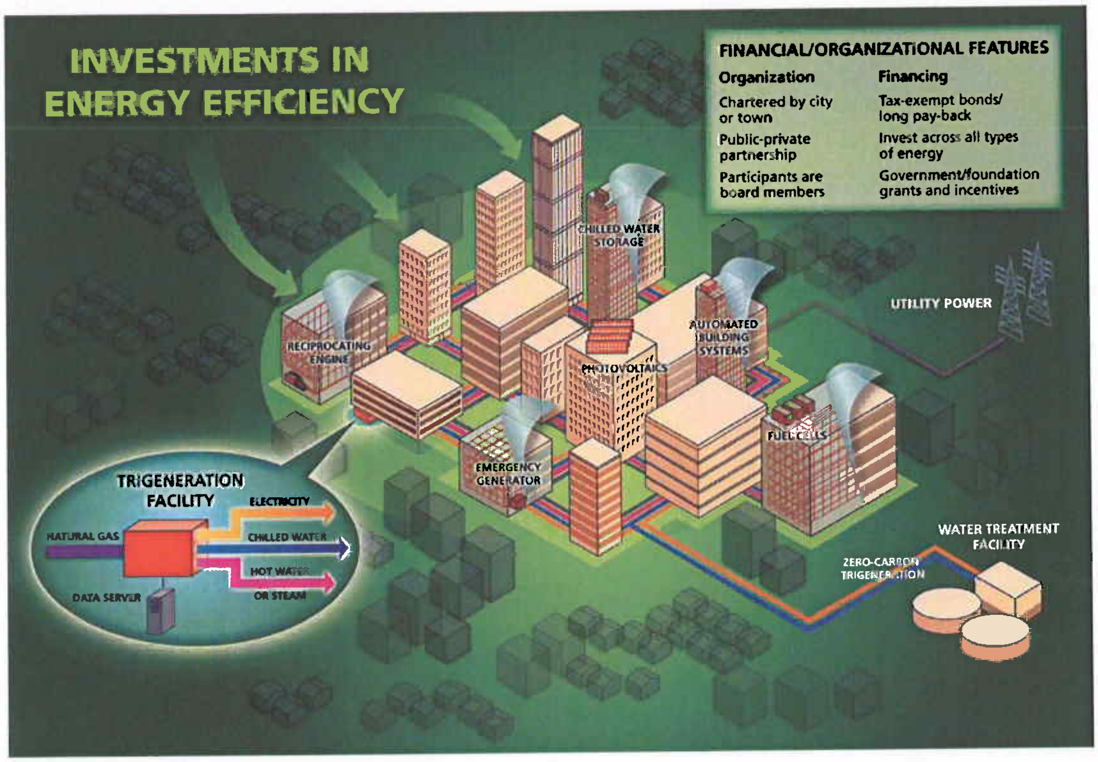
A typical microgrid topology has been shown in Exhibit A. Note that an additional benefit of the microgrid is the ability to integrate different types of generation and fuels (e.g., pipeline gas, the sun, waste-to-energy gas).

Companies such as General Electric, IBM, Intel, and Lockheed Martin, among others, have recently recognized the value of microgrids for DG efficiency and fuel diversity. These companies have begun to prepare microgrid product and service offerings. In addition to the cost and efficiency advantages of a microgrid, the successful track record of such companies in selling new technologies suggest that their entry into the microgrid space will increase the market penetration of distributed generation.

C. Decentralized Waste-to-Energy Systems

With reference to Exhibit A, note that one new source of energy is local waste-to-energy gas. New technologies for biodigesting human waste and using plasma arcs to gasify solid wastes, suggests that instead of paying tipping fees to dispose of waste communities will now look to turn waste streams into microgrid feed stocks. The avoided tipping fees, which can be particularly high for specialty refuse such as medical waste, will tend to drive the net cost of microgrid fuels down and further increase market penetration for distributed energy systems.

Exhibit A: Typical Microgrid Topology



III. NEW LAWS AND REGULATIONS

A. Critical Infrastructure

The US Congress will soon vote on two measures related to grid independence of critical infrastructure that are expected to pass. These measures may have a similar effect as the technological innovations in spurring DG market penetration. The first action is part of the defense appropriations bill and calls for military bases to install microgrids. The second, known as the GRID Act, directs the President to designate to the Federal Energy Regulatory Commission ("FERC") those domestic facilities that are: (1) most critical to the national defense; and (2) most vulnerable to an electric energy supply disruption. It also directs FERC to require an owner or operator of defense critical electric infrastructure to implement measures to protect it against any vulnerability that has not been adequately addressed. Developers of distributed generation projects believe that microgrid projects with on-site power, fuel diversity, and enhanced cyber-security could be one of the FERC-required measures for protecting defense critical electric infrastructure.

It is likely that states already having critical infrastructure such as ports, military bases and Federal R&D centers will see more demand for DG and that states that do not have such critical infrastructure will be able to attract it along with the associated economic development and jobs if they are prepared to integrate DG into their grids.

B. Cybersecurity

Congress has also entrusted a Federal definition of smart grid standards to FERC which has delegated the work to the National Institute of Standards and the Electric Power Research Institute. One key concern has been the extent to which a more digital smart grid could increase exposure to cyber attacks. Microgrids have been emerging as a solution by which critical infrastructure could become more secure against cyber attacks.

Again, states that have made efforts to easily integrate DG into their power grids will become more attractive locations for critical infrastructure and be able to thereby generate more economic development and employment.

C. Climate Action

Of all states and cities in the Country, Oregon and Portland are relatively committed to climate actions. This is a clear driver of DG and so it will be prudent to better prepare for a larger penetration of DG, especially considering the continuing likelihood that eventually Congress will pass Federal climate action.

IV. NEW PROJECT FINANCING OPTIONS

A. The Impact of Federal Stimulus

As noted above, microgrid benefits align with Federal policy on grid rebuilding. With new federal tax credits and incentives, a private developer can design, build, own, operate and transfer microgrids that not only would provide cleaner, more secure energy, but also do so at less cost than current rates for grid power.

1. Stimulus as a Source of Equity

The Federal Government redefined grants and credits to alternative energy projects in the following legislation: 1) Division B of the Federal Emergency Economic Act of October 2008 known as The Energy Improvement and Extension Act of 2008 ("Bailout Bill"); and 2) The American Recovery and Reinvestment Act of 2009 ("Stimulus Bill").

With these Acts of Congress, it is possible that the Federal Government incentives could be used to raise most of the project equity needed for financing the project. The Bailout Bill enhanced investment tax credits, which can now cover 10 to 30 percent of project costs. Conveniently, the Stimulus Bill allows a developer or owner to receive a grant from the federal government instead of a tax credit. The grant is 30% of the tax basis of the property for bioenergy, wind, solar, and fuel cells and 10% for combined heat and power and energy efficiency investments. Note that the Bailout and Stimulus bills provide for numerous other grants and loan guarantees. Rules for, and timing of, applications for these grants are still being developed.

In addition to the 30 percent tax credit for renewable DG, project owners can claim accelerated depreciation that amount to an additional 12 percent tax credit.

Finally, here is a sample of other types of grants and loan guarantees for DG projects:

- $6 billion in loan guarantees for an innovative technology program designed to promote projects that limit greenhouse gases, including renewable energy systems;
- $4.5 billion for converting federal buildings to High Performance Green Buildings;
- $3.84 billion for upgrading military facilities, including improving the energy efficiency of those facilities;
- $3.2 billion in federal grants to states for reducing fossil fuel emissions and improvements in energy efficiency;

- $3.1 billion for the State Energy Program destined for the funding of efficiency and renewable energy projects, in particular for hospitals and schools;
- $4.5 billion in appropriations for "Smart Grid" (electricity delivery and reliability programs);
- $2.4 billion in Energy Conservation Bonds.

2. *Stimulus as a Source of Debt*

By declaring the microgrid to be a cooperative of energy users, the Federal Government also could be the source of debt financing for certain renewable energy systems. The Bailout Bill creates a new zero interest Clean Renewable Energy Bond program of $800 million with one-third allocated to projects of public power providers, one-third to governmental bodies, and one-third to cooperative electric companies. The Stimulus Bill authorizes an additional $1.6 billion of Clean Renewable Energy Bonds. The Secretary of the Treasury has the authority to allocate the bonds among qualified projects, which are defined to be wind, closed and open-loop biomass, geothermal, solar, small irrigation power, landfill gas, trash combustion, new hydropower, and wave energy.

B. Public-Private Partnerships for Project Financing

It will be noted that some Federal grants provide funding to private tax-paying entities. Others provide funding for non-tax paying government or institutional entities. Consequently, many private developers are forming public-private partnerships with hospitals, ports, universities and municipal governments. One such public-private partnership entity that has been enacted in some states are energy improvement districts ("EIDs").

EID's manage infrastructure as a common pooled resource ("CPR"). CPRs are facilities developed collectively by users who pool their resources to install facilities for joint use. For example, the internet is governed as a CPR. Key characteristics for successful management of a CPR may be summarized as follows:

- Group boundaries are small areas and clearly defined (the most well-known CPR, the internet, is one of the only successful CPR's that does not adhere to this "small-area" characteristic).
- Rules governing the use of collective infrastructure are well matched to local needs and conditions.
- Most individuals affected by these rules can participate in modifying the rules.
- The rights of community members to devise their own rules is respected by external authorities.

- A system for monitoring member's use of infrastructure exists; the community members themselves undertake this monitoring.

The importance of EIDs to the emergence of DG has been noted in other States where enabling legislation has been passed:

> "One of the chief obstacles to developing efficient power generation … in developed areas including urban centers in NJ has been the inability of developers to sell all three of the energy streams (combined cooling, heating and power or CCHP) they produce to end users … The first large city to implement an EID with the assistance of Pareto Energy was Stamford Connecticut. Pennsylvania has incorporated enabling language for EID's in their upcoming energy bill supported by DEP Commissioner Kate McGinty and Governor Ed Rendell. For New Jersey to develop efficient urban CCHP as an effective tool to reduce energy cost and to achieve green house gas reduction requirements under the Global Warming Response Act we will need to develop similar projects for EID's. Investors in energy technologies and capital will seek states and communities which represent the best potential for development. Currently this is in Connecticut and soon will be in Pennsylvania. The implementation of the New Jersey Energy Master Plan, when it is adopted, together with the Global Warming Response Act creates a need for innovative development of energy projects. The model adopted in Connecticut and the pending initiative in Pennsylvania have established a mechanism by which EID's can be used as a effective alternative to traditional transmission and distribution solutions."
>
> – Report of NJ Bureau of Public Utility Ombudsman, 11/7/07
>
> "The state General Assembly's authorization last year of local Energy Improvement Districts is catching on in a handful of the region's communities - and that's a harbinger of good things to come … The concept behind the Energy Improvement Districts is to allow entities to produce energy locally at a lower cost, both monetarily and environmentally. The hope is that the green energy-generating potential will help attract businesses to a community, improve revenue and lower taxes for residents. In addition, producing energy alternatively should also reduce the demand for major power companies, which could ease the load on stressed electrical infrastructure and lower costs that have come with managing that problematic infrastructure. There also is the expectation that the districts will improve reliability. Stamford Director of Economic Development Michael Freimuth has said that power has become an issue greater than taxes, transportation, real estate costs and even the skills of the labor force. It's worth noting that Ansonia reportedly is using the energy improvement district to attract businesses for once-bustling buildings that became vacant when manufacturing companies closed or moved out … Certainly, it will take time and money to get such districts up and running. But the districts do hold promise for some communities and the state overall of a brighter and less costly energy future."
>
> – Stamford Advocate Editorial, February 8, 2008

V. CONCLUSIONS AND RECOMMENDATIONS

A. A Practical System to Account for DER Costs and Benefits

The IRP has observed the difficulty of measuring DG benefits. Fortunately, the Association of State Energy Offices and a number of utility companies have tested and perfected a practical cost benefit approach. A report on their work, prepared by Navigant Consulting has been attached herewith as Appendix B.

B. Real Options Models to Optimize DER Siting

Because Chapter 10 of the IRP contains some impressive optimization modeling and shows PGE's dedication to precise measurements and sensitivity analysis, Pareto Energy is pleased to recommend some practical tools for the optimization of distributed energy resources. Appendix C summarizes a DG optimization methodology.

C. Decoupled Rates or Other Regulations to Address Throughput Bias

If DG achieves more penetration than envisioned, Pareto Energy believes that new regulatory mechanisms such as decoupled rates and DG ownership models would be useful in balancing customer and utility interests. Appendix D provides a summary of rate structures that have been used in other states to balance the costs and benefits of DG adopters with utility companies.

D. Pilot Projects at Universities

Many universities have begun installing microgrids. These seem to be compelling projects because the microgrid provides a test bed and creates first-hand data for integration with the educational curricula. With their engineering brain trusts engaged, many universities intend to serve as extension services for other energy users that want to optimize DG at their own sites and also to provide continuing education for engineers, electricians and assembly workers that could be employed on the development of DG systems. PGE may want to consider promoting the installation of a microgrid at a top research institution somewhere in Oregon that can help perfect engineering, economic and legal models for DG deployments.

CERTIFICATE OF SERVICE

I CERTIFY that I have on this day served the foregoing document **PARETO ENERGY LTD'S REPLY COMMENTS** on all parties of the record listed on the Service list below, in this proceeding via electronic mail and/or via mailing a copy properly addressed with first class postage prepaid.

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Of Attorneys for Pareto Energy LTD

Appendix A:
Overview of Non-Synchronous Interconnection Technology

PARETO ENERGY

MICROGRIDS AND CYBER SECURITY

Alan McDonnell

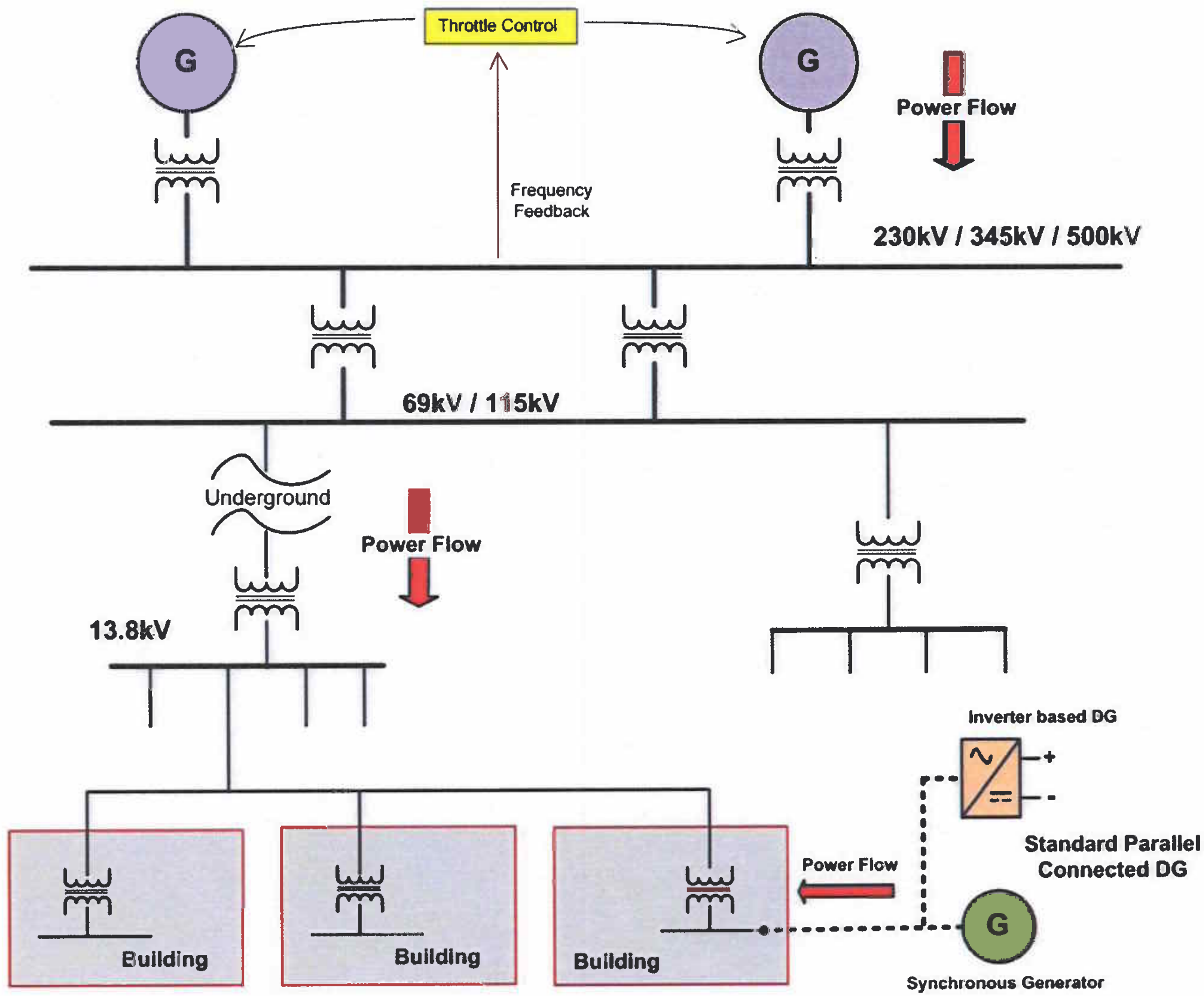
President

Non-Synchronous Energy Electronics, LLC

For

Pareto Energy Ltd.

A brief review of how the existing grid works



Frequency & Power Flow Controls

The existing system includes an analog frequency trim signal sent to large generator throttles. (In WECC...larger than 50MW)

It is very cyber secure due to the fact that it is not digital, and was developed before the internet.

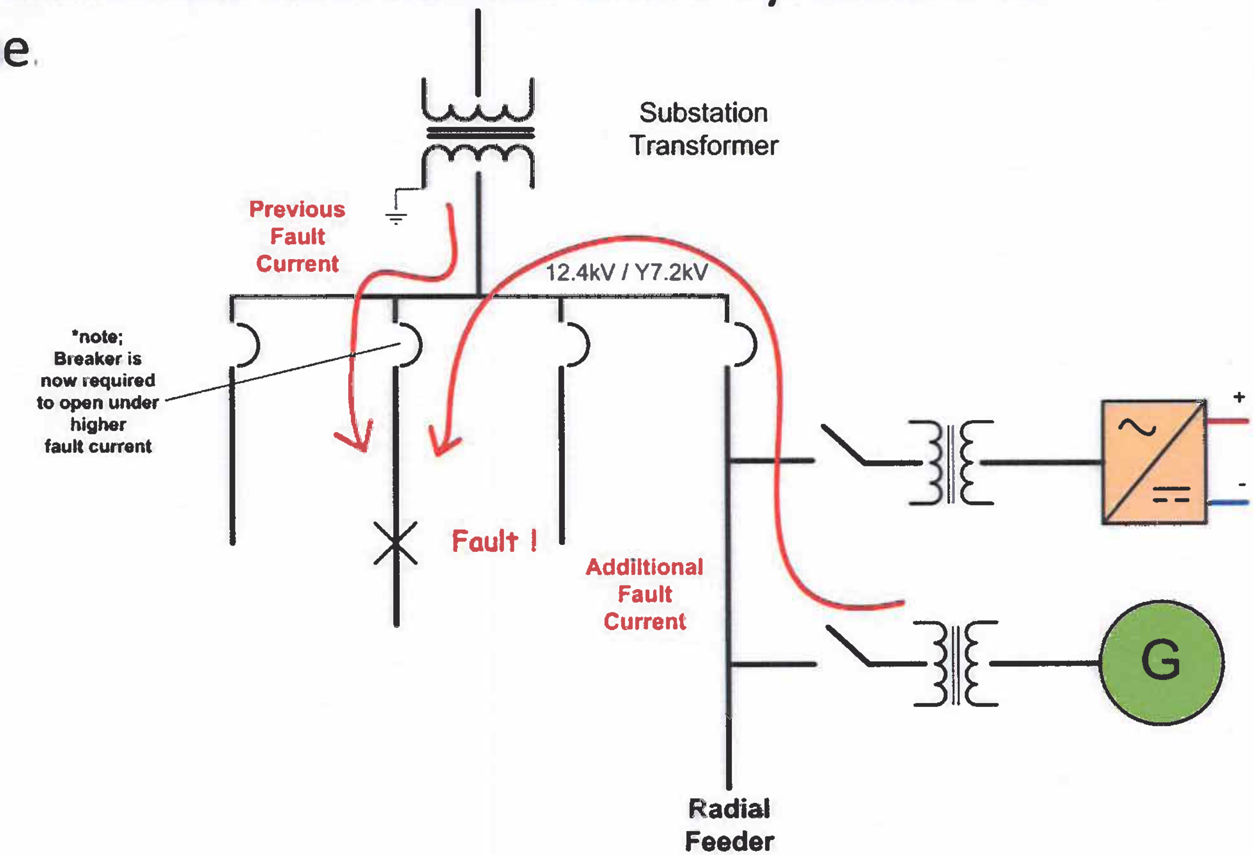
It is also expensive to modify and add to, and this limits the ability of small distributed power sources to become a significant part of the generation mix.

The Gridlink Microgrid design was developed to overcome these limits, such that we can add as much DG as we can consume the energy.

PARETO ENERGY

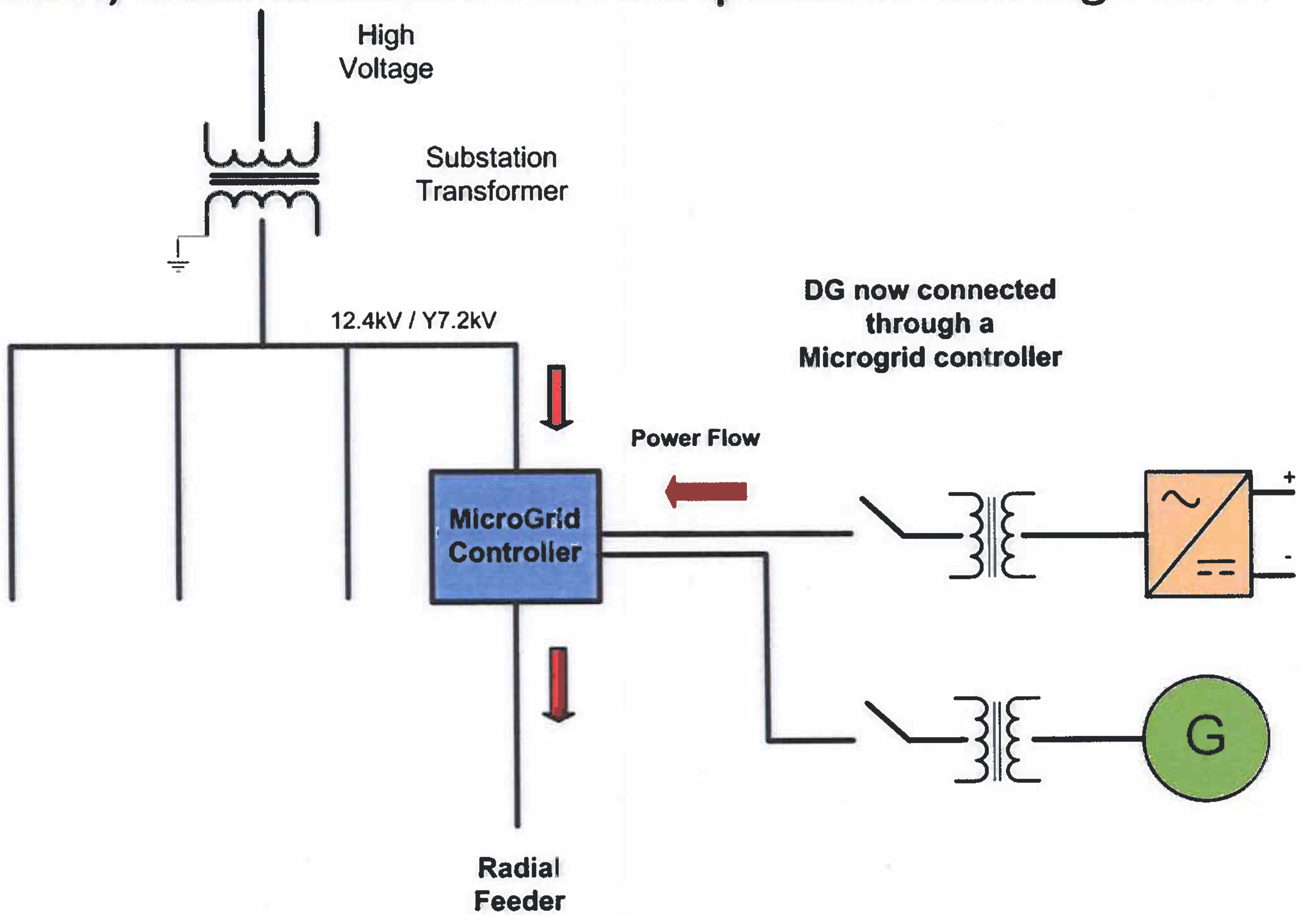
Fault Current and Stability Issues

The distribution system is generally not well monitored or controlled, and DG is limited to just a few percent of the total power. The additional fault current added by traditional DG is also an issue.



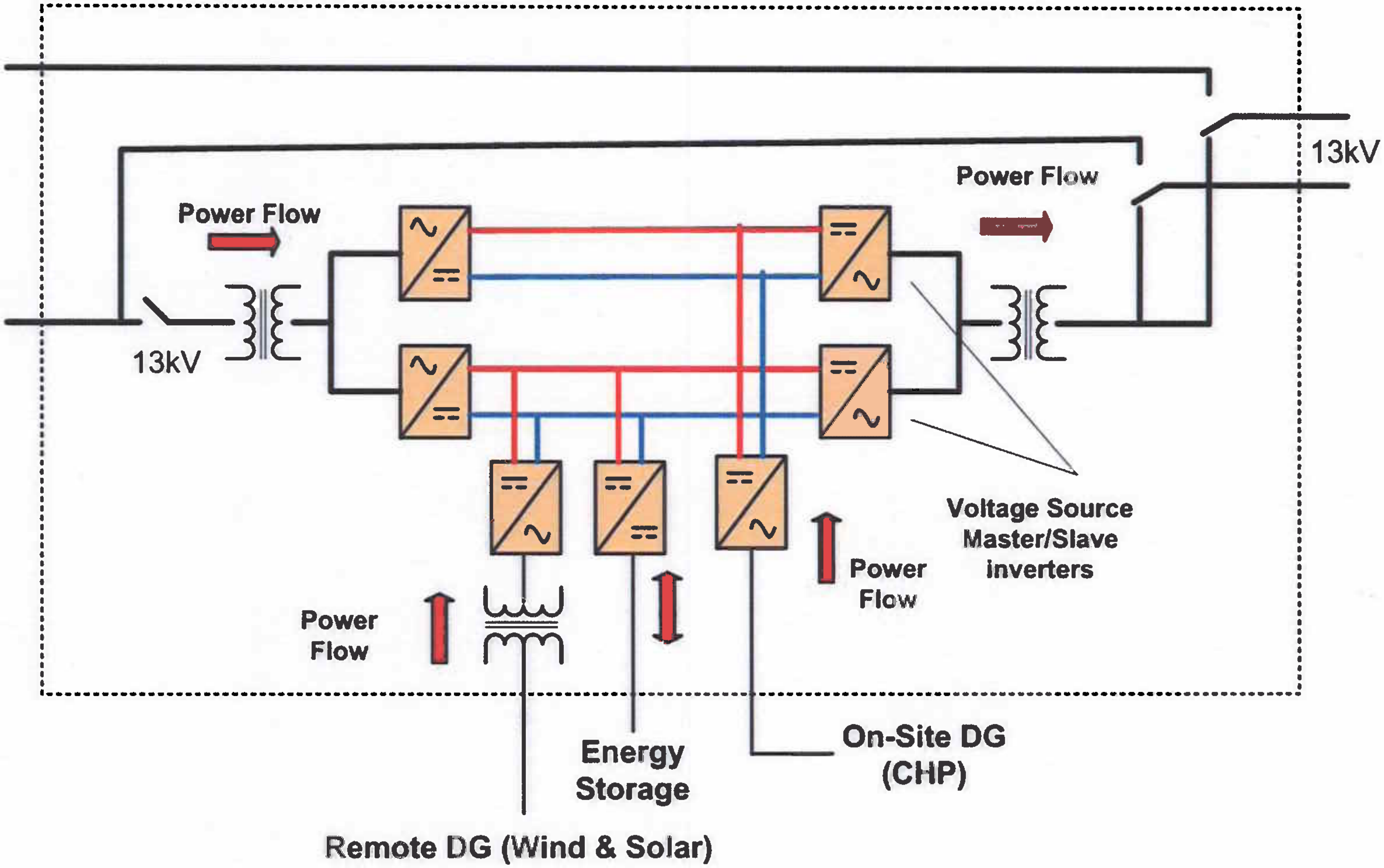
The Solution…use a Gridlink Microgrid

This allows for the addition of as much DG as can be consumed, without concern for the previous limiting issues.

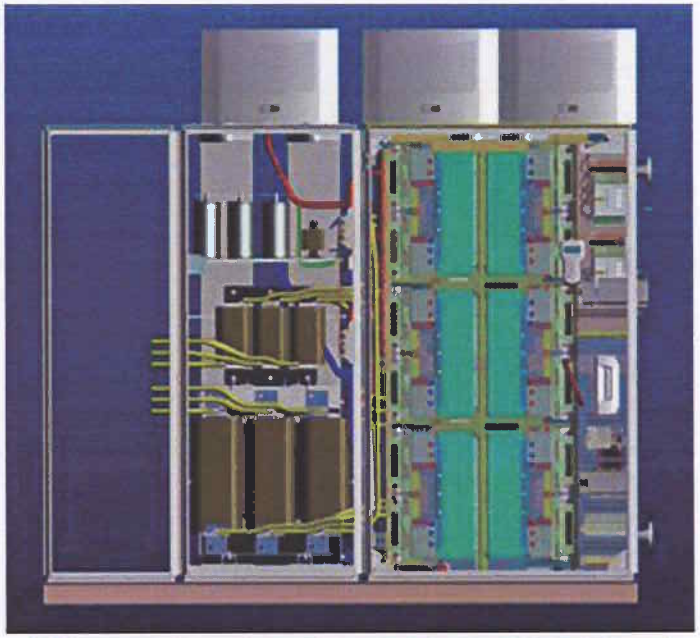


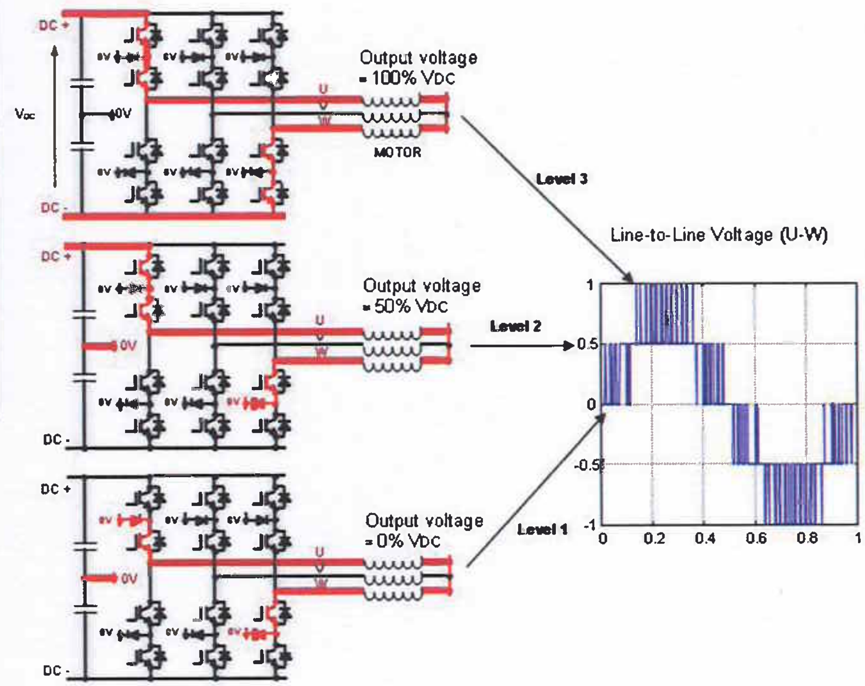
PARETO ENERGY

Controller Details: What's Inside the Blue Box?

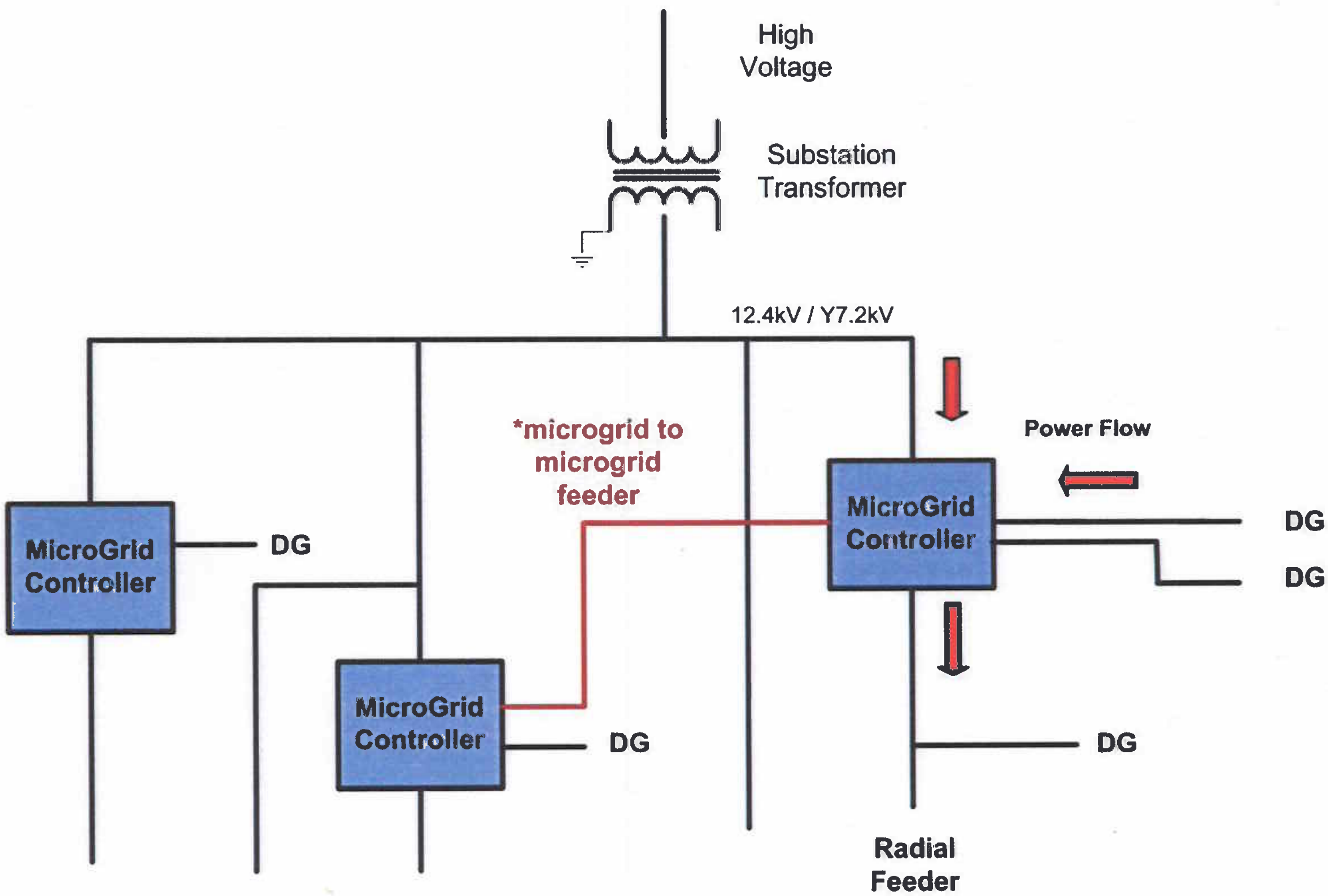


Modern Power Electronic Converters Make This Possible

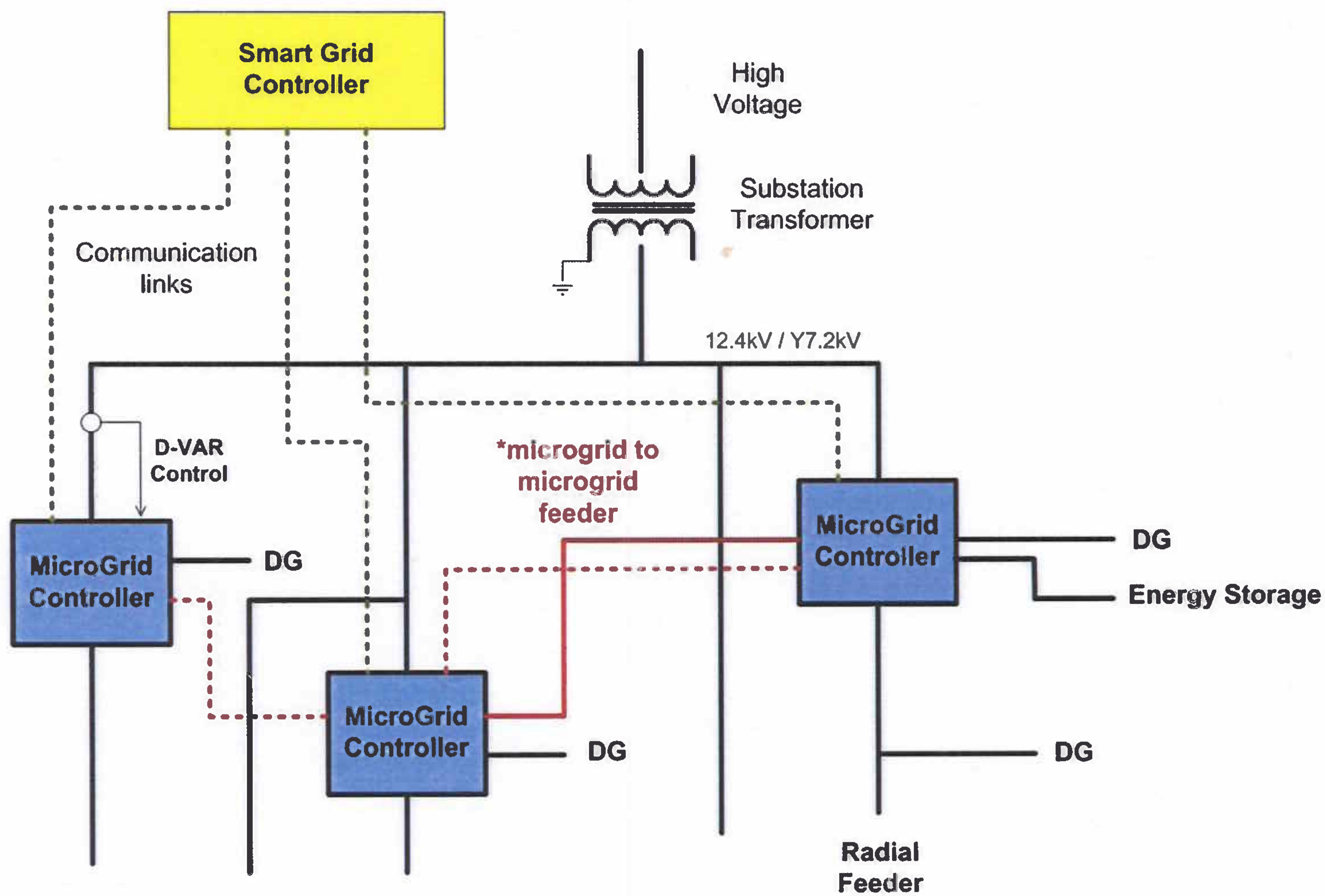




Many Microgrids can be added where needed



With Communications, More Possibilities



Appendix B:
Navigant Report on DG Cost-Benefit Measures

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4 Benefit/Cost of DG Beyond Distribution Deferral

- A Approach and Assumptions
- B Category A Benefits/Costs
- C Category B Benefits/Costs

To analyze the benefits/costs of DG beyond deferral, NCI leveraged the results of the eight distribution planning opportunities.

Can DG provide distribution value, meet customer needs, and offer net benefits greater than costs?

Can DG contribute value to distribution planning and meet customer needs? (the "hypothesis")

- What conditions must be met for DG to provide value to the distribution system?
- Will utility owned DG provide value to the distribution system?
- What conditions must be meet for DG to meet customer needs? Is DG attractive for customers? Without incentives or a market transformation program, will customer owned DG provide value to the distribution system?
- Will customer owned DG provide value to the distribution system, if customers are provided incentives?
- What are the characteristics of good DG/distribution planning opportunities?

Are there significant opportunities to achieve a societal win/win outcome considering all benefits and costs? *

- What costs and benefits should be considered?
- Can these costs and benefits be quantified and captured today?
- Is there a net benefit given the additional cost?
- How do the benefits/costs vary by technology and location?

* Note: As stated in the DG Collaborative's 2005 Annual Report, "if the hypothesis appears to be valid," the DG Collaborative plans to propose in its June 2006 Report "a framework for business and regulatory models that would be needed to provide distribution value, meet customer needs and achieve a societal win/win/win outcome with net benefits greater than costs for all stakeholders."

NCI performed two analytical tasks that included modeling, research and interaction with the DG Collaborative.

Can DG provide distribution value, meet customer needs, and offer net benefits greater than costs?

Can DG contribute value to distribution planning and meet customer needs? (the "hypothesis")

Economic Analysis of the Eight DG/Distribution Planning Opportunities

- Build upon the results of the DG Collaborative's initial analysis of the eight DG/Distribution Planning opportunities
- Refine data to provide more accurate estimates of capacity deferral for each of the eight opportunities
- Review each of the input assumptions and data estimates in detail, and recommend adjustments where appropriate
- Perform sensitivity analyses of key variables and rank DG capacity deferral opportunities for each of the eight utility locations

Are there significant opportunities to achieve a societal win/win outcome considering all benefits and costs?

Benefit/Cost of DG Beyond Distribution Deferral

- Build upon the eight distribution planning opportunities to include system-wide benefits such as T&D losses, transmission congestion relief, reliability, and emissions.
- Develop an analytical framework for calculating net benefits from stakeholders perspectives
- Make estimates of benefits and costs from existing literature
- Seek DG Collaborative input and support on these estimates and study results

The DG Collaborative provided feedback on assumptions, approach and methodology through conference calls, meetings and off-line discussions.

NCI followed a three-step process that leveraged the existing body of DG Benefits/Costs research.

1. Establish the Boundaries for the Analysis

NCI determined which stakeholders are impacted by the Future DG Owner, before DG is added. These stakeholders are those that will be considered within the boundaries of the analysis after DG is added.

2. Identify and Categorize the Benefits and Costs for Stakeholders

NCI identified what benefits and costs are generated after DG is installed. Benefits are categorized into transfer payments or incremental benefits/costs. Transfer payments occur when a benefit for one stakeholder results in a cost for another stakeholder (e.g. DG's fuel consumption is a cost to the DG owner, but a benefit to the natural gas distribution company). Incremental benefits/costs occur when a benefit for one stakeholder is not a cost for another (e.g. reduced emissions).

3. Calculate Benefits/Costs for Stakeholders

Leveraging the Distribution Deferral analysis, NCI identified a distribution planning opportunity (NSTAR Framingham) where DG is attractive as a deferral strategy with customer ownership. NCI identified a mix of customers with attractive paybacks for DG. The benefits/costs were calculated for each of these customers.

Analytical Framework | **Benefits/Costs Identification** | **Calculation Methodology and Assumptions**

Existing Body of DG Benefits/Costs Research
(see Section D for bibliography)

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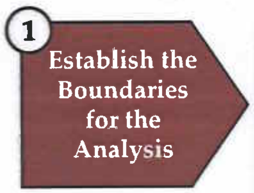
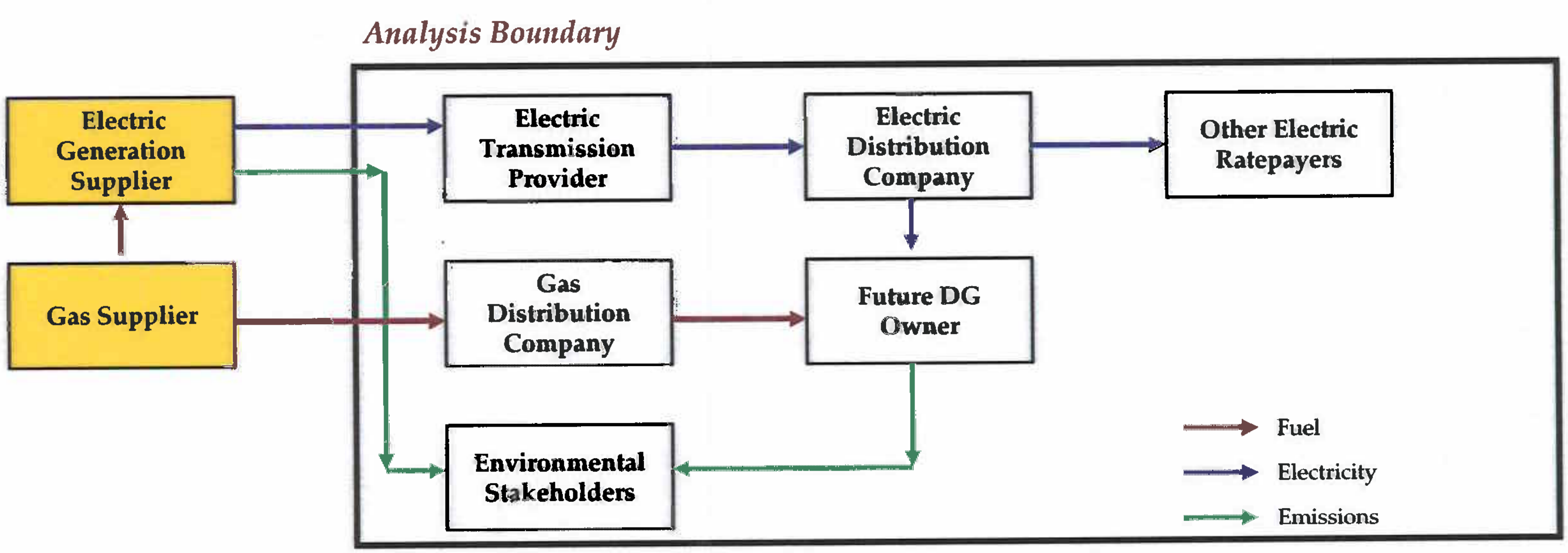
To establish the analysis boundary, NCI considered the regulated entities, environmental stakeholders and other ratepayers that are impacted currently by the Future DG Owner, before the DG is added.



The analysis boundary was determined by identifying the regulated entities, environmental stakeholders and other electric ratepayers that are impacted currently by the Future DG Owner, before the DG is added. The Environmental Stakeholders are those government, non-government or other customers that have taken on responsibility for environmental stewardship. These stakeholders are included since they are impacted by the emissions that are generated by the Electric Generation Supplier on behalf of the Future DG Owner, and the emissions from the Future DG Owner's boiler. The DG Equipment Supplier is not included since they will not be impacted by the Future DG Owner until after the DG is installed. Other competitive entities (i.e. Electric Generation Supplier and Gas Supplier) are not included in the analysis boundary.



Note: MA DTE 98-100 established methods and procedures to evaluate energy efficiency programs in Massachusetts. These methods and procedures did not isolate the impact on individual stakeholder groups as this analysis is attempting. However, the analysis boundary is consistent with the MA D.T.E. 98-100.

When DG is added, each stakeholder experiences a net benefit/cost change (Δ); the sum of these changes is the "net" benefit/cost.

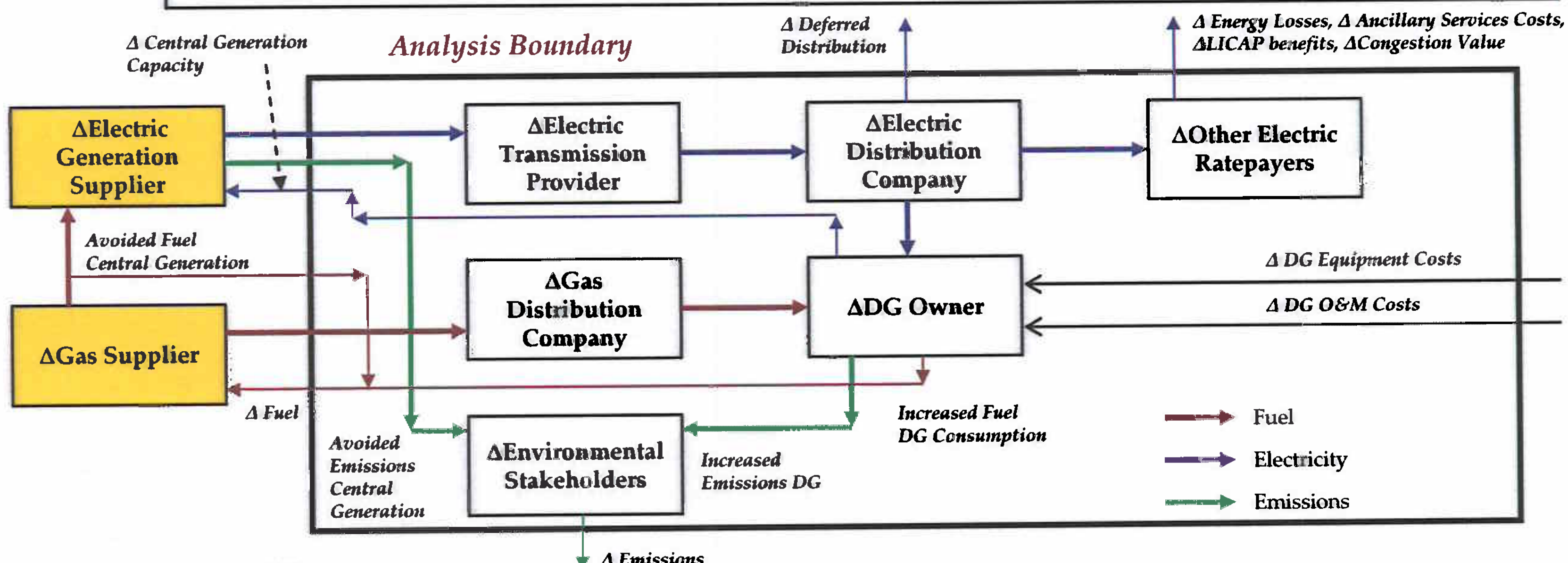
2 Identify and Categorize the Benefits and Costs for Stakeholders

Before DG is added, the system, within the analysis boundary, is in equilibrium. After DG is added, that equilibrium is upset, creating benefits and costs.[1] Each stakeholder, within the analysis boundary, experiences a net benefit/cost change (Δ); the sum of these changes is the "net" benefit/cost. A transfer of payments occurs between stakeholders within the analysis boundary and incremental benefits/costs are generated across the boundary to create a new equilibrium. There are two types of benefits/costs that NCI considered 1) transfer payments (i.e. a benefit for one stakeholder is a cost to another) and 2) incremental benefits/costs (i.e. benefits/costs for one stakeholder that are not costs/benefits for another stakeholder).

Net Benefits/Costs (B/C) = *ΔB/C Electric Transmission Provider* + *Δ B/C Electric Distribution Company* + *ΔB/C Other Ratepayers* + *ΔB/C Gas Distribution Company* + *ΔB/C DG Owner* + *ΔB/C Environmental Stakeholders*

The transfer payments within the analysis boundary will net out and result in the following:

Net Benefits/Costs = Sum of Incremental Benefits/Costs[2] = *ΔDG Equipment Costs* + *ΔDG O&M Costs* + *ΔEmissions* + *ΔFuel* + *ΔCentral Generation Capacity* + *ΔDeferred Distribution* + *ΔEnergy Losses* + *ΔAncillary Services Costs* +*ΔLICAP value, ΔCongestion Value*



1. The graphic illustrates the impact of a CHP installation.
2. Listed are the incremental benefits/costs that NCI calculated. There are additional benefits/costs that NCI identified but did not calculate. These benefits/costs are shown as Category B benefits/costs in following pages.

When DG is added, each stakeholder experiences a net benefit/cost change (Δ); the sum of these changes is the "net" benefit/cost.

3 Calculate Benefits/Costs for Stakeholders

Leveraging the Distribution Deferral analysis, NCI identified a distribution planning opportunity where DG is attractive as a deferral strategy with customer ownership. The NSTAR Framingham opportunity was selected. NCI identified a mix of customers with attractive paybacks for DG. The benefits/costs were calculated for each of these customers on a NPV basis since certain benefits/costs would continue into the future.[1] The results were aggregated to provide the overall benefit/cost for the NSTAR Framingham opportunity. This work was accomplished in three subtasks:

Task 3A) Category A: 1) Transfer Payments and 2) Incremental Benefits/Costs – 1) These costs and benefits are relatively easy to calculate and are realized by customers today. 2) These benefits and costs are more difficult to calculate, however a reasonable methodology and assumptions can be developed.

Task 3B) Category B: Incremental Benefits/Costs – These are benefits and costs that may be present; however it is difficult to develop a reasonable methodology and assumptions with any confidence.

1. NCI assumes a 20 year project life for all DG technologies.

NCI identified 32 benefits and costs for DG and categorized them using the following metrics:

- Type of Benefit/Cost – Transfer payments are a a benefit for one stakeholder is a cost to another. Incremental benefits/costs are benefits/costs for one stakeholder that are not costs/benefits for another stakeholder. *(Transfer Payment or Incremental Benefit/Cost)*
- Economic Impact Captured Today – Whether or not certain costs and benefits for stakeholders are included in tariff designs today. This does not address whether or not a market places a value on the cost and benefit. *(Yes or No)*
- Analytic Tractability – An assessment of the ability to perform a detailed analysis of the value. Where the necessary data is readily available and the algorithms are agreed upon the analytic tractability is considered "Easy". However, when the data is not well known and there is limited agreement how to perform calculations the analytic tractability is considered "Difficult" *(Easy, Moderate or Difficult)*
- Location Specific – Certain costs and benefits depend on the precise location of the DG asset within the electric power system. While other costs and benefits can be determined irregardless of the location of the DG asset. *(Yes or No)*
- Requirement for a High Penetration of DG – Certain costs and benefits require more than one DG asset to have the desired impact on the electric power system. *(Yes or No)*
- Confidence in Value – The combination of the analytic tractability, whether or not benefit is location specific, and requirement for high penetration of DG determine the confidence in the value of the cost or benefit *(Low, Medium or High)*.
  - Low: Greater than 100%
  - Medium: Less than 100%
  - High: Less than 25%

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Category A includes all the transfer payments and incremental benefits and costs that are relatively easy to calculate.

	Category A Benefit/Cost	Economic Impact Captured Today	Analytic Tractability	Location Specific	Requires a High Penetration of DG	Confidence in Value
Total Electric Bill	DG Owner Electricity Bill: Transfer Payments	Yes	Easy	No	No	High
Total Electric Bill	Reduced Central Power Plant Fuel Consumption	Yes	Easy	No	No	High
Total Electric Bill	Avoided Central Power Plant Capacity	Yes	Easy	No	No	High
Total NG Bill	DG Owner Natural Gas Bill: Transfer Payments	Yes	Easy	No	No	High
Total NG Bill	Increased DG Owner Natural Gas Consumption	Yes	Easy	No	No	High
State and Federal Incentives		Yes	Easy	No	No	High
Renewable Energy Certificates		Yes	Easy	No	No	High
DG Equipment and Installation		Yes	Easy	No	No	High
Annual O&M Expenses for DG		Yes	Easy	No	No	High
Increased Reliability for DG Owner		No	Moderate	No	No	High
Locational Installed Capacity (LICAP) Value		No	Moderate	Yes	No	Medium
Deferred Distribution System Investment		No	Moderate	Yes	Yes	High
Ancillary Services		No	Moderate	No	Yes	Low
Congestion Value		Yes	Moderate	Yes	No	Low
Emissions – CO2, NOx, and SOx		No	Moderate	No	No	Medium
Avoided Electric System Losses		No	Moderate	Yes	Yes	Low
Benefits Overhead		No	Moderate	Yes	Yes	Medium

Category B benefits and costs that are more difficult to quantify; the data is hard to collect or there is limited agreement on models, or both.

Category B Benefit/Cost	Economic Impact Captured Today	Analytic Tractability	Location Specific	Requires a High Penetration of DG	Confidence in Value
Health Impact of DG	No	Hard	Yes	No	Low
Increased Emissions (CO_2, NO_x and SO_x)	No	Hard	No	No	Low
Noise Disturbance	No	Hard	Yes	No	Low
NIMBY Opposition to DG	No	Hard	Yes	No	Low
Consumer Electricity Price Protection	No	Hard	Yes	No	Low
Power Quality (DG Owner)	No	Hard	Yes	No	Low
Market Price Impacts/Elasticity	No	Hard	Yes	Yes	Low
Fuel Diversity	No	Hard	No	Yes	Low
Deferred Transmissions Capacity	No	Hard	No	Yes	Low
Reduced Security Risk to Grid	No	Hard	Yes	Yes	Low
Fuel Delivery Challenges	No	Hard	Yes	Yes	Low
NIMBY Opposition to Central Power Plants and Transmission Lines	No	Hard	Yes	Yes	Low
Real Options Value of DG	No	Moderate	Yes	Yes	Low
Support of RPS Goals	No	Easy	No	No	High
Local economic impact	No	Hard	Yes	Yes	Low

Different discount rates were used to calculate the NPV of the benefits/costs for each stakeholder.

Stakeholders	Description	Real Discount Rate[1]
Future DG Owner	A consumer of electric and natural gas services.	9%
Electric Distribution Company	A regulated utility company that is responsible for maintaining and operating the electric distribution system.	5%
Electric Transmission Provider	A regulated utility company that is responsible for maintaining and operating the electric transmission system	5%
Other Electric Ratepayers	Consumers of electric services	3%
Natural Gas Distribution Company	A regulated utility company that is responsible for maintaining and operating the natural gas distribution system	5%
Environmental Stakeholders	Citizens that have taken on the responsibility for environmental stewardship	3%
Net	Includes all Stakeholders within the Analysis Boundary (i.e., those described above).	N/A

1. The average cost of capital for the Massachusetts Distribution Companies is 8%. Assuming a 3% inflation rate the real discount rate is ~5%. This rate is also applied to other regulated entities – the Electric Transmission Provider and Natural Gas Distribution Company. The real discount rate for non-regulated industries is approximated as 9.0%.[3] This applies to the DG Owner, except when the DG Owner is a residential customer. A societal real discount rate of 3% was applied to Other Electric Ratepayers, Environmental Stakeholders, and to residential DG Owners.[3]
2. If benefits/costs extend beyond the initial year their value increases at the rate of inflation, 3%.
3. Based on prior NCI studies and experience.
4. *CPUC Self-Generation Incentive Program Preliminary Cost-Effectiveness Evaluation Report, Itron Inc. September 14, 2006. Available at:* http://www.itron.com/asset.asp?path=assets/itr_001094.pdf

4 Benefit/Cost of DG Beyond Distribution Deferral

A Approach and Assumptions

B Category A Benefits/Costs

C Category B Benefits/Costs

As each benefit/cost is described, a sample calculation is included for a 250 kW CHP NG reciprocating engine installation.

- Determine the size of each benefit/cost by assuming Customer 20 in the NSTAR Framingham opportunity installs a 250 kW CHP NG recip Engine.
  - SIC: **8051 (Skilled Nursing Care Facility)**
  - Peak Demand: **746 kW**
  - Annual Energy Use: **2,921,968 kWh**
  - Electric Company: **Boston Edison Company**
  - Electric Load Zone: **NEMA**
  - Gas Company: **NSTAR Gas Company**
- The benefits/costs are presented on a net present value basis, except where noted.
- Benefits/costs include the impact of electric power system losses, if applicable.
  - Average transmission system losses are 2%.[1]
  - Average distribution system losses are 6%.[2, 3]

1. In "Resource Assessment: Strategic Options in Electric Supply and Demand for Cape Cod and Martha's Vineyard 2005-2015, Ridley & Associates, Inc" for the Cape Light Compact it was noted that "NSTAR estimates 2 percent losses on the transmission system and 8 percent losses on the distribution system for the Cape and Vineyard" (Available at: http://www.capelightcompact.org/pdfs/FIN_RSRCE_ASMT.pdf)
2. Aabakken, J. *Power Technologies Data Book: 2003 Edition*, National Renewable Energy Laboratory, June 2004. NREL/TP-620-36347.
3. Connors, S., K. Martin and E. Kern. "Future Electricity Supplies: Redefining Efficiency from a Systems Perspective." MIT Laboratory for Energy and the Environment, March 2004.

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Sample calculation of Category A Benefits and Costs for a 250 kW natural gas engine CHP project at a nursing care facility in Framingham.

	Category A Benefit/Cost	DG Owner	Electric Distribution Company	Electric Transmission Provider	Other Electric Ratepayers	Gas Distribution Company	Environmental Stakeholders	Net
Total Electric Bill	DG Owner Electricity Bill: Transfer Payments	520,000	(280,000)	(55,000)	(330,000)	-	-	(230,000)
	Reduced Central Power Plant Fuel Consumption	1,400,000	-	-	-	-	-	1,400,000
	Avoided Central Power Plant Capacity	330,000	-	-	-	-	-	330,000
Total NG Bill	DG Owner Natural Gas Bill: Transfer Payments	(130,000)	-	-	-	170,000	-	40,000
	Increased DG Owner Natural Gas Consumption	(740,000)	-	-	-	-	-	(740,000)
	State and Federal Incentives (NPV)	-	-	-	-	-	-	-
	Renewable Energy Certificates	-	-	-	-	-	-	-
	DG Equipment and Installation	(500,000)	-	-	-	-	-	(500,000)
	Annual O&M Expenses for DG	(320,000)	-	-	-	-	-	(320,000)
	Increased Reliability for DG Owner	63,000	-	-	-	-	-	63,000
	Locational Installed Capacity (LICAP) Value	-	-	-	54,000	-	-	54,000
	Deferred Distribution System Investment	-	16,000	-	-	-	-	16,000
	Ancillary Services	-	-	-	91,000	-	-	91,000
	Congestion Value	-	-	-	48,000	-	-	48,000
	Emissions - CO_2, NOx & SOx	-	-	-	-	-	230,000	230,000
	Avoided Electric System Losses	-	-	-	260,000	-	12,000	270,000
	Benefits Overhead	-	-	-	-	-	-	(190,000)
	Sub-Total Category A*	580,000	(260,000)	(55,000)	120,000	170,000	240,000	520,000

* Including Category B benefits/costs for CHP could provide additional net positive benefits.

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Category A	Economic Impact Captured Today	Analytic Tractability	Location Specific	Requires a High Penetration of DG	Confidence in Value
DG Owner Electricity Bill: Transfer Payments	Yes	Easy	No	No	High

The DG Owner consumes less *electricity* from the electric power system, reducing their electric bill and the revenues to other stakeholders.

Category A Benefit/Cost	DG Owner	Electric Distribution Company	Electric Transmission Provider	Other Electric Ratepayers	Gas Distribution Company	Environmental Stakeholders	Net
Annual DG Owner Electricity Bill: Transfer Payments	53,000	(21,000)	(4,200)	(21,000)	0	0	**0**
NPV DG Owner Electricity Bill: Transfer Payments	520,000	(280,000)	(55,000)	(330,000)	0	0	**(230,000)**

Assumptions

- The electric bill for the customer is calculated based on the rate class for a particular utility and load zone; and assumes an electric load profile based on the annual kWh and peak kW which scale the average load shape for the rate class.
- The Energy Cost Savings Module (from the analysis of the Eight Distribution Planning Opportunities) replicates each customer's electric bill (before and after DG is installed) using actual tariffs. The DG costs, electric outputs and thermal outputs are calculated for each hour of the year (8760 hours).
- Each component of the bill is apportioned to the appropriate stakeholder; there are no assumptions about billing components that may be avoidable:
  - The DG Owner captures the full benefit
  - Distribution components – Electric Distribution Company
  - Transmission components – Electric Transmission Provider
  - Transition charges – Other Electric Ratepayers
  - Energy Efficiency and Renewable Energy Charges – Net

Calculation

- Each electric bill component is determined in the Energy Cost Savings Module (from the analysis of the Eight Distribution Planning Opportunities) before and after DG is installed.
- *Electric Bill Savings to the DG Owner* = ∑ (Net Electric Bill Component$_i$)
- *Net Electric Bill Component$_i$* = Electric Bill Component$_i$ (after DG installed) – Electric Bill Component$_i$ (original)
  where i = distribution, transmission, transition, and energy efficiency and renewable energy charges.

Note: The electric supply portion of the DG Owner's electric bill is discussed as separate benefits/costs.

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Category A	Economic Impact Captured Today	Analytic Tractability	Location Specific	Requires a High Penetration of DG	Confidence in Value
Central Power Plant Fuel Consumption	Yes	Easy	No	No	High

DG indirectly reduces *central power plant fuel consumption.*

Category A Benefit/Cost	DG Owner	Electric Distribution Company	Electric Transmission Provider	Other Electric Ratepayers	Gas Distribution Company	Environmental Stakeholders	Net
NPV Central Power Plant Fuel Consumption	1,400,000	0	0	0	0	0	1,400,000

Assumptions

- The electric supply portion of the DG Owner's bill is composed of two parts: the *Central Power Plant Fuel Consumption* and *Central Power Plant Capacity*.
- The reduced electricity consumption by the DG Owner reduced the electric generation on the margin. The ISO-NE marginal (price-setting) generation units are powered by natural gas.[2, 3] The marginal cost of electric generation is set by the price electric power generators pay for natural gas. The average heat rate for natural gas power plants on the margin is 7,000 Btu/kWh.[2, 3] In 2005, natural gas cost MA electric generators approximately $9.10/MMBtu.[1]
- NCI made a simplifying assumption that the reduced central power plant fuel is all natural gas. The actual fuel mix of the generation displaced by DG will vary by when the DG unit operates. For PV systems, which are more likely to operate during the peak load hours, the average heat rate may be higher as less efficient power plants are utilized. Therefore, if one were to determine the actual mix of generators and the price of fuel to run those units, this value may be higher.

Calculation

- *Central Power Plant Fuel Consumption ($)* = Electric Output of DG including T&D losses (kWh) × Marginal Cost of Electric Generation ($/kWh)
- Marginal cost of electric generation ($/kWh) = Natural Gas Cost for Power Plants ($/MMBtu) × Heat Rate for Natural Gas Power Plants (Btu/kWh) / 1,000,000

1. For Jan 2005 to Aug 2005. "Massachusetts Natural Gas Price Sold to Electric Power Consumers" Available at: http://tonto.eia.doe.gov/dnav/ng/hist/n3045ma3m.htm. Accessed January 17, 2006. A ratio of 1.2 was used to determine the MA electric power price from the U.S. wellhead price for the period Aug 2005 to Dec 2005. The ratio is based on data from Jul 2002 to Aug 2005.
2. *2005 Quarterly Market Report: First Quarter*. ISO New England, September 20, 2005 - 42% Gas, 28% Oil/Gas and *2005 Quarterly Market Report: Second Quarter*. ISO New England, September 20, 2005 - 65% Gas, 36% Oil/Gas). Note: Percentages may total to more than 100% because at one time more than one unit may be setting prices because of transmission constraints. The ISO-NE Quarterly Market Reports are available at: http://www.iso-ne.com/markets/mkt_anlys_rpts/qtrly_mktops_rpts/.
3. *Natural Gas Impacts of Increased CHP*. Energy and Environmental Analysis, Inc., October 2003. Available at: http://uschpa.admgt.com/CHP_GasOct03.pdf

Category A	Economic Impact Captured Today	Analytic Tractability	Location Specific	Requires a High Penetration of DG	Confidence in Value
Reduced Central Power Plant Capacity	Yes	Easy	No	No	High

DG indirectly avoids *central power plant capacity.*

Category A Benefit/Cost	DG Owner	Electric Distribution Company	Electric Transmission Provider	Other Electric Ratepayers	Gas Distribution Company	Environmental Stakeholders	Net
NPV Central Power Plant Capacity	330,000	0	0	0	0	0	330,000

Assumptions

- The electric supply portion of the DG Owner's bill is composed of two parts: the *Central Power Plant Fuel Consumption* and *Central Power Plant Capacity*.
- The capacity portion is the total energy supply cost minus the fuel portion, which has been calculated on the prior page.

Calculation

- *Central Power Plant Capacity ($)* = Net Energy Supply Cost – [Electric Output of DG including T&D losses (kWh) × Marginal Cost of Electric Generation ($/kWh)]
- Net Energy Supply Cost ($) = Energy Supply Component After DG ($) – Energy Supply Component Before DG ($)
- Marginal cost of electric generation ($/kWh) = Natural Gas Cost for Power Plants ($/MMBtu) × Heat Rate for Natural Gas Power Plants (Btu/kWh) / 1,000,000

Category A	Economic Impact Captured Today	Analytic Tractability	Location Specific	Requires a High Penetration of DG	Confidence in Value
DG Owner Natural Gas Bill: Transfer Payments	Yes	Easy	No	No	High

Natural gas-fired DG consumes more *natural gas*, increasing the DG Owner's natural gas bill and the revenues to the Gas Distribution Co.

Category A Benefit/Cost	DG Owner	Electric Distribution Company	Electric Transmission Provider	Other Electric Ratepayers	Gas Distribution Company	Environmental Stakeholders	Net
Annual DG Owner Natural Gas Bill: Transfer Payments	(13,000)	0	0	0	13,000	0	**0**
NPV DG Owner Natural Gas Bill: Transfer Payments	(130,000)	0	0	0	170,000	0	**40,000**

Assumptions

- If natural gas-fired DG is installed, the DG Owner's demand for natural gas will increase. For CHP, this increase will offset natural gas consumed by the DG Owner's boiler.
- The natural gas bill for the customer is calculated based on the rate class for a particular utility; and assumes a thermal load profile based on the SIC and annual kWh. Because the customer's natural gas usage and load factor will change the customer's rate class may also change. The Energy Cost Savings Module (from the analysis of the Eight Distribution Planning Opportunities) replicates each customer's natural gas bill (before and after DG is installed) using actual tariff components. The DG electric and thermal outputs are calculated for each hour of the year (8760 hours).
- Each component of the bill is apportioned to the appropriate stakeholder; there are no assumptions about billing components that may be avoidable
  - The DG Owner captures the full cost.
  - Distribution components – Gas Distribution Company

Calculation

- Each natural gas bill component is determined in the Energy Cost Savings Module (from the analysis of the Eight Distribution Planning Opportunities) before and after DG is installed.
- *Natural Gas Bill for the DG Owner* = $\sum$ (Net Natural Gas Bill Component_i)
- *Net Electric Bill* $\textit{Component}_i$ = Natural Gas Bill Component_i (after DG installed) – Natural Gas Bill Component_i (original) where i = distribution

NAVIGANT CONSULTING

Category A	Economic Impact Captured Today	Analytic Tractability	Location Specific	Requires a High Penetration of DG	Confidence in Value
Increased DG Owner Natural Gas Consumption	Yes	Easy	No	No	High

Natural gas-fired DG consumes more *natural gas*, which is a cost to the DG Owner.

Category A Benefit/Cost	DG Owner	Electric Distribution Company	Electric Transmission Provider	Other Electric Ratepayers	Gas Distribution Company	Environmental Stakeholders	Net
NPV Increased DG Owner Natural Gas Consumption	(740,000)	0	0	0	0	0	(740,000)

Assumptions

- If natural gas-fired DG is installed, the DG Owner's demand for natural gas will increase. For CHP, this increase will offset natural gas consumed by the DG Owner's boiler.
- The natural gas bill for the customer is calculated based on the rate class for a particular utility; and assumes a thermal load profile based on the SIC and annual kWh. Because the customer's natural gas usage and load factor will change the customer's rate class may also change. The Energy Cost Savings Module (from the analysis of the Eight Distribution Planning Opportunities) replicates each customer's natural gas bill (before and after DG is installed) using actual tariff components. The DG electric and thermal outputs are calculated for each hour of the year (8760 hours).
- Each component of the bill is apportioned to the appropriate stakeholder:
  - Natural Gas Supply components – DG Owner

Calculation

- Each natural gas bill component is determined in the Energy Cost Savings Module (from the analysis of the Eight Distribution Planning Opportunities) before and after DG is installed.
- *Natural Gas Bill for the DG Owner* = ∑ (Net Natural Gas Bill Component_i)
- *Net Electric Bill* $\textit{Component}_i$ = Natural Gas Bill Component_i (after DG installed) – Natural Gas Bill Component_i (original) where i = supply.

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Category A	Economic Impact Captured Today	Analytic Tractability	Location Specific	Requires a High Penetration of DG	Confidence in Value
State and Federal Incentives	Yes	Easy	No	No	High

State and Federal Incentives are a benefit to the DG Owner.

Category A Benefit/Cost	DG Owner	Electric Distribution Company	Electric Transmission Provider	Other Electric Ratepayers	Gas Distribution Company	Environmental Stakeholders	Net
NPV State and Federal Incentives	0	0	0	0	0	0	0

Assumptions

- *State and Federal Incentives* encourage electric generation units that provide value to Environmental Stakeholders.
- There are no Massachusetts or Federal incentives for reciprocating engine based DG or CHP
- There is a Federal tax credit for microturbines
- There are *State and Federal Incentives* for:

  Residential PV
  - Small Renewables Initiative
  - State Personal Income Tax Credit
  - Federal Residential Solar/Fuel Cell Tax Credit

  Commercial PV
  - Large On-site Renewables Initiative
  - State Corporate Income Tax Deduction
  - State Corporate Excise Tax Exemption
  - Business Energy Tax Credit
  - Accelerated Depreciation

Calculation

- See the Energy Cost Savings Module (from the analysis of the Eight Distribution Planning Opportunities) for details on each Massachusetts and Federal incentive program.

Category A	Economic Impact Captured Today	Analytic Tractability	Location Specific	Requires a High Penetration of DG	Confidence in Value
Renewable Energy Certificates	Yes	Easy	No	No	High

Renewable Energy Certificates (RECs) are a benefit to the DG Owner.

Category A Benefit/Cost	DG Owner	Electric Distribution Company	Electric Transmission Provider	Other Electric Ratepayers	Gas Distribution Company	Environmental Stakeholders	Net
NPV Renewable Energy Certificates	0	0	0	0	0	0	**0**

Assumptions

- *Renewable Energy Certificates (RECs)* are used to account for the attributes associated with the electricity generation.
- RECs are available for photovoltaics (PV)
- RECs are not available for natural gas-fired CHP systems.
- RECs for PV systems in 2005 are being bought in Massachusetts for $0.06/kWh (Massachusetts Energy Consumers Alliances (MassEnergy)[1])
- The MassEnergy program continues for the life of the PV project.

Calculation

- *REC Value ($)* = PV production (kWh) × $0.06/kWh

1. "Opportunity for Additional Revenue from Your Solar Installation!" Massachusetts Energy Consumers Alliance. Available at: http://www.massenergy.com/Solar.REC.Sale.html. Accessed: December 9, 2005.

Category A	Economic Impact Captured Today	Analytic Tractability	Location Specific	Requires a High Penetration of DG	Confidence in Value
DG Equipment and Installation	Yes	Easy	No	No	High

DG Equipment and Installation is a cost to the DG Owner.

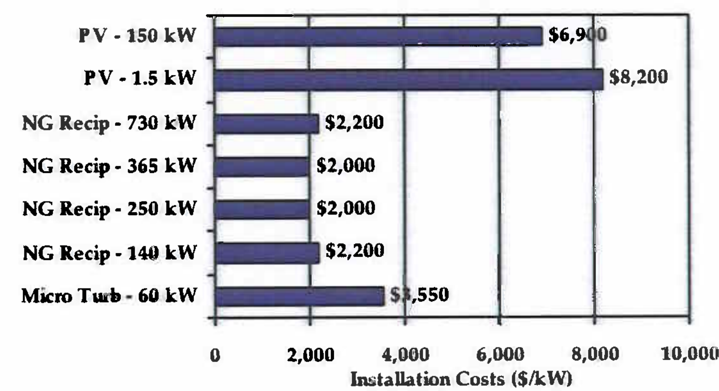
Category A Benefit/Cost	DG Owner	Electric Distribution Company	Electric Transmission Provider	Other Electric Ratepayers	Gas Distribution Company	Environmental Stakeholders	Net
NPV DG Equipment and Installation	(500,000)	0	0	0	0	0	(500,000)

Assumptions

- *DG Equipment and Installation* costs were estimated from publicly available data reported to the California Energy Commission and California Public Utilities Commission as part of the Emerging Renewable Program and the Self-Generation Incentive Program.
- *DG Equipment and Installation* includes costs for equipment, installation, emissions controls, labor, materials, engineering, permitting and interconnection.
- These costs are a benefit to other stakeholders (suppliers, installers, consultants, etc.) that are not explicitly included in this analysis.
- Assumes that after 20 years of product life there is no or minimal salvage value.

Calculation

- The *DG Equipment and Installation* cost depends on the DG option selected for each customer in the Energy Cost Savings Module (from the analysis of the Eight Distribution Planning Opportunities)
- DG Equipment and Installation costs (base case) are provided for selected technologies and sizes in the table below.



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Category A	Economic Impact Captured Today	Analytic Tractability	Location Specific	Requires a High Penetration of DG	Confidence in Value
Annual O&M Expenses for DG	Yes	Easy	No	No	High

Annual Operation and Maintenance Expenses for DG are a cost to the DG Owner.

Category A Benefit/Cost	DG Owner	Electric Distribution Company	Electric Transmission Provider	Other Electric Ratepayers	Gas Distribution Company	Environmental Stakeholders	Net
NPV Annual O&M Expenses for DG	(320,000)	0	0	0	0	0	**(320,000)**

Assumptions

- *Operation and Maintenance Expenses* vary by DG type, size of the unit and the number of hours the DG operates.
- *Operation and Maintenance Expenses* include the cost of replacement parts, consumables, labor and includes minor and major overhauls.
- The EEA report, *Gas-Fired Distributed Energy Resource Technology Characterizations* provides O&M costs for gas-fired DG and other EEA reports.[1]
- The Akeena Solar report, *The Economics of Solar Power for California* provides O&M costs for PV systems.[2]

Calculation

- The *Annual O&M Expenses for DG* depend on the DG option selected for each customer in the Energy Cost Savings Module (from the analysis of the Eight Distribution Planning Opportunities)
- *Annual O&M Expenses ($)* = Variable Costs ($) + Fixed Costs ($)
- Variable Costs ($) = O&M Costs ($/kWh) × Availability × 8760 hrs × DG Size (kW)
- Fixed Costs ($) = O&M Costs ($/kW) × DG Size (kW)

1. Goldstein, L. et al, *Gas-Fired Distributed Energy Resource Technology Characterizations*, NREL/TP-620-34783, November 2003, Prepared under Task No. NREL AS73.2002.
2. Cinnamon, B. et al, *The Economics of Solar Power in California: A White Paper*, Akeena Solar, August 23, 2004

Category A	Economic Impact Captured Today	Analytic Tractability	Location Specific	Requires a High Penetration of DG	Confidence in Value
Increased Reliability (DG Owner)	No	Mod.	No	No	High

Increased Reliability (DG Owner) is a benefit to the DG Owner.

Category A Benefit/Cost	DG Owner	Electric Distribution Company	Electric Transmission Provider	Other Electric Ratepayers	Gas Distribution Company	Environmental Stakeholders	Net
NPV Increased Reliability (DG Owner)	63,000	0	0	0	0	0	**63,000**

Assumptions

- A synchronous DG unit offsets the cost of a diesel back-up generator which would be used by the DG Owner to improve *reliability*.
- The value of increased reliability varies by customer and can be determined by calculating the losses that the customer would incur during reliability events. However, these losses vary widely; they could be substantial for some customers and insignificant for others. The lowest cost solution that a customer could deploy, on their own, would be a diesel engine generator. The cost of the diesel engine, therefore caps the value of increased reliability. For some customers, who would not experience significant losses during a reliability event, this approach could overestimate the value.
- The equipment and installation cost for a diesel back-up generator is $250 per kW.[1]
- This benefit is realized only in the first year. Once the synchronous DG is installed it continues to offer the DG Owner improved reliability for their critical loads.

Calculation

- *Increased Reliability ($)* = DG (kW) × $250/kW

1. A diesel engine without emission controls and is not interconnected to the electric power system.

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Category A	Economic Impact Captured Today	Analytic Tractability	Location Specific	Requires a High Penetration of DG	Confidence in Value
Locational Installed Capacity Value	No	Mod.	Yes	No	Med.

Locational Installed Capacity (LICAP) Value is a benefit to the Other Electric Ratepayers.

Category A Benefit/Cost	DG Owner	Electric Distribution Company	Electric Transmission Provider	Other Electric Ratepayers	Gas Distribution Company	Environmental Stakeholders	Net
NPV Locational Installed Capacity Value	0	0	0	54,000	0	0	54,000

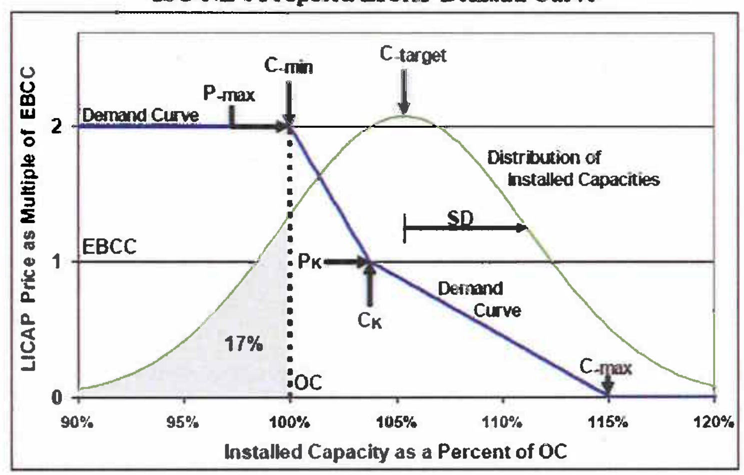
Assumptions

- The *Locational Installed Capacity* (LICAP) is a charge that applies to ratepayers within regions where generation capacity deficits exist.
- The Estimated Benchmark Cost of Capacity (EBCC) is $7.70/kW/month in 2011 and increases annually at 3%. The EBCC increases from $1/kW/month in 2006 to $5/kW/month in 2010 at $1/yr.
- The LICAP value includes an EBCC multiplier which is a function of Installed Capacity as a percent of the Objective Capability[1] (OC), shown to the right.[2]
- The Installed Capacity is assumed to be 100% or less until 2008 and then increases at 1% per year.
- When the Installed Capacity reaches 115% of the OC the LICAP payment is $0/kW/month.
- The proposed LICAP charge applies to ratepayers located in the NEMA load zone; WCMA and SEMA ratepayers would not be charged.
- Except for PV, which is given a 20% credit, other DG would capture the full benefit.
- The LICAP value only applies during June, July and August when Installed Capacity is likely to be 100% or less of the OC.

Calculation

- *Annual LICAP Value ($)* = EBCC ($/kW/month) × (EBCC Multiplier) × Number of Months × DG Size (kW) × Effective Capability

ISO-NE's Proposed LICAP Demand Curve



1. The Objective Capability (OC) is approximately equal to the constrained area peak load.
2. Federal Energy Regulatory Commission (FERC) Initial Decision in Docket No. ER03-563-030, June 15, 2005.

NAVIGANT CONSULTING

Category A	Economic Impact Captured Today	Analytic Tractability	Location Specific	Requires a High Penetration of DG	Confidence in Value
Deferred Distribution System Investment	No	Mod.	Yes	Yes	High

Deferred Distribution System Investment is a benefit to the Electric Distribution Company.

Category A Benefit/Cost	DG Owner	Electric Distribution Company	Electric Transmission Provider	Other Electric Ratepayers	Gas Distribution Company	Environmental Stakeholders	Net
NPV Deferred Distribution System Investment	0	30,000	0	0	0	0	**30,000**

Assumptions

- The net present value (NPV) of the *Deferral Savings* is determined by a revenue requirements approach.
- The timing and proposed upgrade costs for traditional T&D solutions was provided by the Massachusetts Distribution Companies for 8 specific opportunitues.[1]
- There is sufficient DG, EE and DR (DER) in the opportunity to enable a deferral of the asset for 3 years.
- The contribution of this DG asset to the distribution system deferral is on kW basis and is independent of the type of DG.
- A factor of 1.5 is used to approximate the actual capacity of DG that would be required to ensure sufficient reliability to meet distribution system needs.[2]
- There is a net positive societal impact because the budget that would have been spent on deferral is spent to upgrade another part of the distribution system.
- Except for PV, which is given a 20% credit, other DG would capture the full benefit

Calculation

- *Distribution Deferral ($)* = DG (kW) × Deferral Value ($/kW)
- Deferral Value ($/kW) = NPV of Deferral Savings ($) / (1.5 × Capacity Shortfall 3 years after proposed upgrade (kW)) × Effective Capability
- NPV of Deferral Savings, see Utility Distribution Deferral Module (from the analysis of the Eight Distribution Planning Opportunities)

1. "Utility Distribution Planning Situations Analysis," March 9, 2005. Available at: http://www.masstech.org/renewableenergy/public_policy/DG/resources/Collab_2005Collab05_03_09_DP_UtilityList.xls
2. This factor depends on the mix and number of DER in each opportunity area to ensure the electric distribution company's reliability needs are met.

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Category A	Economic Impact Captured Today	Analytic Tractability	Location Specific	Requires a High Penetration of DG	Confidence in Value
Ancillary Services	No	Mod.	No	Yes	Low

A market for *Ancillary Services* is a benefit to Other Electric Ratepayers

Category A Benefit/Cost	DG Owner	Electric Distribution Company	Electric Transmission Provider	Other Electric Ratepayers	Gas Distribution Company	Environmental Stakeholders	Net
NPV Ancillary Services	0	0	0	91,000	0	0	**91,000**

Assumptions

- *Ancillary Services* include: VAR Support, Load Following, Operating Reserves, and Dispatch and Scheduling.
- The DG units are unlikely or unable to participate in the markets for Load Following, Operating Reserves, and Dispatch and Scheduling.
- Although unlikely to participate in the market, synchronous DG may provide some of these services when operating.
- The potential value of *Ancillary Services* to Other Electric Ratepayers for synchronous DG is estimated at $0.003/kWh.[1]

Calculation

- *Ancillary Services ($)* = Electricity Provided by DG (kWh) × $0.003/kWh

1. In Energy and Environmental Economics' model of avoided costs in CA (http://www.ethree.com/cpuc_avoidedcosts.html), there is a $0.003/kWh adder to the energy component of avoided costs to account for the reliability benefits that DG provides through ancillary services. *CPUC Self-Generation Incentive Program Preliminary Cost-Effectiveness Evaluation Report*, Itron Inc. September 14, 2006. Available at: http://www.itron.com/asset.asp?path=assets/itr_001094.pdf

Category A	Economic Impact Captured Today	Analytic Tractability	Location Specific	Requires a High Penetration of DG	Confidence in Value
Congestion Value	Yes	Mod.	Yes	No	Low

Congestion Value is a benefit to Other Electric Ratepayers.

Category A Benefit/Cost	DG Owner	Electric Distribution Company	Electric Transmission Provider	Other Electric Ratepayers	Gas Distribution Company	Environmental Stakeholders	Net
NPV Congestion Value	0	0	0	48,000	0	0	**48,000**

Assumptions

- The *Congestion Value* is the average of the congestion component of the locational marginal price (LMP) for electricity in 2005.[1]
- The congestion and loss components of LMP are specific to each node in ISO-NE. However, it is not know which node these customers are served by. Therefore, average day ahead (DA) congestion prices for each load zone are employed:
  - NEMA: DA $1.58/MWh
  - SEMA: DA $(1.72)/MWh
  - WCMA: DA $(1.20)/MWh
- The congestion price for each node varies, negative or positive, within a load zone.
- An alternative valuation of congestion in the NEMA load zone is $23.50/kW/yr.[2]

Calculation

- *Congestion Value ($)* = Annual DG Electric Output (MWh) × Load Zone LMP Day Ahead Congestion Component ($/MWh)

1. Data for the time period: 01/01/2005-12/7/2005, 12/8/2004-12/31/2004 for each load zone in MA. "DA and RT Hourly LMP Data", ISO New England Inc. Available at: http://www2.iso-ne.com/smd/operations_reports/da_rt_lmp.php?warp=1.
2. Kosanovic, D and C. Beebe, *System Wide Economic Benefits of Distributed Generation in the New England Energy Market*, Center for Energy Efficiency and Renewable Energy University of Massachusetts, February 2005. Available at: http://www.ceere.org/iac/pubsdownloads/DG%20Benefits%20Report.pdf.

The emissions value to Environmental Stakeholders is determined by calculating total emissions and by valuing each pollutant.

Emission Rates

Emission	2003 Avoided Emission Rates[2] (lb/MMBtu)	Natural Gas Boiler[4,5] (lb/MMBtu)	PV DG (lb/MMBtu)	CHP DG (lb/MMBtu)
SO2	0.24	0.0006	0	0.0006
NOx	0.09	0.3	0	0.0431
CO2	143	117	0	117

Assumptions

- Marginal Central Power Plant
  - Electric generator emission rates are based on 2003 ISO-NE annual average marginal emission rates.[1]
- Natural Gas Boiler
  - Boiler emission rates are based on historic emission levels[4] rather than new boiler regulations[5] and assumes a sulfur content limit on natural gas.
- DG
  - DG emission rates are based on the technical specifications for the DG equipment.
- Note: NCI applied a simplifying assumption that the emission rates for each technology would remain unchanged during the analysis period.[6]

1. PV systems, which are more likely to operate during the highest load hours, the avoided emission rates may be higher as less efficient power plants are utilized. Stephen Connors estimated this impact for PV systems in New England and determined that the 2002 avoided emission rates are - SO2: 4.47 lb/MWh; NOx: 1.66 lb/MWh; and, CO2: 1632 lb/MWh.[3] The 2002 ISO-NE Marginal Emission Rates are - SO2: 3.27 lb/MWh; NOx: 1.12 lb/MWh; and, CO2: 1337.8 lb/MWh.
2. *2003 NEPOOL Marginal Emission Rate Analysis*, ISO New England Inc. December 2004. Available at: http://www.iso-ne.com/genrtion_resrcs/reports/emission/Marginal_Emissions_Analysis_2003.pdf
3. Connors, S. et al. *National Assessment of Emissions Reduction of Photovoltaic (PV) Power Systems*. 2004. Available at: http://www.masstech.org/renewableenergy/public_policy/DG/resources/EconomicsofDG-Renewables.htm
4. DE Solutions, Inc.*Clean Distributed Generation Performance and Cost Analysis*. April 2004. ORNL Subcontract No. 4000026015. Available at: http://www.eere.energy.gov/de/pdfs/clean_distributed_generation.pdf. Boiler Efficiency: 80%, CO2: 117 lb/MMBtu, NOx: 0.3 lb/MMBtu
5. Boiler Emission Limitations in pounds per million BTU heat input 310 CMR 7.26(33)(b) NOx: 0.0350 lb/MMBtu, PM: 0.010 lb/MMBtu, CO: 0.080 lb/MMBtu, VOC: 0.030 lb/MMBtu, SO2: The sulfur content of the fuel is limited to 0.0006 lbs/MMBtu
6. In February 2003, LaCapra Associates and MSB Energy Associates performed a study that forecasts marginal emission rates for ISO-NE. *Electric Sector Emissions Displaced due to Renewable Energy Projects in New England: February 2003 Analysis*, LaCapra Associates and MSB Energy Associates. February 2003. Available at: http://masstech.org/renewableenergy/public_policy/DG/resources/2003-09-12_LCA_NE-Emissions-Report-for-MTC.doc

Category A	Economic Impact Captured Today	Analytic Tractability	Location Specific	Requires a High Penetration of DG	Confidence in Value
Emissions – CO2, NOx, and SOx	No	Mod.	No	No	Med.

Reduced *Emissions (CO2, NOx, and SOx)* are a benefit to Environmental Stakeholders.

Category A Benefit/Cost	DG Owner	Electric Distribution Company	Electric Transmission Provider	Other Electric Ratepayers	Gas Distribution Company	Environmental Stakeholders	Net
NPV Emissions – CO2, NOx, and SOx	0	0	0	0	0	230,000	**230,000**

Assumptions

- The reduced electricity consumption by the DG Owner reduces electric generation on the margin.
- The amount of electricity generated by the supplier includes the impact of T&D losses.
- The DG Owner's boiler burns natural gas as their primary fuel because these customers have access to natural gas (For PV customers this assumption can be ignored because there is no net change in boiler emissions).
- If the DG has a CHP capability, it will offset natural gas consumed by the DG Owner's boiler.
- The value of CO2 emissions is based on ICF Consulting projections in the "Very High Emissions" scenario and that an unlimited number of offsets are available for $6.50/ton, effectively providing a backstop to the CO2 allowance price.[1]
- The value of NOx emissions is its commodity value in the EPA SIP NOx Trading Program. For November 2005 the average monthly price was about $2,500 per ton.[2]
- The value of SOx emissions is its commodity value in the cap and trade market for the EPA's Acid Rain Program. For November 2005 the average monthly price was $1,300 per ton.[2]

Calculation

- *Emissions Benefit ($)* = $\sum$ [(Pollutant$_i$ After DG (tons) × Pollutant$_i$ Value ($/ton)) – (Pollutant$_i$ Before (tons) × Pollutant$_i$ Value ($/ton))]
  where i = CO2, NOx and SOx.
- Pollutant (tons) = Electric Generator Emissions + Boiler Emissions + DG Emissions
- Electric Generator Emissions = DG Owner Annual Electricity (kWh) × Emission Rate (lb/kWh)
- Boiler Emissions = Fuel Input (MMBtu) × Emission Rate (lb/MMBtu)
- DG Emissions = Fuel Input (MMBtu) × Emission Rate (lb/MMBtu)

1. "RPS Sensitivity & Very High Emissions Reference & Package Cases - 10/26/05," ICF Consulting. Regional Greenhouse Gas Initiative, October 2005. Available at: http://www.rggi.org/docs/rps_hi_emis_10_26_05.ppt
2. Evolution Markets, http://www.evomarkets.com/

Category A	Economic Impact Captured Today	Analytic Tractability	Location Specific	Requires a High Penetration of DG	Confidence in Value
Avoided Electric System Losses	No	Mod.	Yes	Yes	Low

Avoided Electric System Losses are a benefit to Other Electric Ratepayers and Environmental Stakeholders. (Includes the impact of the incremental change in distribution system losses for all customers in the opportunity)

Category A Benefit/Cost	DG Owner	Electric Distribution Company	Electric Transmission Provider	Other Electric Ratepayers	Gas Distribution Company	Environmental Stakeholders	Net
NPV Avoided Electric System Losses	0	0	0	260,000	0	12,000	**270,000**

Assumptions

- The average electrical losses in the transmission and distribution system are 2% and 6%, respectively.
- The distribution system losses are composed of fixed no-load losses (2%) and line/winding losses (4%).
- The electric generation supplier is responsible for the transmission and distribution losses when it generates electricity, which then impacts
  - total emissions from central power plants
  - cost of electricity to Other Electric Ratepayers
- Heat losses increase as the square of load. Therefore a load reduction – for example, from running DG – will reduce line/winding losses (per kW of DG running) more than the average loss per kW of total load. In other words, loss reductions at the margin are greater than average losses. For typical substation and feeder load profiles reduced on the order of 5% by DG, the savings (per kW of DG) will be roughly 1.9 times the pre-DG line/winding loss per kW of load on the feeder.[1]
- The value of each kWh of losses to Other Electric Ratepayers is the full cost of electricity generation, transmission, and distribution.

Calculation

- *Emissions Benefit ($)* = $\sum$ [Net Electric Generation × Emission Rate_i (lb/kWh) × Pollutant_i Value ($/ton)]
  where i = CO2, NOx and SOx.
- *Impact to Other Electric Ratepayers ($)* = Net Electric Generation × Average Cost of Electricity ($/kWh)
- Net Electric Generation = [Generation for incremental losses] – [Generation for average losses]
- Generation with Losses = DG Owner (kWh) / (1 – Distribution System Losses) / (1 – Transmission System Losses); where losses are either average or incremental.
- Average Cost of Electricity = Sum of electricity costs ($) for all customers / Opportunity kWh

1. NCI analysis based on typical feeder load factors.

Category A	Economic Impact Captured Today	Analytic Tractability	Location Specific	Requires a High Penetration of DG	Confidence in Value
Benefits Overhead	No	Mod.	Yes	Yes	Med.

Benefits Overhead is a net cost that is associated with capturing and monetizing the various value streams.

Category A Benefit/Cost	DG Owner	Electric Distribution Company	Electric Transmission Provider	Other Electric Ratepayers	Gas Distribution Company	Environmental Stakeholders	Net
NPV Benefits Overhead	0	0	0	0	0	0	(190,000)

Assumptions

- *Benefits Overhead Costs* are the costs associated with capturing and monetizing all the various value streams.
- Includes program administration and other equipment costs such as advanced metering and/or the cost to address technical issues for including DG in a distribution deferral solution.[1]

Calculation

- *Benefits Overhead ($)* = Benefits Overhead Costs ($/kW) × DG kW

1. *CPUC Self-Generation Incentive Program Preliminary Cost-Effectiveness Evaluation Report*, Itron Inc. September 14, 2006. Available at: http://www.itron.com/asset.asp?path=assets/itr_001094.pdf
The program administration (salaries, facilities, program design and implementation) and program evaluation costs (costs to hire meter installation subcontractors) in California's Self-Generation Incentive Program are 12.5 million. If allocated equally on a per kW basis across all active and complete projects, the cost is equal to $47.75/kW.

4 Benefit/Cost of DG Beyond Distribution Deferral

A Approach and Assumptions

B Category A Benefits/Costs

C Category B Benefits/Costs

Including Category B benefits/costs for CHP could provide additional net positive benefits for some stakeholders and Society.

Combined Heat and Power – Category B Benefits							
Category B Benefit/Cost	DG Owner	Electric Distribution Company	Electric Transmission Provider	Other Electric Ratepayers	Gas Distribution Company	Environmental Stakeholders	Net
Health Impact of DG	0	0	0	0	0	-	-
Increased Emissions (CO2, NOx and SOx)	0	0	0	0	0	-	-
Noise Disturbance	0	0	0	0	0	-	-
NIMBY Opposition to DG	0	0	0	0	0	-	-
Consumer Electricity Price Protection	++	0	0	0	0	0	++
Power Quality (DG Owner)	+	0	0	0	0	0	+
Market Price Impacts/Elasticity	0	0	0	+++	0	0	+++
Fuel Diversity	0	0	0	0	0	+	+
Avoided Transmission Capacity	0	0	0	+	0	0	+
Reduced Security Risk to Grid	0	0	0	0	0	0	+
Fuel Delivery Challenges	0	0	0	0	-	0	-
NIMBY Opposition to Central Power Plants and Transmission Lines	0	0	0	0	0	+	+
Real Options Value of DG	0	+++	0	0	0	0	+++
Support of RPS Goals	0	0	0	0	0	0	0
Local economic impact	0	0	0	0	0	0	++

+++ Benefit: same order of magnitude as the customer's electricity bill savings
++ Benefit: one order of magnitude less than the customer's electricity bill savings
+ Benefit: two orders of magnitude less than the customer's electricity bill savings
0 No impact

- Cost: two orders of magnitude less than the customer's electricity bill savings
-- Cost: one order of magnitude less than the customer's electricity bill savings
--- Cost: same order of magnitude as the total customer's electricity bill savings

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Category B benefits/costs are all positive for PV and would likely make PV substantially more attractive for Society.

Photovoltaics – Category B Benefits							
Category B Benefit/Cost	DG Owner	Electric Distribution Company	Electric Transmission Provider	Other Electric Ratepayers	Gas Distribution Company	Environmental Stakeholders	Net
Health Impact of DG	0	0	0	0	0	+	+
Increased Emissions (CO2, NOx and SOx).	0	0	0	0	0	0	0
Noise Disturbance	0	0	0	0	0	0	0
NIMBY Opposition to DG	0	0	0	0	0	0	0
Consumer Electricity Price Protection	+++	0	0	0	0	0	+++
Power Quality (DG Owner)	0	0	0	0	0	0	0
Market Price Impacts/Elasticity	0	0	0	++	0	0	++
Fuel Diversity	0	0	0	0	0	+++	+++
Avoided Transmission Capacity	0	0	0	+	0	0	+
Reduced Security Risk to Grid	0	0	0	0	0	0	+
Fuel Delivery Challenges	0	0	0	0	0	0	0
NIMBY Opposition to Central Power Plants and Transmission Lines	0	0	0	0	0	+	+
Real Options Value of DG	0	+	0	0	0	0	+
Support of RPS Goals	0	0	0	0	0	+++	+++
Local economic impact	0	0	0	0	0	0	++

+++ Benefit: same order of magnitude as the customer's electricity bill savings
++ Benefit: one order of magnitude less than the customer's electricity bill savings
\+ Benefit: two orders of magnitude less than the customer's electricity bill savings
0 No impact

\- Cost: two orders of magnitude less than the customer's electricity bill savings
-- Cost: one order of magnitude less than the customer's electricity bill savings
--- Cost: same order of magnitude as the total customer's electricity bill savings

NAVIGANT CONSULTING

Increased local emissions could make CHP less attractive for society; PV would lead to a net reduction in local and global emissions.

Category B	DG Owner	Electric Distribution Company	Electric Transmission Provider	Other Electric Ratepayers	Gas Distribution Company	Environmental Impact	Net
CHP	0	0	0	0	0	-	-
PV	0	0	0	0	0	+	+
Health Impact of DG	DG units are located closer to end-use customers and as a result of this proximity, people may be exposed to higher pollutant levels per kWh, even if regionally or globally there are decreased emissions. The higher exposure to pollutants increases health risks and associated costs. For CHP, this effect may be mitigated since on-site boiler emissions are avoided. Photovoltaics would lead to a net reduction in emissions (locally and globally) n all cases and have positive health effects. Heath, G. et al., "Quantifying the Air Pollution Exposure Consequences of Distributed Electricity Generation" (November 1, 2005). University of California Energy Institute. *Development & Technology*. Paper EDT-005. http://repositories.cdlib.org/ucei/devtech/EDT-005 Campbell, T. Heavner, B., Paul, K., Renee, M., Zugel, M. "The Good, the Bad and the Other – Public Health and the Future of Distributed Generation" The California Clean Distributed Generation Campaign, the Coalition for Clean Air, and the California Public Interest Research Group http://www.ceert.org/projects/gbo1.PDF Samuelson, S., Dabdub, D., Brouwer, J., Medrano, M., Rodriguez, M., Carreras-Sospedra, M. "Air Quality Impacts of Distributed Generation" California Energy Commission Public Interest Energy Research Program (October 2005) http://www.energy.ca.gov/2005publications/CEC-500-2005-069/CEC-500-2005-069-F.PDF							

+++ Benefit: same order of magnitude as the customer's electricity bill savings
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+ Benefit: two orders of magnitude less than the customer's electricity bill savings
0 No impact

- Cost: two orders of magnitude less than the customer's electricity bill savings
-- Cost: one order of magnitude less than the customer's electricity bill savings
--- Cost: same order of magnitude as the total customer's electricity bill savings

NAVIGANT CONSULTING

Depending on the central power plant mix and how DG is treated in cap and trade systems, CHP could lead to higher emissions.

Category B	DG Owner	Electric Distribution Company	Electric Transmission Provider	Other Electric Ratepayers	Gas Distribution Company	Environmental Impact	Net
CHP	0	0	0	0	0	-	-
PV	0	0	0	0	0	0	0
Increased Emissions – CO2, NOx, SOx	If the central power plant mix is sufficiently clean, DG may not lead to a reduction in central plant emissions. If DG is not included in emission cap and trade programs the net effect can be increased emissions because the DG units are offsetting electric generation and DG emissions are not included in the cap. Ianucci, J., S. Horgan, J. Eyer, and L. Cibulka. 2000. "Air Pollution Emissions Impacts Associated with the Economic Market Potential of Distributed Generation in California" Distributed Utility Associates, prepared for the California Air Resources Board. http://www.arb.ca.gov/research/abstracts/97-326.htm Samuelson, S., Dabdub, D., Brouwer, J., Medrano, M., Rodriguez, M., Carreras-Sospedra, M. "Air Quality Impacts of Distributed Generation" California Energy Commission Public Interest Energy Research Program (October 2005) http://www.energy.ca.gov/2005publications/CEC-500-2005-069/CEC-500-2005-069-F.PDF Greene, A. "Making Sure that Clean Power Means Cleaner Air: Imperatives and Opportunities to Expand Cap and Trade Programs," Fourth Annual Green Trading Summit, May 2-3, 2005, New York City. Available at: http://www.navigantconsulting.com/A559B1/navigantnew.nsf/vGNCNTByDocKey/PPC56EDEC22818/$FILE/NCI-AndrewGreene-CleanPower-Cap-Trade-Presentation-May-3-2005-.pdf							

+++ Benefit: same order of magnitude as the customer's electricity bill savings
++ Benefit: one order of magnitude less than the customer's electricity bill savings
+ Benefit: two orders of magnitude less than the customer's electricity bill savings
0 No impact

- Cost: two orders of magnitude less than the customer's electricity bill savings
-- Cost: one order of magnitude less than the customer's electricity bill savings
--- Cost: same order of magnitude as the tot. l customer's electricity bill savings

NAVIGANT CONSULTING

Local noise emissions could be a cost to society for CHP systems.

Category B	DG Owner	Electric Distribution Company	Electric Transmission Provider	Other Electric Ratepayers	Gas Distribution Company	Environmental Impact	Net
CHP	0	0	0	0	0	-	-
PV	0	0	0	0	0	0	0
Noise Disturbance	Some CHP installations can produce levels of noise that are unacceptable to local Electricity generation can be noisy. The proximity of a DG unit to people makes this a potential cost to society. Sound attenuating enclosures mitigates the impact of this cost. With no moving parts or combustion, PV systems do not have noise issues. U.S. Environmental Protections Agency – Combined Heat and Power Partnership , "Catalog of CHP Technologies" http://www.epa.gov/CHP/project_resources/catalogue.htm Gumerman, E. et al, *Evaluation Framework and Tools for Distributed Energy Resources*, February 2003, LBNL-52079 Available at: http://www.eere.energy.gov/de/pdfs/de_evaluation_framework_tools.pdf.						

+++	Benefit: same order of magnitude as the customer's electricity bill savings	-	Cost: two orders of magnitude less than the customer's electricity bill savings
++	Benefit: one order of magnitude less than the customer's electricity bill savings	--	Cost: one order of magnitude less than the customer's electricity bill savings
+	Benefit: two orders of magnitude less than the customer's electricity bill savings	---	Cost: same order of magnitude as the total customer's electricity bill savings
0	No impact		

NAVIGANT CONSULTING

NIMBY opposition to local generation could be a barrier to some CHP systems.

Category B	DG Owner	Electric Distribution Company	Electric Transmission Provider	Other Electric Ratepayers	Gas Distribution Company	Environmental Impact	Net
CHP	0	0	0	0	0	-	-
PV	0	0	0	0	0	0	0
NIMBY Opposition to DG	Some CHP systems may have to overcome NIMBY, or "Not In MY Backyard", objections. These objections could stem from air quality, water quality, aesthetics, water usage, land use, noise, or other economic issues. PV installations have been less susceptible to these concerns Proceedings of the Gulf Coast CHP Roadmap Workshop and Gulf Coast CHP Action Plan, Gulf Coast Regional CHP Applications Center http://www.gulfcoastchp.org/chp/News/Roadmap/ActionPlan.pdf LoPorto, J. "Case Study- DG Uses at Conectiv, Future Challenges & Opportunities" Presentation at US DOE Mid-Atlantic Distributed Energy Resource Workshop (February 21, 2002) http://www.eere.energy.gov/de/pdfs/conf-02_midatlantic_wkshp/loporto_steffel.pdf Broido, C., "Making Solar Work in the US" Presentation at 2nd Renewable Energy Finance Forum, New York (June 2005) http://www.acore.org/programs/05_reff_presentations/05_REFF_Broido.pdf						

+++ Benefit: same order of magnitude as the customer's electricity bill savings
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+ Benefit: two orders of magnitude less than the customer's electricity bill savings
0 No impact

- Cost: two orders of magnitude less than the customer's electricity bill savings
-- Cost: one order of magnitude less than the customer's electricity bill savings
--- Cost: same order of magnitude as the total customer's electricity bill savings

NAVIGANT CONSULTING

DG could reduce the DG Owner's exposure to energy price volatility.

Category B	DG Owner	Electric Distribution Company	Electric Transmission Provider	Other Electric Ratepayers	Gas Distribution Company	Environmental Impact	Net
CHP	++	0	0	0	0	0	++
PV	+++	0	0	0	0	0	+++
Consumer Electricity Price Protection	By installing DG, DG Owners could reduce their exposure to energy price volatility. In the case of PV, since there is no fuel expense the costs of electricity from PV will not increase over the life of the system due to fuel costs. While a CHP system owner may be exposed to fuel price risk, a CHP owner could switch between producing electricity on-site and taking electricity from the power system. Poore, W., Stovall, T., Kirby, B., Rizy, D., Kueck, J., Stovall, J,. "Connecting Distributed Energy Resources to the Grid: Their Benefits to the DER Owner/Customer, Other Customers, the Utility, and Society" Oak Ridge National Laboratory (March 2002) Chapter 4 http://www.eere.energy.gov/de/pdfs/der_benefits.pdf Petrill, E., Rastler, D. Assessment of California CHP Market and Policy Options for Increased Penetration, Draft Consultant Report. California Energy Commission Public Interest Energy Research (April 15, 2005) Chapter 3 http://www.energy.ca.gov/2005publications/CEC-500-2005-060/CEC-500-2005-060-D.PDF Cardell, J., M. Ilic, and R. D. Tabors. 1998. "Integrating Small Scale Distributed Generation into a Deregulated Market: Control Strategies and Price Feedback." Laboratory for Electromagnetic and Electronic Systems, M.I.T., Boston, MA. (April, 1998). 184. http://lfee.mit.edu/public/el98-001.pdf							

+++ Benefit: same order of magnitude as the customer's electricity bill savings
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+ Benefit: two orders of magnitude less than the customer's electricity bill savings
0 No impact
- Cost: two orders of magnitude less than the customer's electricity bill savings
-- Cost: one order of magnitude less than the customer's electricity bill savings
--- Cost: same order of magnitude as the total customer's electricity bill savings

NAVIGANT CONSULTING

For DG owners who value high quality, high reliable power, there could be added benefit from CHP.

Category B	DG Owner	Electric Distribution Company	Electric Transmission Provider	Other Electric Ratepayers	Gas Distribution Company	Environmental Impact	Net
CHP	+	0	0	0	0	0	+
PV	0	0	0	0	0	0	0
Power Quality (DG Owner)	DG could provide power quality benefits to customers. However, these facilities may require the addition of power conditioners or uninterruptible power supplies. Customers' needs for power quality varies widely and will not be valued the same by all customers. Because of its intermittent output, it is more difficult for PV to provide this benefit. Lenssen, N, McNulty, S., "Energy Users and Combined Heat & Power: Market Research Findings". Presentation at California Energy Commission Workshop California's Market Potential for Combined Heat and Power (CHP) and Distributed Generation (April 28, 2005). http://www.energy.ca.gov/distgen_oii/documents/2005-04-28_workshop/Lenssen_McNulty_042805.PDF Poore, W., Stovall, T., Kirby, B., Rizy, D., Kueck, J., Stovall, J,. "Connecting Distributed Energy Resources to the Grid: Their Benefits to the DER Owner/Customer, Other Customers, the Utility, and Society" Oak Ridge National Laboratory (March 2002) Chapter 4. http://www.eere.energy.gov/de/pdfs/der_benefits.pdf California Public Utilities Commission, Energy Division, "Update on Determining the Costs and Benefits of California's Net Metering Program" Section 6.1 (March 29, 2005). http://www.cpuc.ca.gov/WORD_PDF/REPORT/45133.PDF							

+++ Benefit: same order of magnitude as the customer's electricity bill savings
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+ Benefit: two orders of magnitude less than the customer's electricity bill savings
0 No impact

- Cost: two orders of magnitude less than the customer's electricity bill savings
-- Cost: one order of magnitude less than the customer's electricity bill savings
--- Cost: same order of magnitude as the total customer's electricity bill savings

DG will increase electricity demand elasticity and reduce electricity supply prices for all ratepayers.

Category B	DG Owner	Electric Distribution Company	Electric Transmission Provider	Other Electric Ratepayers	Gas Distribution Company	Environmental Impact	Net
CHP	0	0	0	+++	0	0	+++
PV	0	0	0	++	0	0	++
Market Price Impacts/Elasticity	The elasticity of demand for electricity supply increases with more DG. Increased demand elasticity can lower electricity supply prices for all electricity consumers. Since PV is less dispatchable the impact from PV will be lower than CHP. Simons, G. "CPUC Self-Generation Incentive Program Preliminary Cost-Effectiveness Evaluation Report" (September 14, 2005) Itron Corporation. Available at: http://www.itron.com/asset.asp?path=assets/itr_001094.pdf Baer, W., Fulton, B., Mahnovski, S. "Estimating the Benefits of the GridWise Initiative Phase I Report" (May 2004) Rand Corporation. Available at: http://www.rand.org/pubs/technical_reports/TR160/ E. Kyle Datta, Managing Director, Rocky Mountain Institute: "Incorporating Distributed Generation Into Hawaii's Utility Planning and Regulatory Processes" Presentation at Workshop on Distributed Energy Resources and Combined Heat and Power in Regulated and Competitive Markets (August 24, 2004) Available at: http://www.state.hi.us/dbedt/ert/dg/dg04-1datta.pdf Wade, S. "Price Responsiveness in the AEO2003 NEMS Residential and Commercial Buildings Sector Models" Department of Energy's Energy Information Administration. Available at: http://www.eia.doe.gov/oiaf/analysispaper/elasticity/ Gumerman, E. et al, *Evaluation Framework and Tools for Distributed Energy Resources*, February 2003, LBNL-52079 Available at: http://www.eere.energy.gov/de/pdfs/de_evaluation_framework_tools.pdf.						

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0 No impact

- Cost: two orders of magnitude less than the customer's electricity bill savings
-- Cost: one order of magnitude less than the customer's electricity bill savings
--- Cost: same order of magnitude as the total customer's electricity bill savings

NAVIGANT CONSULTING

DG could help to increase fuel diversity and reduce the risks of interruption in fuel supply.

Category B	DG Owner	Electric Distribution Company	Electric Transmission Provider	Other Electric Ratepayers	Gas Distribution Company	Environmental Impact	Net
CHP	0	0	0	0	-	0	-
PV	0	0	0	0	0	+++	+++

Fuel Diversity

A balanced diverse portfolio of fuel supply provides greater security and increased reliability in the case of a specific fuel interruption. It also helps to address future electricity supply and price concerns. The benefit is greater for PV since it eliminates fuel needs. CHP is fueled by natural gas, but its deployment would reduce natural gas consumption at central power plants and lead to a net reduction in fuel demand.

California Energy Commission, 2005 Integrated Energy Policy Report, (November 2005).
Available at: http://www.energy.ca.gov/2005_energypolicy/

E. Kyle Datta, Managing Director, Rocky Mountain Institute: "Incorporating Distributed Generation Into Hawaii's Utility Planning and Regulatory Processes" Presentation at Workshop on Distributed Energy Resources and Combined Heat and Power in Regulated and Competitive Markets (August 24, 2004).
Available at: http://www.state.hi.us/dbedt/ert/dg/dg04-1datta.pdf

California Public Utilities Commission, Energy Division, "Update on Determining the Costs and Benefits of California's Net Metering Program" Section 6.1 (March 29, 2005).
Available at: http://www.cpuc.ca.gov/WORD_PDF/REPORT/45133.PDF

+++	Benefit: same order of magnitude as the customer's electricity bill savings
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+	Benefit: two orders of magnitude less than the customer's electricity bill savings
0	No impact
-	Cost: two orders of magnitude less than the customer's electricity bill savings
--	Cost: one order of magnitude less than the customer's electricity bill savings
---	Cost: same order of magnitude as the total customer's electricity bill savings

NAVIGANT CONSULTING

Deferred transmission capacity would be a benefit to the Electric Transmission Provider.

Category B	DG Owner	Electric Distribution Company	Electric Transmission Provider	Other Electric Ratepayers	Gas Distribution Company	Environmental Impact	Net
CHP	0	0	+	0	0	0	+
PV	0	0	+	0	0	0	+
Deferred Transmission Capacity	Upgrading the transmission system is based on forecasted demand and equipment replacement. At high penetration levels distributed generation would be able to reduce the load requirements of the transmission system. This would enable the transmission company to defer certain upgrades. Gumerman, E. et al, *Evaluation Framework and Tools for Distributed Energy* Resources. February 2003, LBNL-52079 Available at: http://www.eere.energy.gov/de/pdfs/de_evaluation_framework_tools.pdf. Energy and Environmental Economics, Inc. and The Energy Efficiency Group & Transmission Business Line at Bonneville Power Administration. January 2004. *Olympic Peninsula Study of Non-Wires Solutions to the 500 kW Transmission Line from Olympia to Shelton and a Transformer Addition at Shelton.* Bonneville Power Administration. Available at: http://www.transmission.bpa.gov/PlanProj/Non-Wires_Round_Table/NonWireDocs/Olympic_NWS_011204.pdf						

+++ Benefit: same order of magnitude as the customer's electricity bill savings
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+ Benefit: two orders of magnitude less than the customer's electricity bill savings
0 No impact

- Cost: two orders of magnitude less than the customer's electricity bill savings
-- Cost: one order of magnitude less than the customer's electricity bill savings
--- Cost: same order of magnitude as the total customer's electricity bill savings

DG could make energy supply and delivery systems more resilient through dispersed generators and hardened critical facilities.

Category B	DG Owner	Electric Distribution Company	Electric Transmission Provider	Other Electric Ratepayers	Gas Distribution Company	Environmental Impact	Net
CHP	0	0	0	0	0	0	+
PV	0	0	0	0	0	0	+
Reduced Security Risk to Grid	The dispersal of generators makes the energy supply and delivery system less susceptible to a coordinated attack on a few points. DG could also harden individual facilities. EPACT 2005 authorized appropriations for incentives to qualifying security and assured power facilities. These qualifying facilities are powered by distributed energy technologies and ,as determined by Secretary of Homeland Security, are in critical need of secure, reliable, rapidly available, high-quality power for critical governmental, industrial, or commercial applications. Energy Policy Act of 2005, Section 1226 Advanced Power System Technology Incentive Program Available at: http://energycommerce.house.gov/108/energy_pdfs_2.htm Kline, K., Hughes, P. "Energy Security—Approaches to Increase Power Reliability, Reduce Costs, and Save Energy" 29th Environmental and Energy Symposium—DoD Transformation: The Role of Environmental and Energy Programs in Sustaining Readiness" Oak Ridge National Laboratory (April 7–10, 2003) Available at: http://www.energy2003.ee.doe.gov/presentations/energysec/4-FinancingE_Security_DG_NDIA%206_03.pdf Milford, L., Schumacher, A. "Energy Security & Emergency Preparedness: How Clean Energy Can Deliver More Reliable Power for Critical Infrastructure and Emergency Response Missions - An Overview for Federal, State and Local Officials". Clean Energy States Alliance (October 2005) Available at: http://www.cleanenergystates.org/library/Reports/CEG_Clean_Energy_Security_Oct05.pdf							

+++ Benefit: same order of magnitude as the customer's electricity bill savings
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+ Benefit: two orders of magnitude less than the customer's electricity bill savings
0 No impact

- Cost: two orders of magnitude less than the customer's electricity bill savings
-- Cost: one order of magnitude less than the customer's electricity bill savings
--- Cost: same order of magnitude as the total customer's electricity bill savings

NAVIGANT CONSULTING

A large penetration of natural gas-fired distributed generation may require additional natural gas infrastructure investments.

Category B	DG Owner	Electric Distribution Company	Electric Transmission Provider	Other Electric Ratepayers	Gas Distribution Company	Environmental Impact	Net
CHP	0	0	0	0	-	0	-
PV	0	0	0	0	0	0	0
Fuel Delivery Challenges	Fuel delivery systems would have to be maintained and their security and reliability would have to be ensured. A complex natural gas delivery system exists today, but it may need to be expanded to accommodate higher levels of DG penetration. These costs would likely be spread to Other Natural Gas Ratepayers. Quedenfeld, H. "Natural Gas Infrastructure Requirements for the Application of Distributed Generation Technologies" National Energy Technology Laboratory (March 2003) Available at: http://www.netl.doe.gov/publications/factsheets/policy/Policy015.pdf Gumerman, E. et al, *Evaluation Framework and Tools for Distributed Energy* Resources. February 2003, LBNL-52079 Available at: http://www.eere.energy.gov/de/pdfs/de_evaluation_framework_tools.pdf.						

+++	Benefit: same order of magnitude as the customer's electricity bill savings	-	Cost: two orders of magnitude less than the customer's electricity bill savings
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+	Benefit: two orders of magnitude less than the customer's electricity bill savings	---	Cost: same order of magnitude as the total customer's electricity bill savings
0	No impact		

NAVIGANT CONSULTING

Distributed Generation would avoid the siting concerns of large central power plants and transmission facilities.

Category B	DG Owner	Electric Distribution Company	Electric Transmission Provider	Other Electric Ratepayers	Gas Distribution Company	Environmental Impact	Net
CHP	0	0	0	0	0	+	+
PV	0	0	0	0	0	+	+
NIMBY Opposition to Central Power Plants and Transmission Lines	A major obstacle to adding central generation or transmission is siting. DG would avoid these siting issues (including air and water impacts, land use, economic impact, aesthetics, property value impacts, rights of way) that are raised in multiple jurisdictions. US Department of Energy "National Transmission Grid Study" (May 2005) http://www.eh.doe.gov/ntgs/reports.html Oldak, M. Edison Electric Institute "Electric Power Industry Overview: Impact of EPACT 2005" presentation at AGA/EEI DataSource (November 4, 2005) http://www.aga.org/Content/ContentGroups/Events2/assorted_2005+_events/GeneralSessionEnergyOutlookEEIOldak.ppt California Energy Commission, "Strategic Transmission Investment Plan" (September 2005) http://www.energy.ca.gov/2005publications/CEC-100-2005-006/CEC-100-2005-006-CMF.PDF Gumerman, E. et al, *Evaluation Framework and Tools for Distributed Energy Resources*, February 2003, LBNL-52079 Available at: http://www.eere.energy.gov/de/pdfs/de_evaluation_framework_tools.pdf.						

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+	Benefit: two orders of magnitude less than the customer's electricity bill savings	---	Cost: same order of magnitude as the total customer's electricity bill savings
0	No impact		

NAVIGANT CONSULTING

DG could provide distribution companies with a potentially powerful tool to manage load growth risks.

Category B	DG Owner	Electric Distribution Company	Electric Transmission Provider	Other Electric Ratepayers	Gas Distribution Company	Environmental Impact	Net
CHP	0	+++	0	0	0	0	+++
PV	0	+	0	0	0	0	+
Real Options Value of DG	DG could allow distribution companies to make small investments rather than large investments where there is great uncertainty (e.g. load growth). This avoided risk has economic value that goes beyond distribution deferral value and would require a real options economic analysis to calculating and capturing this benefit. Since PV is less dispatchable the impact from PV will be lower than CHP. Feinstein, C. et al., "Capacity Planning Under Uncertainty: Developing Local Area Strategies for Integrating Distributed Resources". *The Energy Journal. Special Issue. Distributed- Resources: Toward a New Paradigm of the Electricity Business*, 1998, pg 85-110. Available at: http://www.epri.com/attachments/264778_Feinsteinetal-CapacityPlanunderUncertainty.pdf. Jonathan A. Lesser, and Charles D. Feinstein. June 1, 2002. "Distributed Generation: Hype vs. Hope" Public Utilities Reports. http://www.pur.com/pubs/3957.cfm						

+++	Benefit: same order of magnitude as the customer's electricity bill savings	-	Cost: two orders of magnitude less than the customer's electricity bill savings
++	Benefit: one order of magnitude less than the customer's electricity bill savings	--	Cost: one order of magnitude less than the customer's electricity bill savings
+	Benefit: two orders of magnitude less than the customer's electricity bill savings	---	Cost: same order of magnitude as the total customer's electricity bill savings
0	No impact		

Providing clean, reliable power could attract businesses; installations typically use local companies to install and maintain facilities.

Category B	DG Owner	Electric Distribution Company	Electric Transmission Provider	Other Electric Ratepayers	Gas Distribution Company	Environmental Impact	Net
CHP	0	0	0	0	0	0	++
PV	0	0	0	0	0	0	++
Local Economic Impact	DG can provide high reliable, high quality power that could be attractive for some high technology industries. DG could also attract businesses that have environmental strategies (e.g. greenhouse gas reductions). DG could also provide local jobs for installers, operators and maintainers. Lovins, A. et al. Small Is Profitable: The Hidden Economic Benefits of Making Electrical Resources the Right Size, 2002 California Public Utilities Commission, Energy Division, "Update on Determining the Costs and Benefits of California's Net Metering Program" Section 6.1 (March 29, 2005) http://www.cpuc.ca.gov/WORD_PDF/REPORT/45133.PDF Austin Energy Strategic Plan, December 4, 2003. http://www.austinenergy.com/About%20Us/Newsroom/Reports/index.htm							

+++	Benefit: same order of magnitude as the customer's electricity bill savings	-	Cost: two orders of magnitude less than the customer's electricity bill savings
++	Benefit: one order of magnitude less than the customer's electricity bill savings	--	Cost: one order of magnitude less than the customer's electricity bill savings
+	Benefit: two orders of magnitude less than the customer's electricity bill savings	---	Cost: same order of magnitude as the total customer's electricity bill savings
0	No impact		

NAVIGANT CONSULTING

Appendix C: Two Examples of DG Optimization Models

NREL

National Renewable Energy Laboratory

Renewable Energy Technologies & Real Options Analysis

Presentation to:
The National Renewable Energy Laboratory

Brandon Owens (NREL)
brandon_owens@nrel.gov

Graham A. Davis (CSM)
gdavis@mines.edu

March 8, 2001

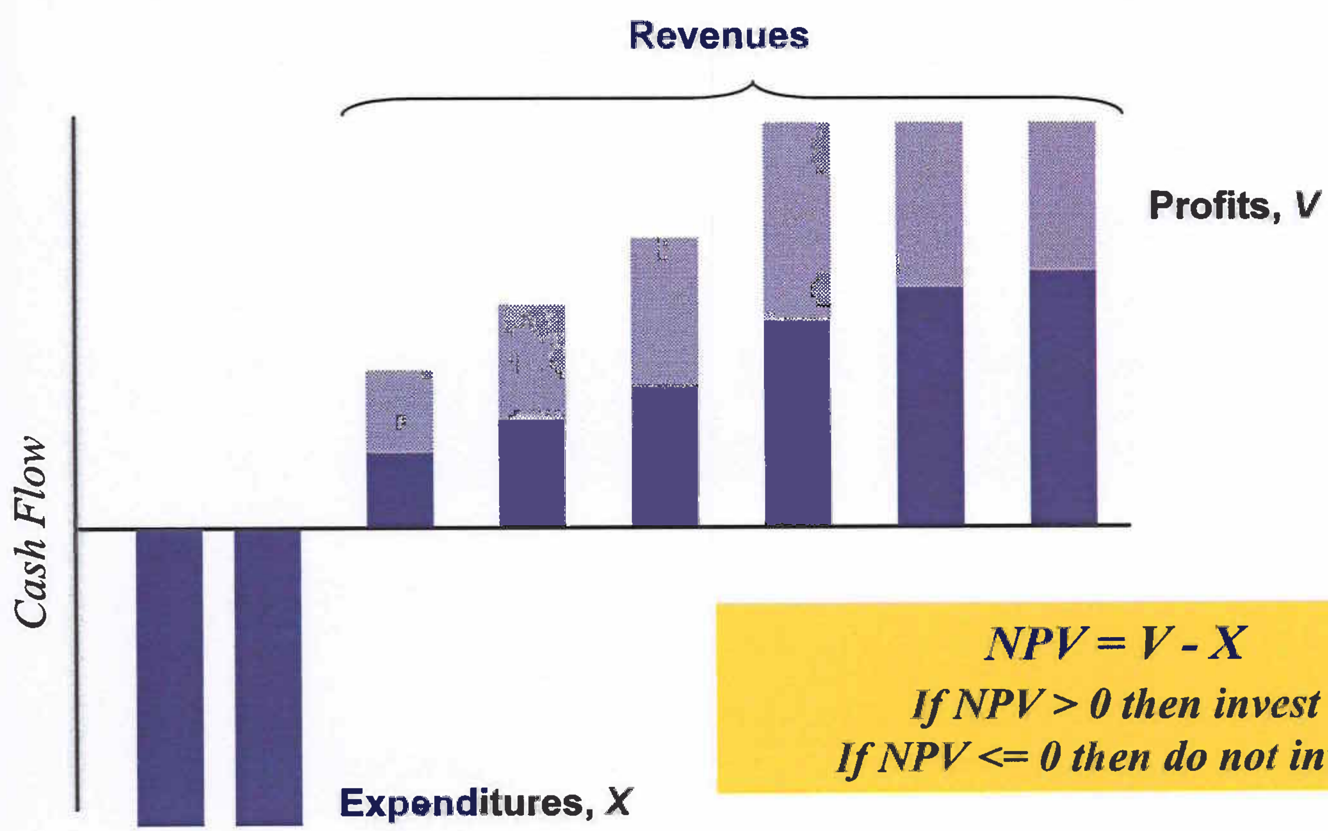
Available on the web at http://analysis.nrel.gov/realoptions

Operated for the US Department of Energy by MRI • Battelle • Bechtel

The Real Options Approach to Investment Analysis

The NPV Rule

According to traditional investment theory, the Net Present Value (*NPV*) of an investment is the difference between the expected stream of profits (*V*) and the expected stream of expenditures (*X*).



$$NPV = V - X$$

If NPV > 0 then invest

If NPV <= 0 then do not invest

What's Missing?

Traditional investment theory often ignores two important investment characteristics:

- There is **uncertainty** over the future rewards from investments.
- Investors often have some leeway about the **timing** of investments. Actions can be postponed in order to get more information about the future.

These characteristics have important implications:

- Investments are optional.
- A negative NPV does not necessarily mean that an investment should be abandoned.
- A positive NPV is not sufficient to warrant immediate investment.
- The option to delay investing has value.

Valuing the Flexibility of Electricity Generation Technologies

Distributed Generation

- Distributed generation (DG) technologies are modular electricity generation resources that are located at or near customer load centers.
- This includes a number of emerging technologies such as Microturbines, Reciprocating Engines, Fuel Cells, and Photovoltaics.
- A number of factors have emerged that have created favorable conditions for DG systems, including: DG technological advances, demand growth uncertainty.
- DG systems are particularly valuable in uncertain demand environments because of their **modularity**, which allows investors to embark on a staged investment program that closely matches demand growth, and their **reduced construction lead-time**, which allows investors to react quickly to changing market conditions.
- The "one-time" aspect of NPV analysis means that NPV cannot be used to determine the value of a multi-staged investment program in which capacity additions closely match demand growth.

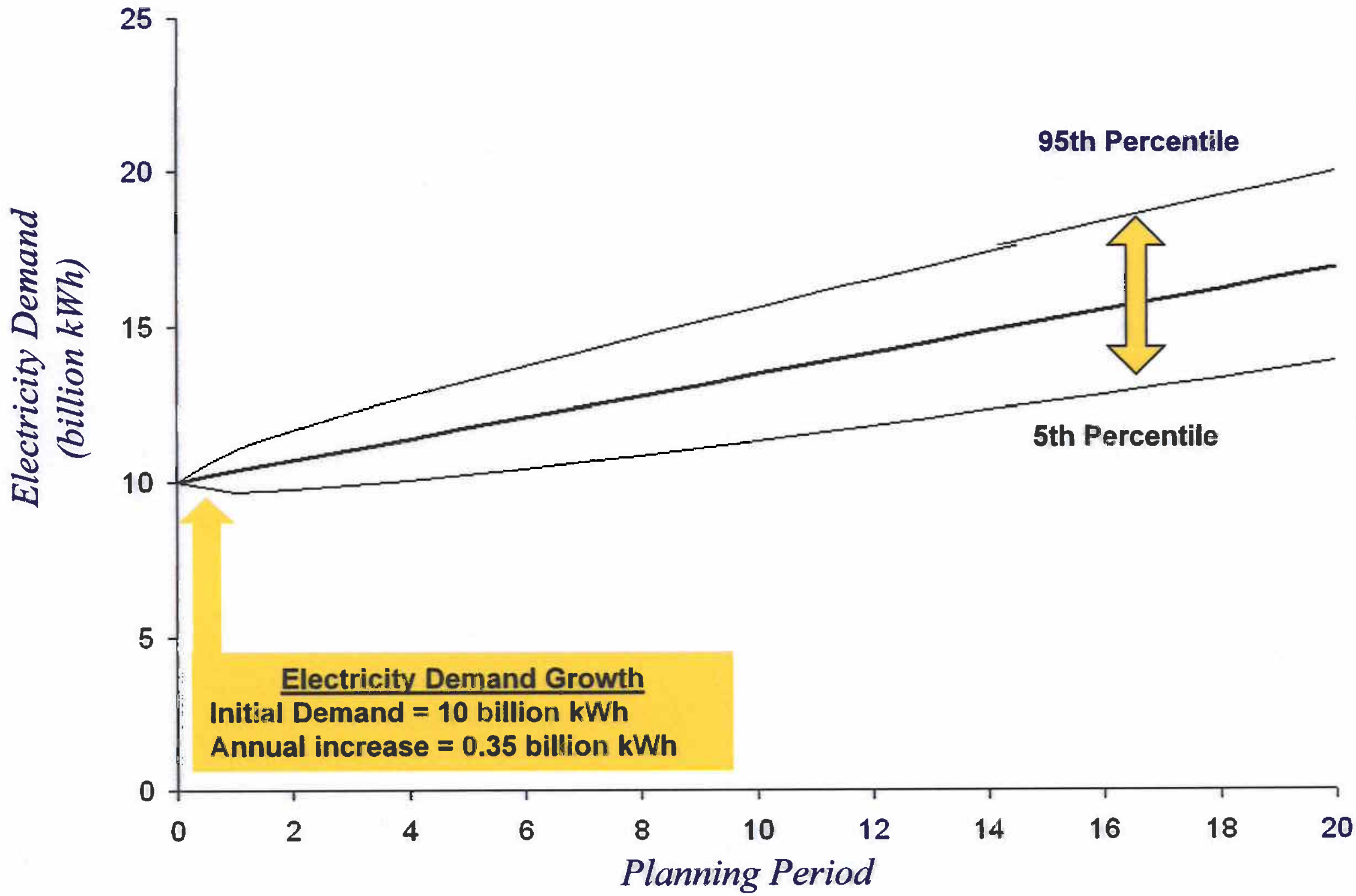
The Option Analogy

Real options is ideally suited to the valuation of generation technologies because it can account for the value of flexibility, model compound investment opportunities, and quantify the value of waiting before investing.

To value electricity generation technologies as a real option we must map the characteristics of electricity generation technologies into the properties of a financial option:

What is the value today...	**Value of Stock Option**	**Value of Generation Technology**	What is the value today...
...for the right (but not the obligation) to buy a stock for $50...	**Strike Price, *X***	**Capital Cost, *X***	...of the option to meet unmet demand by investing in a generation technology..
...one year from now...	**Duration**	**Time Until Installation**	...sequentially over time as uncertainty is resolved...
...if the current stock price is $45...	**Stock Price, *V***	**Electricity Sales Revenue, *V***	...if the current price of electricity is 7 cents/kWh...
...and the volatility is 25%?	**Volatility**	**Demand Growth Uncertainty**	...while considering demand growth uncertainty?

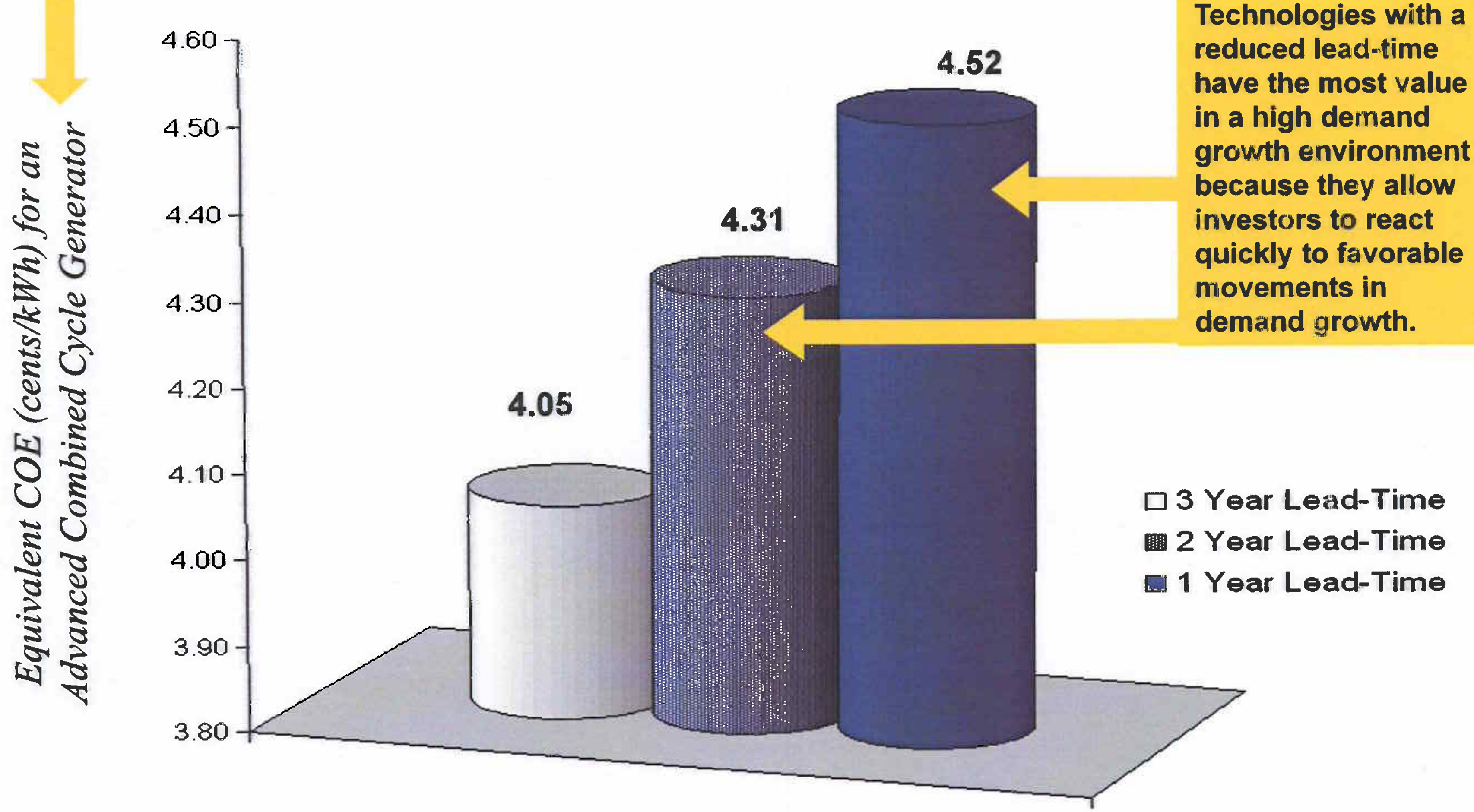
Characterizing Demand Growth Uncertainty



High Demand Growth Scenario

The "Equivalent" cost-of-energy (COE) is the traditional COE (which includes capital, fixed and variable costs) plus the "capital premium" that makes investors indifferent between the original and the modified technology.

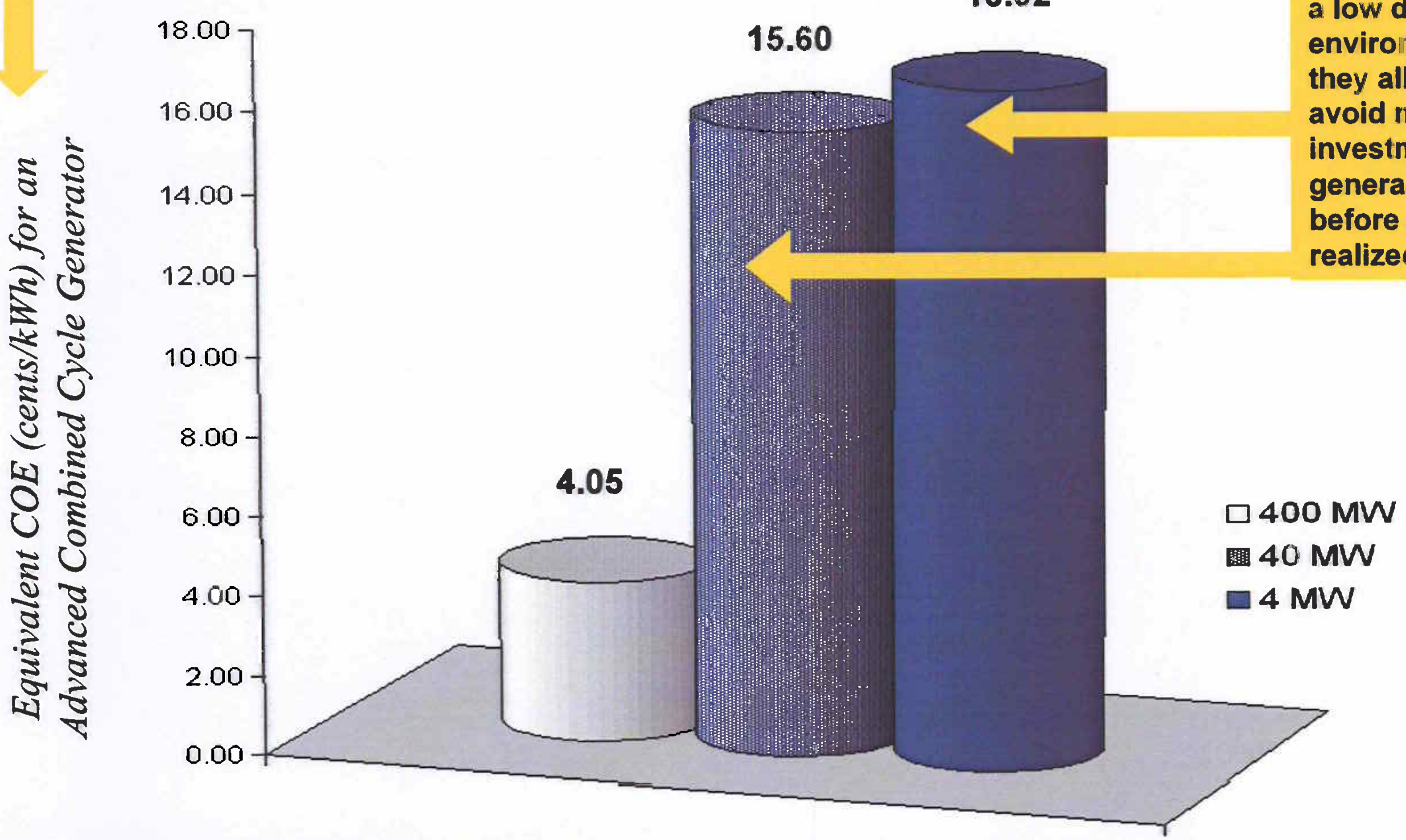
Technologies with a reduced lead-time have the most value in a high demand growth environment because they allow investors to react quickly to favorable movements in demand growth.



Low Demand Growth Scenario

The "Equivalent" cost-of-energy (COE) is the traditional COE (which includes capital, fixed and variable costs) plus the "capital premium" that makes investors indifferent between the original and the modified technology.

Technologies with increased modularity have significant value in a low demand growth environment because they allow investors to avoid making investments in large generating capacity before demand is fully realized.



Conclusions

Conclusions

- Real options analysis is an investment valuation framework that is currently being used by the top international corporations such as Chevron, Enron, GM, HP, Lucent, Sprint, and Texaco.
- Real options analysis extends NPV by incorporating the Nobel-prize winning mathematics behind financial options valuation in order to properly consider investment timing and future uncertainty.
- Real options analysis is ideally suited for the valuation of renewable energy technologies.
- The analysis presented today demonstrates that the real options approach is a valuable analytic tool for assessing renewable energy investment options.
- Other promising applications include R&D portfolio management, environmental compliance strategies, valuing fuel switching, technology learning, and the treatment of T&D investments and stranded assets.

Appendix D: Sample Studies of New Regulations for DG

Decoupling Works

READY FOR NATIONAL ROLLOUT

GUEST OPINION

By Mark Dodson

THE PACIFIC NORTHWEST is a unique region. Being environmentally conscious here is as much a part of daily life as enduring rainy winters and enjoying views of snowcapped peaks in late summer. Northwesterners have high expectations that their energy providers will go the extra mile to conserve energy and be responsible environmental stewards.

That made NW Natural Gas territory of western Oregon and southwest Washington a natural setting to pioneer a decoupling mechanism. While the story of how we broke the link between revenues and sales volume is unique, the mechanism is readily exportable to other states. In fact, there is no reason why electric utilities, which flirted with decoupling in the 1990s, shouldn't embrace the concept now.

By the mid 1990s, per capita use of natural gas was dropping. We detected this trend earlier than most utilities for two reasons. First, in the 1990s the Northwest enjoyed relatively low natural gas prices. As prices rose, customers felt the pinch and began to conserve aggressively. Second, a housing boom in the Northwest brought a large number of new homes with more efficient appliances and insulation.

With the Energy Crisis of 2000-2001, these forces converged. The pressure from all sides to help customers reduce consumption and manage bills became enormous. We stepped up and increased our conservation programs and in turn saw use decline even further. It didn't make sense that we were doing the right thing for our customers and being penalized financially. So we developed a mechanism we called the Conservation Tariff.

We worked closely with regulators, customer and environmental advocates instead of battling them. We found it more productive to put our shareholders on the same side of the table as our customers. It took a concerted effort, but eventually all saw that this was a sincere effort to encourage conservation while solving our business problem.

The tariff includes two adjustments, one for price elasticity and the other for conservation. The first occurs any time our prices increase or decrease. If they go up, they go up a little more to account for the expected decrease in demand. If prices are going down, they go down a little more to account for the expected increase in usage. The conservation adjustment occurs on a monthly basis and is essentially a true up of what people used versus what we expected them to use. The difference is multiplied by our distribution margin, and the dollars produced are held in a deferral account for collection or refund at year-end.

As part of this new tariff, the company agreed to step up its energy-efficiency efforts, including adding a charge to our bills to help fund energy efficiency programs and to support bill-paying assistance for low-income customers. So today, we can promote conservation without working against our shareholders.

The Conservation Tariff went into effect in Oregon in 2002. In late 2005, our regulators renewed it for four years, actually increasing the amount we can recover from 90 percent to 100 percent of the decline in usage.

The Conservation Tariff proved popular with customer groups, environmental advocates and regulators. We're gratified that many other natural gas utilities are working toward similar decoupling mechanisms. Proposals are under consideration by regulators in Arizona, California, Montana, North Carolina, New Jersey, Indiana, Utah, Washington and Oregon.

It is time to reexamine our utility rates in light of current concerns about conservation and the environment. Many rate mechanisms were originally designed in the 1930s to encourage the abundant use of energy. This was appropriate when we were building massive power projects to industrialize a nation. But do they still make sense for a forward-looking utility in the 21st century?

The key to a successful decoupling mechanism is to find a way to share the risks and benefits of lower volumes and volatile prices. The dynamics of a company's place in the energy market and its regulatory environment will dictate precisely how it should approach decoupling. But the principle of risk and benefit sharing is critical in any situation.

NW Natural's particular territory and its long-term commitment to environmental stewardship made our strategy unique. But it is clear that much has changed in the energy business in the last few years. We can't afford to be caught in the middle between regulators, shareholders and customers. Working cooperatively and productively with all of our key stakeholders is essential for long-term success.

Mark Dodson is president and chief executive officer of NW Natural Gas.

News Flash>>
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LNG SURGES

The liquefied natural gas industry will need $120 billion in investments for new plants in the next 15 years and $30 billion for LNG terminals, according to Stephen Craen, with Societe Generale.

Growth in the LNG sector between now and 2020 will outstrip growth in oil and other sectors of the natural gas industry, Craen said, according to a Dow Jones & Co. report.