



ENVIRONMENTAL REVENUE STREAMS FOR COMBINED HEAT AND POWER

**U.S. Environmental Protection Agency
Combined Heat and Power Partnership**



December 2008

FOREWORD

The U.S. Environmental Protection Agency (EPA) established the Combined Heat and Power (CHP) Partnership as a voluntary program that seeks to reduce the environmental impact of power generation by promoting the use of CHP. CHP is an efficient, clean, and reliable approach to generating power and thermal energy from a single fuel source. CHP can increase operational efficiency and decrease energy costs, while reducing the emissions of greenhouse gases that contribute to global climate change. The CHP Partnership works closely with energy users, the CHP industry, state and local governments, and other stakeholders to support the development of new CHP projects and promote their energy, environmental, and economic benefits.

The CHP Partnership provides resources about CHP technologies, incentives, emissions profiles, and other information on its Web site at <www.epa.gov/chp>.

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EXECUTIVE SUMMARY

Federal and state policymakers have created numerous incentives to encourage the deployment of clean distributed generation (DG), such as combined heat and power (CHP). Increasingly, governments have also created incentives intended to monetize the environmental attributes of clean, onsite power generation. These types of incentives are helping developers capture the full benefits of DG/CHP and overcome some of the financial hurdles created by market inefficiencies.

CHP, also known as cogeneration, is the simultaneous production of electricity and thermal energy from a single fuel source, such as natural gas, biomass, biogas, coal, or waste heat. By using waste heat recovery technology to capture a significant proportion of the heat created as a byproduct in electricity generation, CHP systems typically achieve total system efficiencies of 60 to 80 percent for producing electricity and thermal energy. Because CHP uses less fuel than conventional generation, it reduces emissions of greenhouse gases (GHGs) and air pollutants.

Environmental revenue streams (ERSs) are one-time or ongoing payments by an entity (such as a state) to the developer or owner of an energy-generation project. ERSs reward the use of highly efficient and/or renewable energy generation technologies. Programs established to monetize the environmental benefits of clean DG offer the possibility of improving project economics and increasing the acceptance of CHP by energy users who are committed to reducing GHG emissions. Similar to CHP project development, every project will have unique attributes and be sited in an area that has a unique set of policies and programs in place. With the exception of companies that specialize in biomass or biogas projects, participation in programs such as emissions trading, offsets, or renewable energy credit (REC) programs has not been part of the typical CHP project development process to date. Many in the CHP industry are unfamiliar with the nuances of these programs, where and how they could be applicable to their projects, what the potential value of the ERS could be, and how to access the ERS to improve project economics and success.

This paper discusses three key types of programs or policies (i.e., cap and trade, offset, and REC programs). It can also help project developers determine what ERS programs are available in their state, if CHP systems qualify, and if a project might be eligible for more than one program. The paper also provides a case study example of a CHP project in which potential ERS payments under several of the policies/programs discussed are calculated. An appendix contains guidance on how to estimate the monetary impacts of an ERS on a specific project.

INTRODUCTION

By improving project economics, environmental revenue stream (ERS) payments encourage both the deployment of combined heat and power (CHP) or renewable energy projects and reductions in emissions of greenhouse gases (GHGs) and air pollutants.

Specifically, ERSs provide revenue through the sale of credits for achieving emission reductions of nitrogen oxides (NO_x) or carbon dioxide (CO₂), or credits for the electricity generation from renewable energy sources or waste energy (e.g., CHP). The following three types of programs or policies offer ERSs for which CHP projects might qualify:

- Cap and trade programs
- Offset programs
- Renewable energy certificate (REC) programs

The monetary value of ERS varies. CHP projects possess unique energy and environmental attributes, and states have different environmental and energy policy goals that place different emphases on ERS. As such, the value of an ERS for a specific project is determined by that project's emission profile and local market and policy conditions.

This paper discusses the three types of programs or policies listed above to help project developers determine what ERS programs are available in their states, if a project might be eligible for more than one ERS program, and whether CHP projects qualify. Following the discussion of these policies and programs, the paper presents potential ERS payments for a sample CHP project. The appendix includes guidance for estimating the monetary impacts of an ERS on a specific project.

KEY PROGRAMS AND POLICIES

Calculating the monetary impact of ERS on a specific project requires understanding the ERS program requirements, the energy and environmental profile of the project, and the market value of the credits. The key characteristics of the three types of programs and policies that offer ERS are described as follows.

Cap and Trade Programs

A cap and trade program is a market-based regulatory approach to reducing emissions across specific industry sectors (e.g., the electricity sector) in a specified geographic region. An emission cap is established for the sector, and tradable emission allowances are distributed to

What Is CHP?

CHP, also known as cogeneration, is the simultaneous production of electricity and thermal energy from a single fuel source, such as natural gas, biomass, biogas, coal, or waste heat. By using waste heat recovery technology to capture a significant portion of the heat created as a byproduct in electricity generation, CHP systems typically achieve total system efficiencies of 60 to 80 percent. Because CHP uses less fuel than conventional generation, it reduces emissions of GHGs and air pollutants. More information about CHP can be found at www.epa.gov/chp/basic.

affected sources. Allowances are allocated either at no cost to the regulated entities or for a fee (usually through an auction). Each allowance represents the right to emit one unit of the regulated pollutant—typically 1 ton—in one year. To comply with the cap, an affected source must surrender allowances equal to its actual emissions during each compliance period. Because fewer allowances are issued than tons of emission released at the start of the program, the program ultimately results in emission reductions. A source can comply with the cap by installing pollution controls, implementing efficiency measures, or purchasing additional allowances from the market.¹

Cap and trade programs historically have been an effective means for reducing emissions of NO_x and sulfur dioxide (SO₂), which contribute to the formation of acid rain and smog. Because CHP projects reduce the emissions of these pollutants, some states encourage these projects by allowing them to participate in allowance trading. States that want to encourage clean energy projects typically set aside a portion of their tradable allowances and allocate them to projects that reduce or displace electricity generation. A clean energy project developer or owner can then sell the allowances to generate a revenue stream. Other states permit clean energy projects to participate directly in the cap and trade program, comparable to all other participants. In these cases, CHP projects can benefit from participation because their emission profiles can create extra allowances that may be sold.

Several cap and trade programs that provide allowance allocations to CHP systems are in place or under development:

- § The Regional Greenhouse Gas Initiative (RGGI) is a CO₂ cap and trade program in the Northeast. Implementation rules in participating states vary in the extent to which they will use the program to promote CHP.
- § The Western Climate Initiative (WCI) is developing a CO₂ cap and trade program that could include CHP facilities. The design of the program is under development, and implementation is scheduled to begin in 2012.

The NO_x Budget Trading Program (previously called the NO_x SIP Call) provides allocations to CHP facilities in several states; however, this program ends in 2008.

Each of these programs is described in more detail below.

Regional Greenhouse Gas Initiative (RGGI)

RGGI is a cooperative effort by several northeastern and mid-Atlantic states to reduce CO₂ emissions. RGGI is being implemented through a multistate cap and trade program for electric power generators larger than 25 MW. As of November 2008, 10 states were participating in RGGI (see Table 1). The CO₂ cap will take effect in 2009 and will be reduced after 2014, thus requiring additional emission reductions.

On August 16, 2006, RGGI released a model rule, subsequently updated on January 5, 2007, that has served as the basis for individual state rules. Each state was required to determine how to allocate allowances, track emissions and allowances, incorporate emission offsets, and address

¹ Learn more about cap and trade programs from EPA's Clean Air Markets Division Web site at www.epa.gov/airmarkets/cap-trade/index.html.

the issue of leakage.² Each participating RGGI state must propose a state plan based on the model rule by December 31, 2008.

The states agreed that at least 25 percent of each state's allowances must be held for a consumer benefit set-aside to promote renewables and energy efficiency. As of November 2008, five states have proposed to auction 95 percent or more of their allowances, with the proceeds to be used to support energy efficiency and renewable energy. Two of the states that are auctioning a lower percentage of allowances—Connecticut and Maine—have established specific allowance set-asides that will be used to support CHP. In addition, New Jersey has established regulations that will explicitly promote the development of CHP. Other states may choose to support CHP as part of their efficiency and renewable energy programs, the details for which have not yet been established. The specifics on the three state efforts to date are:

- **Connecticut** has set aside up to 21.5 percent of allowances to benefit CHP across three set-aside accounts.³ The customer-side distributed resources (CDR) set-aside account will include 3.5 percent of allowances, for which CHP is eligible. The CHP useful thermal energy set-aside account contains 5 percent of allowances. The CHP long-term Power Purchase Agreement (PPA) set-aside account includes 13 percent of allowances.
- **Maine** is setting aside allowances to benefit CHP units that are located at integrated manufacturing facilities.⁴ Such facilities are eligible to receive allowances free-of-charge equal to their behind-the-meter CO₂ emissions.⁵
- **New Jersey** provides direct allocation of CO₂ allowances to affected cogeneration facilities that meet certain thermal efficiency criteria.⁶ Additionally, the New Jersey Economic Development Authority, which will receive 60 percent of the state's auction revenue, is required to provide grants and other forms of financial assistance to support end-use energy efficiency projects and new, efficient electric generation facilities, including CHP.⁷

The first RGGI auction of allowances occurred on September 25, 2008. The 12,565,387 allowances offered for sale reached an auction clearing price of \$3.07 per ton, generating more than \$38.5 million. The proceeds from the auction will be distributed to Connecticut, Maine, Maryland, Massachusetts, Rhode Island, and Vermont, the six RGGI states that offered allowances for sale during the first auction. The schedule for subsequent auctions has been set through 2009 as occurring each quarter (i.e., in December, March, June, and September).⁸

² Leakage refers to the idea that to meet the cap, an activity (such as electric generation) could be shifted to a region outside the cap (e.g., by purchasing electricity from a company outside the cap region). If such shifts occur, emissions would be reduced within the cap region, but overall emissions would not be reduced.

³ www.ct.gov/dep/lib/dep/air/regulations/mainregs/22a-174-31.pdf

⁴ "Integrated manufacturing facilities" are defined as a facility that (1) received an air emissions license from the Department of Environmental Protection prior to June 2007, (2) produces electricity from one or more carbon dioxide budget units, including one or more combined heat and power units, for transmission over the facilities of a transmission and distribution utility, and (3) routinely produces one or more other products for sale.

⁵ www.maine.gov/dep/air/greenhouse/rggi.htm

⁶ www.nj.gov/dep/rules/adoptions/adopt_081117a.pdf

⁷ www.njleg.state.nj.us/2006/Bills/PL07/340_.pdf

⁸ http://www.rggi.org/docs/Submission_Schedule_July_11_2008.pdf

Table 1. RGGI State CO₂ Budgets

State	CO ₂ Budget (short tons)	Auction Proportion
Connecticut	10,695,036	77%
Delaware	7,559,787	60% in 2009, increasing by 8% each year until 2014
Maine	5,948,902	85-90%
Maryland	37,503,983	85%
Massachusetts	26,660,204	99%
New Hampshire*	8,620,460	at least 70% (up to 2011); at least 83% thereafter
New Jersey	22,892,730	99%
New York	64,310,805	100%
Rhode Island	2,659,239	100%
Vermont	1,225,830	100%
Total	188,076,976	

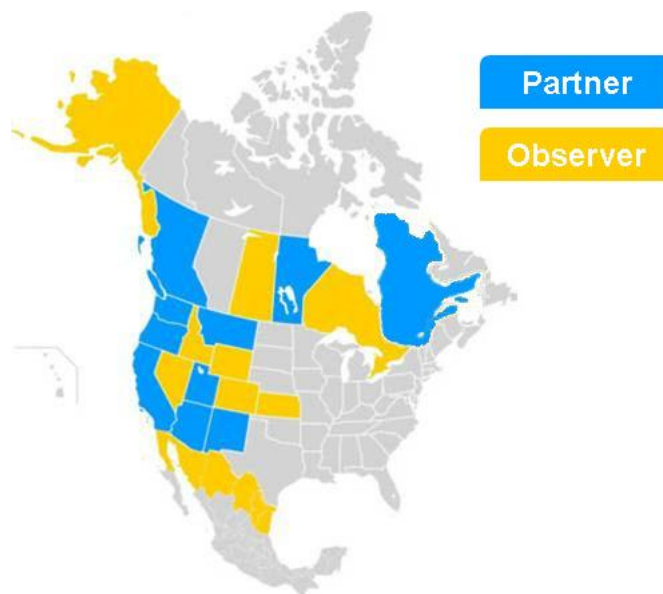
* Proposed auction proportions; regulations and rulemakings are not yet final.

Source: Regional Greenhouse Gas Initiative. (2008, September 24). www.rggi.org/home; EPA. (2008, September 24). State and Regional Climate Policy Maps—Power Sector GHG Cap and Trade. www.epa.gov/climatechange/wyacd/stateandlocalgov/state_power_sec.html#four.

The Western Climate Initiative (WCI)

Launched in February 2007, WCI is a collaboration among seven U.S. governors and four Canadian Premiers to develop regional strategies to address climate change. WCI is identifying, evaluating, and implementing cooperative ways to reduce GHGs in the region. Other U.S. and Mexican states and Canadian provinces have joined as observers. Figure 1 shows WCI partners and observers as of November 2008.

Figure 1. Western Climate Initiative Partners and Observers

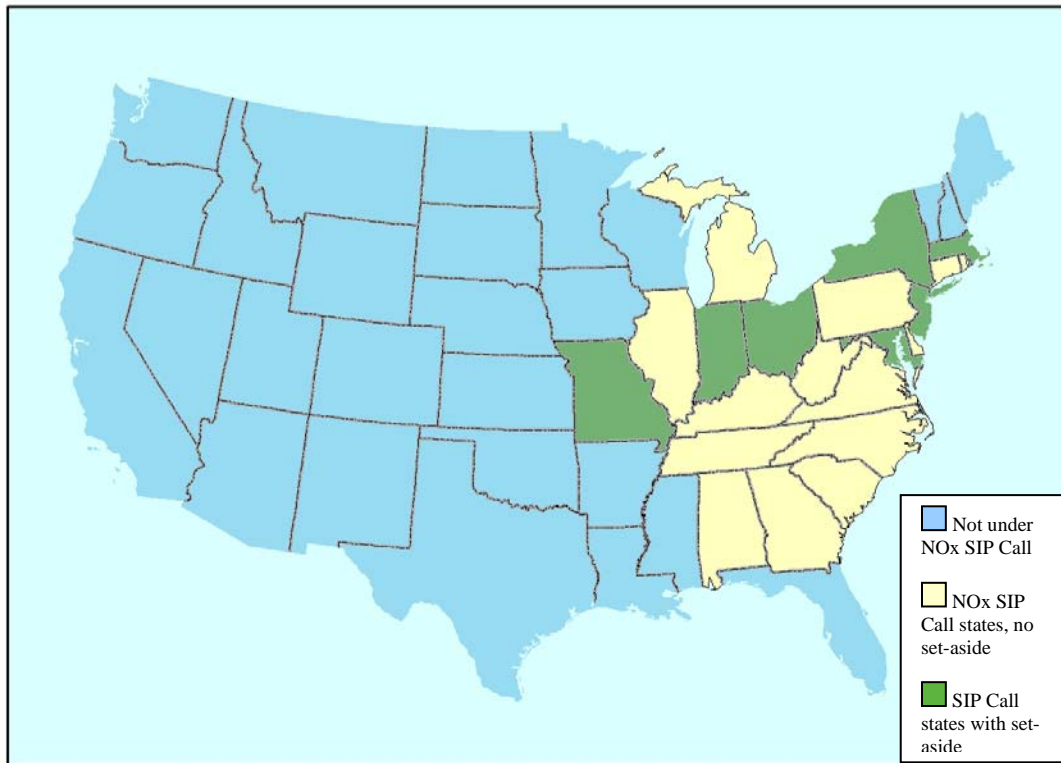


In August 2007, WCI partners set an overall regional goal to reduce aggregate GHG emissions 15 percent below 2005 levels by 2020 through the use of a market-based mechanism (cap-and-trade). On September 23, 2008, WCI released its “Design Recommendations for the WCI Regional Cap and Trade Program,”⁹ which presents an initial set of guidelines for designing the regional cap and trade program. Partner states and provinces still need to formally adopt design principles. The cap and trade system will most likely provide allowance allocations to CHP systems.

The NO_x Budget Trading Program (NBP)

The NBP, previously called the NO_x SIP Call, was promulgated by EPA in 1998. The NBP/NO_x SIP Call applies to 22 eastern states (see Figure 2) and was implemented in two phases. The first phase began in 2003 or 2004, depending on the state; the second phase began in 2007. The program is set to expire at the end of 2008. The NBP/NO_x SIP Call was created to reduce emissions of NO_x—a primary component in smog formation—from power plants and other large combustion sources. It is a cap and trade program and applies to NO_x emissions from fossil-fuel power plants and large industrial boilers during the ozone season (from May through September).

Figure 2. NO_x Budget Trading Program Map



Source: EPA Clean Air Markets Division. www.epa.gov/airmarkets/index.html.

Although EPA mandated emission reductions, the Agency gave states some flexibility in overall program design—in particular, with regard to the allocation of allowances to affected sources.

⁹ www.westernclimateinitiative.org/ewebeditpro/items/O104F19865.pdf

As part of this flexibility, some states decided to reward clean energy projects by establishing energy efficiency and renewable energy (EE/RE) set-asides in their allocation systems. Under the set-aside, clean energy projects such as biomass, CHP, wind, solar, hydro, and other electricity generation projects may be eligible to receive allowances that could be sold to other facilities. The seven states with set-asides include Indiana, Maryland, Massachusetts, Missouri, New Jersey, New York, and Ohio. These states allocate from 1 percent to 5 percent of their NO_x allowance budget to the EE/RE set-aside. Additionally, the Massachusetts allowance allocation is an output-based allocation¹⁰ that includes credit for the thermal output of CHP facilities.

Allowances received from the EE/RE set-aside or CHP allocation can provide an additional revenue stream for existing projects, encouraging the deployment of new renewable and CHP projects. The value of the revenue stream is determined by:

- How many allowances are allocated to each project
- The price of allowances in the market

Most states use a similar approach to identify facilities eligible for the set-aside and to allocate allowances to those units. Typically, energy efficiency projects including demand-side management (DSM) and renewables such as wind, hydro, biomass, landfill methane generation, and solar are eligible. For states that include CHP, a minimum overall efficiency requirement of 60 percent is typically present.

Allowances are often allocated at a rate of 1.5 lbs NO_x/MWh generated; however, states might have different methodologies depending on the technology. Additionally, if the set-aside pools are oversubscribed or undersubscribed, then allowances often will be allocated on a pro rata basis. Allowances typically are awarded for one year, and applicants may reapply for a period ranging from 3 to 7 years.

The price of allowances varies based on the conditions of the allowance market throughout the NBP/NO_x SIP Call region. Historically, prices have ranged from \$500 to \$7,000 per ton.¹¹

Offset Programs

Offsets counteract emissions that would have been emitted into the atmosphere. Acting as a compensating equivalent for reductions made at a specific source of emissions, offsets are generated by the reduction, avoidance, or sequestration of GHG emissions from a specific project. Discussed below are the two primary offset programs in which CHP projects can participate.

New Source Review

The new source review offset program applies in all areas of the country that are not in attainment with the National Ambient Air Quality Standard (NAAQS).¹² The program requires

¹⁰ Output allocations are based on the productive electric (and thermal) output of the unit versus the heat input. More information on structure of output-based regulations can be found in EPA's *Handbook on Output-Based Regulations for Air Regulators* at <www.epa.gov/chp/publications>.

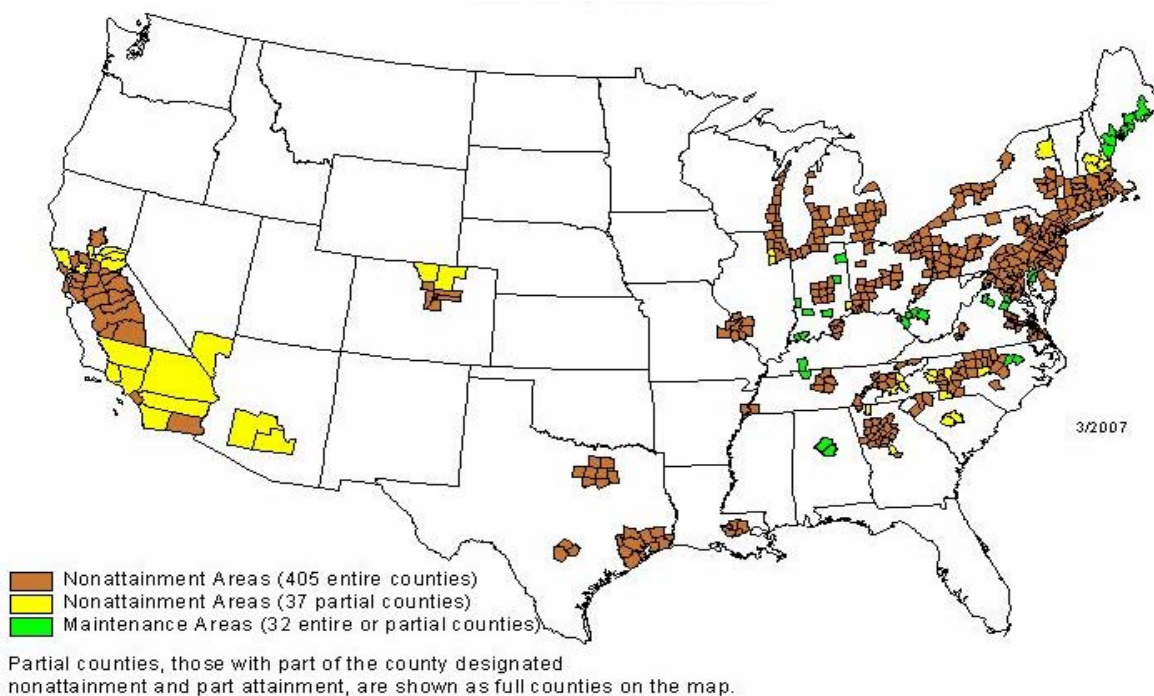
¹¹ Ozone Transport Commission. (2003, March). NO_x Budget Program, 1999-2002 Progress Report. www.epa.gov/airmarkets/progress/docs/otcreport.pdf.

¹² The NAAQS has been established for lead, nitrogen dioxide (NO₂), carbon monoxide (CO), particulate matter (PM), ground-level ozone (smog), and SO₂. Air quality is monitored throughout the United States, and areas are

major new or expanded emission sources to offset more than 100 percent of their increased emissions by making emission reductions within the local airshed. The offsets must be obtained as part of the air permitting process.

To satisfy emission reduction requirements, industries may purchase emission reduction credits (ERCs) from other sources that have reduced equivalent emissions. ERCs are a commodity that can be traded among facilities within a limited geographic area. This trading market can provide a one-time payment to the source generating the emission reductions. CHP projects that replace more highly emitting combustion sources can create ERCs, most commonly for NO_x emissions. NO_x ERCs currently can be marketed in states with nonattainment areas for ozone (Figure 3).

Figure 3. 8-Hour Ozone Standard Nonattainment and Maintenance Areas in the United States (2007)



Source: EPA. (2007, March). *Green Book Nonattainment Areas for Criteria Pollutants*. www.epa.gov/oar/oaqps/greenbk/map8hrnm.html.

Each ERC represents 1 ton per year of reduced emissions. ERCs can only be created through strictly defined emission control actions, although specific ERC creation requirements vary widely by state. In general, ERCs can only be used in the state in which they are created, or in some cases within a limited interstate region. The reductions must be permanent, measurable, surplus to any emission limits that would otherwise apply, and enforceable. Typically, the source creating the reductions must take an enforceable permit condition for the reductions.

Creation of ERCs usually entails a quantification process, negotiation with the state air permitting agency, and air permit modifications. This process can be time-consuming and costly. To be worthwhile, the project must create a significant emission reduction in an area where a

designated as “nonattainment” for any pollutants that exceed the standard. The new source review offset program applies to the nonattaining pollutants in each nonattainment and maintenance area.

high demand for ERCs creates a favorable price. To learn about the local market for ERCs, contact the appropriate state environmental agency or an emission broker who is familiar with the market.¹³

The market for ERCs depends on the level of new construction activity in the region, as well as the local supply of ERCs. In California, prices for NO_x ERCs can sometimes approach \$120,000 per ton.¹⁴ More commonly, however, prices are in the \$3,000 to \$7,000 per ton range.

CO₂ Offset Programs

Separate from CO₂ cap and trade programs, several states regulate CO₂ emissions from particular sources. To help regulated sources comply cost effectively, these states allow the sale of CO₂ emission offset credits. Projects that reduce CO₂ emissions or other GHGs at one location generate CO₂ credits that can be sold to offset emissions at another location. CHP projects can be used to create these offsets.

States or program administrators specify the criteria for projects that are eligible to earn CO₂ offsets. One common criterion is the “additionality” of an offset project. Additionality refers to the requirement that a project be one that would not have existed under a business-as-usual scenario without the incentive, funding, or other policy-related intervention being offered. The exact means of proving additionality varies by program and is rarely defined quantitatively.¹⁵ Offsets also may need to be validated by a third party.

Existing state offset programs in Oregon and Washington are summarized in the following sections. Because many of the programs are relatively new, rules and methods of implementation are continually evolving. As additional programs become available, the price of CO₂ offsets could change, perhaps substantially.

Oregon CO₂ Emission Standards

Oregon has established CO₂ emission standards for certain types of new facilities.¹⁶ Affected facilities include baseload power plants fueled by natural gas, non-baseload power plants (all fuels), and non-generating energy facilities (all fuels). The emission limits require new facilities to offset a portion of their GHG emissions before construction begins.

Given the limitations of current technologies, power plants cannot meet the established emission rate through efficiency alone. Thus, regulated facilities have two options for meeting the CO₂ limits: 1) implement offset projects, either directly or through a third party; or 2) contribute to a monetary fund that is used to fund offset projects. CHP projects can be used to generate offsets

¹³ The California South Coast Air Quality Management District posts a list of ERC brokers at <www.aqmd.gov/permit/ERCbrokers.html>. A recent report on the opportunities related to ERC creation from CHP facilities in New York provides background on this topic. See PACE Energy Project for The New York State Energy Research and Development Authority. (2006, January). *Guidebook for Small Combined Heat and Power Systems Seeking to Obtain Emissions Reduction Credits in New York State*.

¹⁴ Evolution Markets (2002, April 17). *An Overview of NO_x Emission Credit Markets in the U.S.* www.evomarkets.com/assets/presentations/pres_2-1019219509.pdf.

¹⁵ EPA’s Climate Leaders program has released guidelines on using offsets to help Partners achieve their GHG reduction goals. These guidelines use a “performance standard” methodology to quantitatively define additionality and selection and setting of the baseline. For more information see <www.epa.gov/climateleaders>.

¹⁶ Oregon Energy Facility Siting. (n.d.). *Oregon Carbon Dioxide Emission Standards for New Energy Facilities*. www.oregon.gov/ENERGY/SITING/docs/ccnewst.pdf.

to displace CO₂ emissions. Only new projects qualify, but the Oregon regulations place no limitations on the geographic location of offset projects.

The Climate Trust, an Oregon nonprofit organization, is the only organization that is authorized to generate offsets from the monetary fund.¹⁷ In practice, power plant developers pay a fixed fee per metric ton of excess CO₂ to the Climate Trust. The Climate Trust issues a request for proposal that specifies the criteria for eligible offset projects.¹⁸ These criteria always include an additionality requirement. Selected offset projects are paid a fee per metric ton of CO₂ offset produced. Both the fee and the method of payment are negotiated on a case-by-case basis. The fee has been increasing with each round of funding. In 2005, The Climate Trust paid \$4.80 per metric ton of CO₂. The expected price for 2007-2008 is \$5.00 per metric ton. To date, the trust has invested \$8.8 million in offset projects.

To date, only one CHP project, a CHP plant at Oregon State University, has received funding through The Climate Trust. Currently under construction, the university's CHP plant is expected to receive two separate rounds of offset funding from The Climate Trust. The Climate Trust awarded the first round of funding in 2007, providing funding for a 5.5 MW combustion turbine generator, a heat recovery steam generator, and two auxiliary boilers. The second round of funding is contingent on the delivery of proof of commercial operation of the facility.

Washington State CO₂ Offset Program

Washington first established regulations to limit CO₂ emissions from new fossil fuel-fired power plants in 2004.¹⁹ The limits apply to plants constructed after July 1, 2004, and modified facilities that increase production by more than 15 percent or 25 MW. These facilities must offset 20 percent of their new CO₂ emissions. Because facilities with CHP systems receive a credit, they are not required to offset the full 20 percent.

SB 6001, passed in May 2007, revised the 2004 statute and requires Washington to adopt California's emission performance standard of 1,100 lbs of CO₂/MWh for all new, long-term baseload electric power generation contracts, starting July 1, 2008.²⁰ The Washington Department of Ecology developed the final rule and it was adopted on June 19, 2008.²¹ The CO₂ mitigation requirements under Part I remain relatively unchanged from the original requirements passed in 2004. The regulations apply to fossil-fueled thermal generating facilities that submit an application to the Department of Ecology on or after July 1, 2004, and have a generating capability that is above 25 MWe, but less than 350 MWe, and are not considered a "fossil-fueled floating thermal electric generation facility subject to regulation by the energy facility site evaluation council." The regulations also apply to facilities that increase production by more than 15 percent or 25 MW. Facilities have three ways to comply:

¹⁷ For more information, see <www.climatetrust.org>.

¹⁸ The Climate Trust. (n.d.). *The Climate Trust's Criteria for Offset Projects*. www.climatetrust.org/pdfs/CT%20offset%20criteria.pdf.

¹⁹ Washington State Statute. (2004, December 22). Chapter 173-407 WAC, *Carbon Dioxide Mitigation Program for Fossil-Fueled Thermal Electric Generating Facilities*. www.ecy.wa.gov/pubs/wac173407.pdf.

²⁰ SB 6001. (2007, May). www.leg.wa.gov/pub/billinfo/2007-08/Pdf/Bills/Senate%20Passed%20Legislature/6001-S.PL.pdf.

²¹ Chapter 173-407 WAC. (2008, June 19). *Carbon Dioxide Mitigation Program, Greenhouse Gases Emissions Performance Standard and Sequestration Plans and Programs for Thermal Electric Generating Facilities*. www.ecy.wa.gov/laws-rules/wac173407_218/x0711a.pdf.

- § Invest in CO₂ offset projects directly
- § Purchase carbon credits (verified by a recognized trading authority)
- § Make payments to a third party to implement offsets

Eligible offset projects include alternative energy resources, energy efficiency measures, and CHP. Either the Washington Department of Ecology or the Energy Facility Site Evaluation Council approves all proposed offsets projects. For facilities that choose to make payments to a third-party organization,²² the minimum payment is \$1.60 per metric ton of CO₂. The actual cost of the reductions acquired by the third party could exceed \$1.60 per metric ton, for example, if acquired through the Oregon Climate Trust.

Part II of the regulations concerns the new emissions performance standard. The new standard will apply to all new baseload generation and cogeneration facilities that are permitted for construction and operation after June 30, 2008, and that use fossil fuel or nonrenewable fuels for all or part of their fuel requirements. The emissions performance standard also applies to existing facilities if a new baseload generation facility or unit is issued a notice of construction approval or site certification agreement; if the existing facility is upgraded; or if the existing facility or unit enters into a new long-term financial contract. Facilities can meet the standard through the use of nongeologic and geologic sequestration methods.

Renewable Energy Certificate (REC) Programs

Several vehicles have emerged to promote the development of clean and renewable power generation, including: 1) renewable portfolio standards (RPS) and 2) the voluntary green power market. An RPS is typically mandated by law, while the green power market is a voluntary market guided by consumer choices.

Both programs work, in part, through a trading program of RECs. A REC represents the property rights to the environmental, social, and other nonpower qualities of renewable electricity generation. A REC, and its associated attributes and benefits, can be sold separately from the underlying physical electricity associated with a renewable-based generation source. RECs are sometimes referred to as green tags, green energy certificates, or tradable renewable certificates. RECs usually are sold in units of 1 megawatt-hour (MWh) each. The certificates can be sold separately from the electricity with which they are associated. This flexibility enables purchasers to offset their conventional electricity use with renewable energy generated elsewhere.

Renewable Portfolio Standards (RPSs)

An RPS requires that electric power providers supply a specified percentage of customer load with electricity generated from eligible renewable energy technologies.²³ Many state RPSs have established a market for RECs on either a state or regional basis. Eligible sources receive a certain number of RECs each year based on their electricity generation. Electricity providers then purchase RECs to help meet their RPS targets.

²² The Energy Site Evaluation Council maintains a list of qualified third-party organizations for generating emission offsets.

²³ Some states have energy portfolio standards (EPS). An EPS is similar to an RPS but includes broader energy resources such as energy efficiency, waste energy, and CHP.

Through November 2008, 33 states plus the District of Columbia had established RPS requirements or goals (see Table 2).²⁴ The eligibility of projects to qualify for RECs varies widely by state. Nonemitting renewables, such as solar and wind power, are almost always included. All states currently include biomass as eligible under their standard; most states include landfill gas; and 12 states include CHP or waste heat recovery as eligible resources. The types of CHP energy that are eligible and the vintage date for projects that qualify vary greatly. For example, some RPS programs specify that CHP systems must meet a certain efficiency threshold to qualify (e.g., 50 percent total efficiency in Connecticut). In some states (e.g., Connecticut, Pennsylvania), CHP is in a separate tier from other renewables and has separate goals.²⁵

²⁴ EPA. (2007, June). *Energy Portfolio Standards and the Promotion of Combined Heat and Power*; EPA. (2008, October). *State Clean Energy Policy Maps—Energy Supply Actions*. www.epa.gov/cleanenergy/energy-programs/state-and-local/supply_actions.html#rps.

²⁵ Additional information about state EPS/RPS programs, including expanded descriptions of those that include CHP, can be found in *Energy Portfolio Standards and the Promotion of Combined Heat and Power*. www.epa.gov/chp/documents/eps_and_promotion.pdf.

Table 2. Eligibility of Technologies Under State Energy Portfolio Standards

	Biofuels	Biomass	CHP/Waste Heat	Energy Efficiency	Fuel Cells [†]	Geothermal	Hydro	Landfill Gas	Municipal Waste	Ocean Thermal	Photovoltaics	Solar Thermal Electric	Tidal	Waste Tire	Wave	Wind
AZ		●	●*			●	●	●			●	●				●
CA	●	●				●	●	●	●	●	●	●	●		●	●
CO		●	●**			●	●	●			●					●
CT		●	●	●	●		●	●	●	●	●	●	●		●	●
DE		●				●	●	●		●	●	●	●		●	●
DC		●				●	●	●	●	●	●	●	●		●	●
HI	●	●	●	●		●	●	●	●	●	●	●	●		●	●
IA		●					●	●	●		●					●
IL		●		●			●	●			●	●				●
MA		●						●		●	●	●	●		●	●
MD		●				●	●	●	●	●	●	●	●		●	●
ME		●	●		●	●	●	●	●		●	●	●			●
MI		●				●	●	●	●	●	●	●	●		●	●
MN		●			●***		●	●	●		●	●				●
MO [☆]		●		●				●			●	●				●
MT		●				●	●	●			●	●				●
NC		●	●	●		●	●	●			●	●	●		●	●
ND [☆]		●	●**			●	●				●	●				●
NH	●	●				●	●	●		●	●	●	●		●	●
NJ		●				●	●	●	●		●	●	●		●	●
NM		●				●	●	●			●	●				●
NV	●	●	●**	●		●	●	●	●		●	●		●		●
NY	●	●			●		●	●		●	●		●		●	●
OH		●	●	●	●	●	●	●	●		●	●				●
OR		●				●	●	●		●	●	●	●		●	●
PA		●	●	●	●	●	●	●	●		●	●				●
RI	●	●				●	●	●		●	●		●		●	●
SD		●	●**			●	●	●	●		●	●				●
TX		●				●	●	●		●	●	●	●		●	●
UT [☆]		●	●	●		●	●	●		●	●	●	●		●	●
VA [☆]		●				●	●				●	●	●		●	●
VT [☆]		●					●	●			●	●				●
WA	●	●	●	●		●	●	●		●	●	●	●		●	●
WI		●				●	●	●			●	●	●		●	●

☆ States with RPS goals, not mandatory requirements.

* Renewable CHP systems are eligible; fossil-fuel CHP systems are not eligible.

** Waste heat only.

*** After January 1, 2010, hydrogen must be generated by renewable energy sources.

† Includes only those states that allow fuel cells using nonrenewable energy sources of hydrogen. Some states (i.e., Arizona, California, Colorado, Delaware, Massachusetts, Maryland, Missouri, New Mexico, New York, Rhode Island, and Wisconsin) allow only renewable fuel cells as eligible technologies.

Source: Database of State Incentives for Renewable Energy (DSIRE). Last accessed October 2008.

www.dsireusa.org.

One significant variable in RPS program design is whether generators are eligible for both RECs and emission allowances under an applicable cap and trade program. Some states consider earning RECs and emission allowances from the same project to be “double counting” and prohibit it; others do not. For example, in New York, qualifying RPS facilities that receive RECs must transfer ownership of environmental attributes to the New York State Research and Development Authority.

REC prices vary by state. Prices are influenced primarily by renewable energy supply, geographic limitations, resource eligibility, and vintage restrictions. States with stricter RPS eligibility generally have higher REC prices (see Table 3). Furthermore, RECs from zero-emitting renewables often garner the highest prices. For example, in New Jersey, the price of a solar REC for the 2007 and 2008 calendar years was \$265.^{26, 27}

Voluntary Green Power Programs

Voluntary green power programs offer electricity customers a way to reduce the environmental impacts of their electricity use. Participants can purchase green power by paying a higher price to their electricity provider for renewably produced electricity, or they can buy RECs through a REC marketer.²⁸

Green power is a subset of renewable energy and represents those renewable energy resources and technologies that provide the highest environmental benefit. EPA defines green power as electricity produced from solar, wind, geothermal, biogas, biomass, and low-impact small hydroelectric sources. Customers often purchase green power for avoided environmental impacts and GHG reduction benefits

In general, eligibility for voluntary RECs is limited to zero-emitting resources, with the exception of certain biomass fuels.^{29,30} Fossil fuel-fired CHP is ineligible

**Table 3. REC Prices as of July 2008
(1 REC = 1MWh)**

Connecticut	
Class I*	
2008	\$25.00
Class II*	
2008	\$0.65
Class III*	
2008	\$26.75
Maine	
2008	\$0.15
Massachusetts	
2008	\$45.50
Texas	
Q3-Q4 2007	\$5.25
Q1-Q2 2008	\$4.00
Delaware	
2007 Existing	\$0.65
2007 New	\$13.75
Rhode Island	
2008	\$48.00
New Jersey	
Solar	
2007/2008	\$265.00
Class I *	
2007/2008	\$6.00
2008/2009	\$17.50
Class II *	
2007/2008	\$0.60
Maryland	
Tier I *	
2006	\$0.70
2007	\$0.75
2008	\$1.00
Tier II *	
2006	\$0.40
2007	\$0.55
2008	\$0.60
DC	
Tier I *	
2007	\$0.65
2008	\$1.15
Tier II *	
2007	\$0.75
Pennsylvania	
Tier I *	
2007/2008	\$8.50

*For more information on the resources included under various classes and tiers for a state, visit the RPS description for each state available on the

²⁶ RECs in these markets represent 1 MWh. RECs in some western states represent 1 kWh.

²⁷ Evolution Markets (2008, July). *REC Markets, Monthly Market Update*. www.evomarkets.com.

²⁸ EPA provides numerous resources to members of the public interested in purchasing green power, or developers seeking access to green power markets. EPA’s Green Power Partnership is a voluntary EPA program that seeks to increase the use of green power among leading U.S. organizations, providing educational and technical assistance to those seeking to purchase green power. More information on green power purchase requirements and green power can be found at <www.epa.gov/greenpower>.

²⁹ Green-E. *Green-E National Standard*. www.green-e.org/getcert_re_stan.shtml.

³⁰ *Revised Uniform National Standard for EcoPower® Renewable Energy Certificates*. www.ert.net/ecopower/index.html.

under both Green-E and Environmental Resource Trust (ERT) requirements.

The voluntary market functions, in part, through the use of third-party certifiers. Third-party certifiers ensure that RECs come from the type of renewable resource claimed and that RECs have been sold only once. As in the mandatory RPS market, each certifier specifies the environmental attributes that transfer with the REC. For example, a Green-E REC includes all environmental attributes except cap and trade pollutants. An ERT REC includes indirect GHG emission reductions but no other emission reductions (e.g., NO_x). In July 2008, prices paid for RECs on the voluntary market ranged from \$3 to \$12 for new facilities.³¹

CHP PROJECT EXAMPLE

To demonstrate the ERS that a CHP project might earn, the following highlights a 10-MW gas-turbine-based CHP system located in Massachusetts and the ERS possible through three of the policies or programs discussed in this paper. Table 4 shows the performance and emissions characteristics for the gas turbine system. Table 5 presents a summary of the ERS payments under each program.

Table 4. Performance and Emissions Characteristics for Gas Turbine CHP System

	Gas Turbine CHP System
<i>Performance</i>	
Net Capacity (kW)	10,146
Fuel Use (MMBtu/hr, HHV)	123.6
Heat Rate (Btu/kW)	12,178
Electric Efficiency (%)	28.0%
Steam Output (lbs/Hr)	48,150
Steam Pressure (psig)	150
Steam Temperature (°F)	365.9
Recoverable Thermal Energy (Btu/kWh)	5,220
Electric /Thermal Output Ratio	0.65
CHP Efficiency (%)	70.9%
<i>Emissions*</i>	
NO _x Emissions (lb/MWh)	0.672
NO _x Emissions (tons/year)	28.2
Net CO ₂ Emissions CHP Basis (lbs/MWh)	738
CO ₂ Emissions (metric tons/year)	28,195

* Capacity factor assumed at 95 percent. Thermal utilization factor of 90 percent.

³¹ Evolution Markets. (2008, July). *REC Markets, Monthly Market Update*. www.evomarkets.com.

Table 5. Summary of ERS Payments for Sample Project

	New Source Review Program	CO₂ Offset Program (\$5/metric ton)	CO₂ Offset Program (\$10/metric ton)	REC Program
ERS Payment	\$275,100*	\$100,085**	\$200,170**	\$168,104**

* This is a one-time payment made at the beginning of the project.

** These are annual payments made over the life of the project.

New Source Review

Calculating the impact of an offset project under the NO_x new source review offset program is somewhat more complicated than other potential revenue streams because the emission reduction value depends on the emission reduction relative to the equipment that is being replaced. The program applies only to CHP projects that can show that they will result in the permanent retirement of NO_x emissions from boilers. Using the sample 10-MW CHP facility, it is assumed that the CHP system replaces a relatively high-emitting residual oil-fired boiler. The estimate of the offset program's impact on the CHP project is based on the following assumptions:

- The thermal output of the CHP system contributes to the retirement of a 53 MMBtu/hour residual (#6) fuel oil boiler that emits NO_x at 0.367 lb/MMBtu.
- The annual boiler capacity factor is 85.5 percent, equivalent to a CHP system with a 95 percent electric capacity factor and 90 percent utilization of recovered thermal energy.
- The payment for permanent NO_x removal is assumed to be \$4,500 per ton. This payment is a one-time payment made at the beginning of the project. There is an assumed \$7,500 transaction cost for the developer to participate in this project (based on typical permitting costs for a small project).

Based on these assumptions, the sample 10-MW CHP project could expect a one-time payment of \$275,100. Table 6 shows the results.

Table 6. ERS Payment for Sample Project Under NO_x New Source Review Offset Program

	Gas Turbine CHP System
NO _x Emissions from CHP (tons/year)	28.2
NO _x Emissions from Retired Unit (tons/year)	91.0
Total NO _x Credits (tons/year)	62.8
Transaction Cost (\$)	\$7,500
Initial One-time Payment* (\$)	\$275,100

* Based on NO_x payment of \$4,500 per ton.

CO₂ Offset Programs

The potential ERS payment for the sample project under a CO₂ offset program in Massachusetts is based on two scenarios: offset payments valued at either \$5 per metric ton or \$10 per metric ton. The \$5 per metric ton payment is in line with past Oregon Climate Trust solicitations, and the \$10 per metric ton payment is used to show the potential impacts on project economics from an increased value of offsets due to competition from other programs. The Oregon Climate Trust bases the CO₂ emission offsets on regional marginal electric grid CO₂ emission factors. The 2005 eGRID subregion CO₂ emission factor for Massachusetts is 0.571 metric tons CO₂/MWh.

Table 7. ERS Payment for Sample Project Under CO₂ Offset Program

	Gas Turbine CHP System
NERC Subregion CO ₂ Emission Rate for Massachusetts (metric ton/MWh)*	0.571
CHP System CO ₂ Emissions (metric tons/year)	28,195
CO ₂ Credits (metric tons/year)	20,017
Value of CO ₂ Credits at \$5/metric ton (\$)	\$100,085
Value of CO ₂ Credits at \$10/metric ton (\$)	\$200,170

*Obtained from eGRID 2007 subregion GHG output emission rates for 2005.

www.epa.gov/cleanenergy/documents/egridzips/eGRID2007V1_0_year05_GHGOutputRates.pdf

Renewable Energy Certificate Programs

Eligibility for an RPS can have a significant effect on project economics. As of July 2008, the Massachusetts REC price was approximately \$45.50. RECs in Massachusetts are reserved for renewable energy projects; CHP projects can generate RECs as well, but the values are much lower because they are based only on the increased efficiency of CHP heat recovery. Currently, the REC value for CHP is approximately \$2/MWh. Table 8 shows the potential ERS.

Table 8. ERS Payment for Sample Project Under REC Program

	Gas Turbine CHP System
RECs Generated	84,052
Market Value of RECs (\$/MWh)	\$2
Total ERS	\$168,104

Appendix: Calculating Environmental Revenue Streams

The following table provides guidance for estimating the potential revenue from the sale of emission allowances, emission offset credits, and RECs. Be aware that the calculation methodologies presented might not be applicable in every situation because not all state programs operate in the same way. The table provides a framework, however, for comparing the monetary value of different environmental revenue streams to assist in estimating the economic benefits for your project.

Code	Information Needed	Project Data	Notes
A	Generator nameplate capacity, MW		
B	Annual capacity factor, %		
C	NO _x emissions, tons/year		
D	CO ₂ emissions, tons/year		
NO_x New Source Offsets for CHP			
J	NO _x emissions from retired unit, tons/year		Actual historical emissions from recent period for existing unit to be retired.
K	Offset transaction cost, \$		One-time payment. Fees can range from \$5,000 to \$15,000.
L	NO _x credits, tons/year		$L = J - C$
M	Market value of NO _x credits, \$/ton		Obtain latest price from local emission credit brokers.
N	Environmental revenue stream, \$ (one-time payment)		$N = (L \times M) - K$
CO₂ Offsets			
O	CO ₂ regional emission rate, tons CO ₂ /MWh		Obtain from eGRID 2007 or other state-approved source for your region of the electrical grid.
P	Cost of monitoring and verification, \$/yr		Typical costs could be \$2,500 per year.
Q	CO ₂ credits, tons/year		$Q = (A \times B \times O \times 8760) - D$
R	Market value of CO ₂ credits, \$/ton		Obtain latest price from local emission credit brokers.
S	Environmental revenue stream, ³² \$/year		$S = (Q \times R) - P$
REC Market			
T	RECs generated, MWh		$T = A \times B \times 8760$
U	Market value of REC, \$/kWh		Obtain latest price from local emission credit brokers.
V	Environmental revenue stream, \$/year		$V = T \times U$

³² One-time costs might apply for due diligence negotiations, legal fees, and development of a monitoring and verification plan.