

Energy Supply Technical Work Group

Summary List of Recommended High Priority Mitigation Options

Draft Version for April 5, 2007 ES TWG Meeting

Yellow highlight indicates text added/revised as a result of the March 1, 2007 CCAC meeting.

	Mitigation Option	GHG Reductions (MMtCO ₂ e)			Net Present Value 2007-2020 (Million \$)	Cost-Effectiveness (\$/tCO ₂ e)	Status of Option
		2010	2020	Total 2007-2020			
Group A	Renewable Energy and Energy Efficiency						
ES-1	Environmental Portfolio Standard (Renewables and Energy Efficiency)	<i>Quantification in Progress</i>					Pending
ES-2	Renewable Energy Incentives (Biomass, Wind, Solar, Geothermal)	<i>Not Quantified Separately (see ES-1 and ES-4)</i>					Pending
ES-4	Incentives and Barrier Removal (Including Interconnection Rules and Net Metering Arrangements) for Combined Heat and Power (CHP) and Clean Distributed Generation (DG)	<i>Quantification in Progress</i>					Pending
ES-7	Demand-Side Management (RCI TWG will take lead for analysis, with ES TWG providing review)	<i>Not Quantified Separately (see ES-1 and RCII)</i>					Pending
Group B	Advanced Fossil Fuel and Other Technologies						
ES-3	Research and Development (R&D), Including R&D for Energy Storage and Advanced Fossil Fuel Technologies	<i>Not Quantified</i>					Pending
ES-5	Incentives for Advanced Fossil Fuel Generation and Carbon Capture and Storage (CCS), Including Combined Hydrogen and Electricity Production with Carbon Sequestration	<i>Quantification in Progress</i>					Pending
ES-6	Efficiency Improvements and Repowering of Existing Plants	<i>Not Quantified</i>					Pending

	Mitigation Option	GHG Reductions (MMtCO ₂ e)			Net Present Value 2007–2020 (Million \$)	Cost-Effectiveness (\$/tCO ₂ e)	Status of Option
		2010	2020	Total 2007–2020			
Group C	Direct GHG Policies						
ES-8	CO ₂ Tax (to be considered jointly with RCI TWG)	<i>Not Quantified</i>					Pending
ES-9	GHG Cap-and-Trade	<i>Not Quantified</i>					Pending
ES-10	Generation Performance Standards or GHG Mitigation Requirements for New (and/or Existing) Generation Facilities, with/without GHG Offsets	<i>Quantification in Progress</i>					Pending
Group D	Fossil Fuel Production and Processing						
ES-11	Methane and CO ₂ Reduction in Oil and Gas Operations, Including Fuel Use and Emissions Reduction in Venting and Flaring	<i>Quantification TBD</i>					Pending
ES-12	GHG Reduction in Refinery Operations, Including in Future Coal-to-Liquids Refineries	<i>Quantification TBD</i>					Pending
ES-13	CO ₂ Capture and Storage or Reuse (CCSR) in O&G Operations, Including Refineries and Coal-to-Liquids Operations	<i>Quantification in TBD</i>					Pending

Note: Italicized text reflects questions or items still under consideration by the TWG as it continues its work on elaborating option descriptions.

Approach for the Estimation of Emissions Reductions from Electricity Policies

Production-basis vs. Consumption-basis for reporting GHG emission reductions

The CCAC process has discussed two accounting approaches for estimating electricity emissions: (a) the consumption-basis approach, which aims to reflect the emissions associated with electricity sources used to deliver electricity to consumers in the state; and (b) the production-basis approach, which considers the emissions from Montana power plants, regardless of where the electricity is delivered. The emissions impact of Energy Supply (ES) policy options will differ depending on which approach/perspective is taken. For instance, an Environmental Portfolio Standard (EPS, ES-1) will result in the increased delivery of renewable electricity and energy efficiency programs to Montana consumers, thereby directly displacing the delivery of fossil fuel-based electricity (i.e., a consumption-based impact). The impacts of an EPS from a production-based perspective are more uncertain. An EPS might well avoid or delay the construction of new fossil-fired power plants in Montana, to the extent these plants might otherwise be sited in Montana and contracted to meet Montana demands. Its effect on the operation of existing coal plants is less clear, since these plants could well continue to generate and sell more electricity to other states. Other options, such as Incentives for Advanced Fossil Fuel Generation and Carbon Capture and Storage (ES-5) will have a direct focus on reducing emissions from electricity production. In this case, the effects on electricity generation for Montana's consumption is less clear; for example, much of the lower-GHG generation could be exported. For the initial estimates of GHG emission reductions and costs, the approach for calculating emission reductions will depend on the option being evaluated, and will be clearly indicated. As the analysis is refined, CCS will work with the TWG and the CCAC to develop a preferred approach for reporting.

Avoided Electricity Emissions

To estimate emissions reductions from policy options that are expected to displace conventional grid-supplied electricity (i.e., those that reduce grid demand such as efficiency/conservation, renewable energy and combined heat and power) a simple, straightforward approach is used. Through 2010, we assume that these policy options would displace generation from the then-current mix of fuel-based electricity sources. (We assume that sources without significant fuel costs would not be displaced, e.g., hydro or other renewable generation). After 2010, we assume that the policy options under consideration here are likely to avoid or delay new capacity additions, then generation from existing power plants in the event capacity additions are fully avoided.

This approach provides a transparent way to estimate emissions reductions and to avoid double counting (by ensuring that the same MWh from a fossil fuel source is not "avoided" more than once). It also yields results that are consistent with the state-level inventory and forecast developed as part of the CCAC process. It can be considered a "first-order" approach; it does not attempt capture a number of factors such as the distinction between peak, intermediate, and baseload generation; issues in system dispatch and control; impacts of non-dispatchable and intermittent sources such as wind and solar; or the dynamics of regional electricity markets.

These relationships are complex and could mean that policy options affect generation and emissions (as well as costs) in a manner somewhat different than estimated here. Nonetheless, this approach provides reasonable first-order approximations of emissions impacts and offers the advantages of simplicity and transparency that are important for stakeholder processes.

Note that for options that target individual facilities (e.g. ES-5: Advanced Fossil Fuel and Carbon Capture and Storage...), avoided emissions are based directly on the assumed displaced resource (e.g. conventional PC coal plant with no capture).

Reference Case and High Fossil Fuel Case

Two scenarios have been developed for projections of future Montana's GHG emissions from the electric sector and the fossil fuel production sector. The two scenarios acknowledge the significant uncertainty of future energy production in Montana (due to economics and policy actions in Montana, other States, Canada and internationally) – the reference case assumes lower growth in electricity generation and fossil fuel production than the High Fossil Fuel case. The GHG emission reductions associated with several of the Energy Supply options will depend on which scenario is being considered. For example, the High Fossil Fuel case assumes a greater number of coal plants will be developed than in the Reference Case – and this case will have a larger potential to reduce GHG emissions from carbon capture and storage than the reference case. For the relevant options, the GHG emission reductions and costs are reported for both the Reference Case and the High Fossil Fuel case.

Option Implementation – single options vs. combined options assessment

The emissions reduction estimates shown for each option (as well as the economic analyses) presume that each option is implemented alone. Many options, particularly for electricity supply, are related in so far as they target the displacement of the same reference case resources (e.g., growth in emissions from new coal plants), or otherwise have interactive effects. Therefore, if multiple options are implemented, the results will not simply be the sum of each individual option result. For this reason, we will also conduct a “combined policies” assessment to estimate total emission reductions if all policies were to be implemented together.

The combined assessment will consider actions on both sides of the electricity meter. Demand reduction (RCII options that are additional to the energy conservation/efficiency requirements of ES-1) and customer-sited renewable energy (ES-4) reduce requirements for grid electricity; as a result, fewer MWh from renewables are needed to meet the targets described in options ES-1. These interactions will be captured in the ES options analysis during subsequent refinements.

ES-1 Environmental Portfolio Standard (Renewables and Energy Efficiency)

Policy Description

A renewable portfolio standard (RPS) is a requirement that utilities must supply a certain percentage of electricity from an eligible renewable energy source(s). For example, an RPS of 5% would mean that for every 100 kilowatt hours (kWh) that a utility or a “load serving entity” (LSE) supplies to end users, 5 kWh must be generated from renewable resources. An environmental portfolio standard (EPS) expands that notion to include energy efficiency as an eligible resource as well, exchangeable or not depending on design. About 20 states currently have an RPS in place (including Montana), while a handful have implemented an EPS (Washington and Nevada among them). In some cases (as in Montana), utilities can also meet their RPS (or EPS) requirements by purchasing certificates from eligible energy projects, typically referred to as Renewable Energy Certificates (RECs) in the case of RPS policies.

Policy Design

This policy options involves extending the existing RPS to include renewable energy requirements for 2020 and 2025 and requiring utilities to pursue cost-effective end-use energy conservation.¹

Goals:

Each investor-owned and public utility should:

- Meet 20% of its load using renewable energy resources by 2020, increasing to 25% by 2025.
- Implement a plan to achieve 100% of cost-effective energy conservation by 2025.
 - By 2010, identify its achievable cost-effective energy conservation for the subsequent 10 years.
 - Update its energy-efficiency assessment and plan regularly, possibly every two years. *“Energy conservation” refers to both electricity and natural gas.*

Timing: See above.

Parties Involved: Investor-owned utilities, electric cooperatives, Montana PSC, state government.

Other: None Cited.

¹ End-use energy conservation comprises changes at electricity customer sites to both (i) reduce energy used to provide services – such as heating, cooling, illumination, entertainment – through increased energy efficiency of appliances and other technologies and (ii) reduce demand for these services – for example, by turning off unused lights and televisions, turning down thermostats, etc.

Implementation Mechanisms

Volunteer group had the following concerns, which will need to be discussed further:

- Need a way to make sure that the utilities are not punished, rather rewarded, for pursuing energy efficiency. [*CCS note: “decoupling” of utility revenues from the level of utility sales is a strategy for removing this barrier that has been proposed, and in some cases implemented, in other states.*]
- May need special consideration for utilities that have no growth, and hold long-term contracts that lock the utilities in to purchases of specific power supply resources.
- May need to define what is “cost-effective.”
- Consider adjustment of cost cap in existing bill.
- Consider possibility of different standards for cost cap to apply to IOUs and co-operatives.

The TWG noted concerns as to how an RPS could be enforced electric cooperatives (since co-operatives are not regulated by the Public Service Commission). Further discussion regarding enforcement mechanisms for cooperatives is needed.

The CCAC noted that technologies and measures to increase electricity production at existing hydroelectric and other related facilities (irrigation drops, etc.) through turbine additions and upgrades should be considered as eligible for the RPS. (*Rudy/DWR to provide more information through DEQ*)

Related Policies/Programs in Place

Montana’s renewables portfolio standard (RPS), enacted in April 2005 as part of the Montana Renewable Power Production and Rural Economic Development Act, requires public utilities to obtain a percentage of their retail electricity sales from eligible renewable resources according to the following schedule:

- 5% in 2008 through 2009.
- 10% in 2010 through 2014.
- 15% in 2015 and thereafter.

Eligible renewable resources include wind, solar, geothermal, existing hydroelectric projects (10 megawatts or less), landfill or farm-based methane gas, wastewater-treatment gas, low-emission, nontoxic biomass, and fuel cells where hydrogen is produced with renewable fuels. Facilities must begin operation after January 1, 2005, and must either (1) be located in Montana or (2) be in another state and delivering electricity to Montana.

Utilities can meet the standard by entering into long-term purchase contracts for electricity bundled with renewable-energy credits (RECs), by purchasing the RECs separately, or a combination of both. The law includes cost caps that limit the additional cost utilities must pay for renewable energy and allows cost recovery from ratepayers for contracts pre-approved by the Montana Public Service Commission (PSC). RECs sold through voluntary utility green power programs may not be used for compliance. The PSC will develop rules to implement the RPS by June 1, 2006.

The RPS includes specific procurement requirements to stimulate rural economic development. For example, the utilities must buy a portion of the required renewable energy (electricity + credits) from community renewable-energy projects with a maximum individual nameplate capacity of 5 megawatts (MW). These include projects in which local owners have a controlling interest and that are interconnected on the utility's side of the meter. In 2015, these projects must provide a total of at least 75 MW of renewable-energy capacity. In addition, public utilities must enter into contracts that include a preference for Montana workers.² [text expanded based on suggestion from TWG member]

As part of its 1997 restructuring legislation, Montana established its Universal System Benefits Program (USBP).³ Beginning January 1, 1999, all electric utilities began annually contributing 2.4% of their 1995 revenues to the USBP. This is an amount equivalent to \$14.9 million annually, collected at a rate of 1.1 mills per kilowatt-hour. The funds support energy efficiency, renewable-energy resources, low-income energy assistance, and renewable-energy research and development. The distribution of the funds among these programs for NorthWestern Energy (formerly Montana Power Company), the first utility to submit a plan for implementation, was established by the Montana Public Service Commission (PSC) in February 1999:

- Large Customer Rebate – \$2.5 million or 29%.
- Market Transformation – \$1.1 million or 13%.
- Local Conservation – \$1.8 million or 21%.
- Low-Income Assistance (includes energy efficiency measures) – \$1.8 million or 21%.
- Renewable-Energy Resources – \$1.1 million or 13%.
- Research and Development – \$225,000 or 3%.

Already, NorthWestern Energy programs have led to the installation of PV on residences, schools fire stations and commercial facilities throughout the state. NorthWestern Energy funding is also going toward buy-downs for central wind generation facilities. Electric cooperatives and Montana-Dakota Utilities Co. also contribute to the USBP.

Montana's USBP is effective until December 31, 2009, when it is scheduled to "sunset." Utilities may spend all or a portion of the funds on internal programs, or they may opt to contract or fund these programs externally. Large industrial customers with average monthly demand loads exceeding 1,000 kilowatts also fall under the law and may choose to "self-direct" the funds that would normally go to the USBP to internal energy programs.⁴

² See

[://www.dsireusa.org/library/includes/tabsrch.cfm?state=MT&type=RPS&back=regtab&Sector=S&CurrentPageID=7&EE=1&RE=1](http://www.dsireusa.org/library/includes/tabsrch.cfm?state=MT&type=RPS&back=regtab&Sector=S&CurrentPageID=7&EE=1&RE=1).

³ A TWG member reported that the Montana Public Service Commission is considering an increase in Universal System Benefit charges for natural gas utilities. Much of the increase would go toward low-income weatherization (*TWG members and others—please confirm*).

⁴ Database of State Incentives for Renewables and Efficiency, at http://www.dsireusa.org/library/includes/incentive2.cfm?Incentive_Code=MT01R&state=MT&CurrentPageID=1&RE=1&EE=1.

At present, some utilities, including NorthWestern, have shifted some of what were previously USB funds spent on energy efficiency into their rate base, and are thus supporting energy-efficiency programs in the same manner that electricity supply resources are supported.

Type(s) of GHG Benefit(s):

- CO₂: By creating a substantial market in renewable generation and energy efficiency programs, an EPS can reduce fossil fuel use in power generation and thus reduce CO₂ emissions.
- Black Carbon: To the extent that generation from coal and oil would be displaced by renewables, black carbon emissions would decrease.

Estimated GHG Savings and Costs Per Ton:

#	Policy	Scenario/Element	Reductions (MMTCO ₂ e)*			NPV (2007– 2020) \$ Millions	Cost- Effective- ness \$/tCO ₂
			2010	2020	Cumulative Reductions (2007 - 2020)		
ES-1	Environmental Portfolio Standard	Efficiency/Conservation	0.04	1.15	6.6	-\$122	-\$18
ES-1	Environmental Portfolio Standard	Renewable Energy					

* - analyzed on the basis of **consumption-based emissions**, since the EPS is focused on load.

Data Sources, Methods and Assumptions:

• Data Sources:

- Renewable Energy Technology costs from Western Governor's Association 2006 (WGA 2006) *Task Force Reports from the Clean and Diversified Energy Initiative*⁵, Energy Information Administration (EIA) Annual Energy Outlook (AEO),⁶ National Renewable Energy Laboratory.⁷
- Cost effective energy efficiency potential and costs of programs to achieve this potential – NWPC 5th power plan, WGA 2005 – report on energy efficiency
- Other data sources as noted below.

⁵ <http://www.westgov.org/wga/initiatives/cdeac/index.htm>

⁶ <http://www.eia.doe.gov/oiaf/aeo/assumption/index.html>

⁷ http://www.nrel.gov/analysis/power_databook/

- **Quantification Methods:** Analysis of the EPS involves the following steps: (1) estimate the level and costs of cost-effective energy conservation [electricity and gas] that is achievable in Montana (*this information was provided by the RCII TWG's analysis*) (2) identify the type of renewable generation that would most likely be used to meet the renewable energy requirements in 2010, 2015, and 2020; (3) estimate the costs associated with each type of renewable technology; (4) estimate the type, cost and GHG emissions of the conventional generation that would be avoided by the increased energy efficiency and renewable energy [see description in the above "Approach" section on avoided costs and emissions]; and (5) calculate the difference in costs and GHG emissions between the EPS scenario and the reference case.

This option will be analyzed in two stages – the first stage estimates the costs and emission reductions from energy efficiency alone (*from the RCII TWG analysis*), while the second stage considers the costs and reductions from the additional renewable energy generation requirements. Costs and emission reductions are calculated as incremental to the reference case, which includes energy efficiency savings expected from current and planned utility programs and the renewable energy generation to meet the existing Renewable Portfolio Standard (see Related Policies/Programs in Place section below).

- **Key Assumptions:**
 - **Efficiency potential and cost:** See RCII-1.
 - **Renewable energy mix:** It is assumed that the renewable portion of the Montana EPS would be met with a combination of wind and biomass. For this preliminary analysis it is assumed that the renewable mix is made up of 90% wind and 10% biomass. *These are initial estimates and we welcome additional input from the TWG members for this and all other methods and assumptions noted here.*
 - **Renewable energy costs:** The costs of the new renewable systems are based on those used in the EIA Annual Energy Outlook for 2006 (or 2007), except where better (e.g., updated or more local) data are available. The cost of renewable generation includes costs associated with connecting renewable technologies to the electric grid, and transmitting the renewable generation to loads, based on information from the 2006 WGA study. The cost of wind generation also includes costs associated with integrating wind onto the system, and can be based on the studies cited in the WGA CDEAC report.
 - **Production Tax Credit:** For qualifying renewable energy technologies, a federal tax credit of \$18/MWh (inflated) is assumed for the first ten years of operation for new facilities that commence operation by the end of 2010.
 - **Transmission Expansion Costs:** Since many renewable resources are located away from existing transmission lines, additional transmission would likely be needed. Since the precise nature of those additional costs would require calculations beyond the scope of the current analysis, we propose using an

average cost of \$80/kW for all new resources, based on a recent scenario analysis by the WGA CDEAC.⁸ *Montana-specific estimates would be helpful if available.*

- **Reference Technology Costs:** For overall consistency, we use technology costs from EIA’s Annual Energy Outlook (AEO) for 2006.⁹ While recently prices have gone up significantly for wind turbines, as well as for other technologies including coal units due to tight markets and high materials prices, these estimates reflect a longer-term view.

Technology Parameters							
	2010			2020			
Technology	Total Overnight Cost (\$/kW)	Variable O&M (mills/kWh)	Fixed O&M (\$/kW)	Total Overnight Cost (\$/kW)	Variable O&M (mills/kWh)	Fixed O&M (\$/kW)	Project Life (Years)
Biomass	1,780	3.13	48.6	1,696	3.13	46.2	30
Wind	1,171	0	27.6	1,159	0	27.3	25

All costs are expressed in year 2004 dollars and represent expectations as of late 2005.

- **Avoided Costs:** Electricity avoided costs are provisionally based on the levelized value of long-term avoided costs used in NorthWestern Energy's 2005 Electric Default Supply Resource Procurement Plan (\$45 per MWh). *Are there are other studies/values TWG members would suggest for a rough Montana average?*
- **Avoided electricity emissions:** see description in the above “Approach” section on avoided emissions.

Key Uncertainties

None Cited.

Additional Benefits and Costs

None Cited.

Feasibility Issues

None Cited.

Status of Group Approval

⁸ CDEAC Transmission Report in the High Renewables case has an average incremental transmission cost of 80 \$/kW compared to the reference case, i.e. 84,641 MW incremental capacity with additional transmission expansion costs of \$6,786 million.

⁹ Electric Market Module, EIA Assumptions to the Annual Energy Outlook 2006.

Pending.

Level of Group Support

TBD

Barriers to Consensus

TBD

ES-2 Renewable Energy Incentives (Biomass, Wind, Solar, Geothermal)

Policy Description

This policy option reflects financial incentives to encourage investment in renewable energy sources by businesses that sell power commercially (smaller-scale renewable sources are covered in ES-4). These financial incentives for renewables include: (1) direct subsidies for purchasing/selling distributed renewable technologies given to the buyer/seller; (2) tax credits or exemptions for purchasing distributed renewable technologies given to the buyer/seller, (3) feed-in tariffs, which provide direct payments to renewable generators for each kWh of electricity generated from a qualifying renewable facility; (4) tax credits for each kWh generated from a qualifying renewable facility; and (5) regulatory policies that provide incentives and/or assurance of cost recovery for utilities that invest in customer-owned renewable energy systems. The policy could also include R&D funding to support development of distributed renewable technologies.

Policy Design

This option is designed to provide additional support to the renewable portion of the renewable and energy-efficiency portfolio standard in ES-1 by providing incentives for utilities and other potential builders/developers/owners of renewable energy supply facilities and local manufacturers of renewable energy technologies. The goal of this option is to increase the supply of renewable energy and reduce its cost. This option is designed to support facilities that sell power commercially (as opposed to, for example, consumer-sited facilities that sell power to the grid via net metering—the latter facilities are covered under ES-4).

Goals: Renewable generation goals are same as ES-1.

Timing: Implement in a time frame that best supports ES-1. Since renewable goals for ES-1 will start in 2008, incentives are needed as soon as practicable. Changes to legislation will need to wait until end of 2009.

Parties Involved: Under Development.

Other: None Cited.

Implementation Mechanisms

Could include the following:

- Tax policies, production tax credits (federal), PURPA requirements (Montana has mini-PURPA law).
- Recent change in property tax specification for wind projects could be expanded to other renewable forms of generation as appropriate.
- Incentives for locating manufacturing plants in the state for renewable generation, with potential sunset provisions as industries mature in Montana.
- Incentives for technologies that support improved integration of intermittent (e.g. wind) resources, including but not limited to advanced storage technologies.

- Target incentives to community wind projects.

Related Policies/Programs in Place

Related policies and programs include:

- **Retail Green Power (69-8-210(6) MCA)** - NorthWestern Energy must offer customers an opportunity to purchase a separately marketed (and possibly differently priced) product composed of power from biomass, wind, solar or geothermal resources.
- **Universal System Benefits Programs (69-8-402 MCA)** - All distribution utilities and cooperatives must collect a Universal System Benefits Charge (USBC), which is used for renewable energy programs, as well as low-income assistance and weatherization, energy efficiency, and R&D programs. Beginning January 1, 1999, 2.4% of each utility's annual retail sales revenue in Montana for the calendar year ending December 31, 1995, was established as the initial funding level for universal system benefits programs. The USBC will remain into effect until December 31, 2009. Utilities, cooperatives and large customers can self-direct their funds to approved internal programs. NorthWestern Energy's, annual USBC collection is around \$8.5 million, and they have funded small and utility scale wind projects and a number of photovoltaic installations.
- **Consumer protection (69-8-403(7) MCA)** - The Public Service Commission requires suppliers to substantiate any claims that their energy is from renewable resources.
- **Net metering (69-8-601 et seq. MCA)** - Net metering is an arrangement that allows surplus energy generated by the customer's renewable energy system to go back on the utility electric system. The customer receives "credit" at retail rates for the electricity put back on the system, up to the amount of power the customer actually consumes at his location. Only NorthWestern Energy is required by legislation to offer net metering. Montana-Dakota Utilities and some rural electric cooperatives are voluntarily offering net metering; terms of the offer vary by utility and can differ from these legislative requirements.
- **Tax incentives for renewable energy:** A variety of tax incentives are available for individuals and businesses. A summary can be found at:
<http://deq.mt.gov/Energy/Renewable/TaxIncentRenew.asp>

Types(s) of GHG Reductions

See ES-1.

Estimated GHG Reductions and Costs (or Cost Savings)

Not Quantified.

As noted above, this option supports the achievement of the renewable energy targets articulated in ES-1. To the extent incentives are able to enable exceedance of these targets, there may be additional emission reductions and costs (or savings).

Key Uncertainties

None Cited.

Additional Benefits and Costs

None Cited.

Feasibility Issues

None Cited.

Status of Group Approval

Pending.

Level of Group Support

TBD

Barriers to Consensus

TBD

ES-3 Research and Development (R&D), Including R&D for Energy Storage and Advanced Fossil Fuel Technologies

Policy Description

R&D funding can be targeted toward a particular technology or group of technologies as part of a state program with a mission to build an industry around that technology in the state and/or to set the stage for adoption of the technology for use in the state. For example, an agency can be established with a mission to help develop and deploy energy storage technologies. R&D funding can also be made available to any renewable or other advanced technology through an open bidding procedure (i.e., driven by bids received rather than by a focused strategy to develop a particular technology). Funding can also be given for demonstration projects to help commercialize technologies that have already been developed but are not yet in widespread use. Funding could be provided to increase collaboration between existing institutions for R&D on technologies.

Policy Design

This policy could include efforts to:

- Seek partners for, and aim to attract, federal R&D funding for high-altitude IGCC demonstration project in Montana as authorized by the Energy Policy Act of 2005. Consider FutureGen process as a potential source of lessons on how to develop and succeed at funding a demonstration project. (TWG member notes that demonstration projects are typically located nearby to active R&D programs.)
- Establish emerging energy technology program in Montana university system, attract federal R&D funding, grow technology expertise, issue advanced degrees, and aim for resulting “multiplier” benefits. Consider elements of the Big Sky Sequestration Partnership as a model. Choose areas for R&D that match well with the Montana resource base. Target, among other technologies, carbon sequestration technologies, compressed air, and other storage technologies to increase penetration of intermittent renewable energy (including wind power) and direct carbon fuel cells.
- Create a small pool of state funding for R&D efforts. Even though overall volume would be limited, it could have important symbolic value and help leverage larger amounts of external funding. Consider such funding for the university program and/or the Big Sky Sequestration partnership.
- Seek industry participation and contributions (e.g. licensing fees) to help pay for R&D activities.
- Make available the results of R&D and pilot programs to inform industrial development.
- Use coal severance tax to fund research and development programs (per above) in clean energy technologies, including clean coal, sequestration, and compressed air storage, among others. (Note legislation HB 715 currently pending)

Goals: Under Development.

Timing: Under Development.

Parties Involved: Under Development.

Other: None Cited.

Implementation Mechanisms

Under Development.

Related Policies/Programs in Place

- **Big Sky Sequestration Partnership (BSCSP)** - Led by Montana State University, BSCSP is one of the U.S. Department of Energy's (DOE) seven regional partnerships. BSCSP goal is to develop infrastructure to support and enable future carbon sequestration carbon sequestration field tests and deployment in Montana, Idaho, Wyoming, Washington, and Oregon.
- **Zero Emission Research and Technology Center (ZERT)** - is a partnership involving Montana State University, as well as DOE laboratories and West Virginia University. ZERT is a research collaborative focused on understanding the basic science of underground (geologic) carbon dioxide storage to mitigate greenhouse gasses from fossil fuel use and to develop technologies that can ensure the safety and reliability of that storage.
- **FutureGen** - is a public-private partnership to design, build, and operate the world's first coal-fueled, near-zero emissions power plant, at a cost exceeding US\$1 billion. The commercial-scale plant will prove the technical and economic feasibility of producing low-cost electricity and hydrogen from coal while nearly eliminating emissions. Two candidate sites in both Illinois and Texas are being evaluated for siting of the FutureGen project.

Types(s) of GHG Reductions

Under Development.

Estimated GHG Reductions and Costs (or Cost Savings)

Not Quantified. As it is difficult to predict the direct impact of R&D programs on greenhouse gas emissions, the emissions reduction resulting from this option will not be quantified, though a rough estimate of option cost is desirable.

Key Uncertainties

None Cited.

Additional Benefits and Costs

None Cited.

Feasibility Issues

None Cited.

Status of Group Approval

Pending

Level of Group Support

TBD

Barriers to Consensus

TBD

ES-4 Incentives and Barrier Removal (Including Interconnection Rules and Net Metering Arrangements) for Combined Heat and Power (CHP) and Clean Distributed Generation (DG)

Policy Description

This option is focused on CHP and DG located on-site at consumer facilities that do not sell power commercially. There are numerous barriers to CHP and clean DG, including inadequate information, institutional barriers, high transaction costs because of small projects, high financing costs because of lender unfamiliarity and perceived risk, “split incentives” between building owners and tenants, and utility-related policies like interconnection requirement, high standby rates, exit fees, etc. The lack of standard offer or long-term contracts, payment at avoided cost levels, and lack of recognition for emissions reduction value provided also creates obstacles. Policies to remove these barriers include: improved interconnection policies, improved rates and fees policies, streamlined permitting, recognition of the emission reduction value provided by CHP and clean DG, financing packages and bonding programs, power procurement policies, education and outreach, etc.

Policy Design

Key elements of design for this CHP/DG incentives and barrier removal policy include:¹⁰

- Create standardized interconnection rules for CHP and DG systems to increase investor and developer certainty and predictability and reduce transaction costs.¹¹
- Consider offering different interconnection and net metering rules for smaller (residential-size, 5-10 kW) systems, as it might be easier for cooperatives to agree on a standard for these systems than for larger systems.
- Remove barriers to the adoption of CHP and DG systems by customers of Montana utilities, including electric coops, while taking into account the potential impact that net metering may have on cross-subsidies between consumers.
- Increase incentives for installing CHP and DG systems. (Note that a bill is currently before the legislature that would double incentives for residential systems.)
- **Improve or expand the existing rotating fund** (supported by air pollution non-compliance fees¹²) to defray some of initial costs of CHP and DG systems.

¹⁰ Two papers on the topic of reducing barriers to CHP and DG in Montana have been referenced in TWG discussions. These are [Reducing Market Barriers to Small-Scale Distributed Generation in Montana](#), and [Reducing Regulatory Barriers to Small-Scale Distributed Generation in Montana](#), both dated May, 2004, and prepared for the Montana Department of Environmental Quality by Thomas Yoder and Brian Gurney of the Center for Applied Economic Research Montana State University – Billings. These are available on the MT Energy Supply TWG website, at http://www.mtclimatechange.us/Energy_Supply.cfm.

¹¹ The Montana Public Service Commission is currently considering interconnection rules in accordance with EAct 2005 (Energy Policy Act of 2005) requirements.

- Encourage the development of a set of state-issued licenses for renewable energy system technicians and installers. These licenses would be separate from existing electricity and plumbing trade licenses, and would be tailored to the renewable energy industry, covering, for example, DC electricity wiring and roofing skills related to installation of solar PV, solar hot water, and other renewable energy systems, as well as safety concerns related to system installation. The State licensing of renewable energy technicians/installers will increase consumer confidence in renewable energy contractors.

Goals: The goals will be determined based on the assessment of CHP and DG potential in the state. See assumptions below.

Timing: Under Development.

Parties Involved: Under Development.

Other: None Cited.

Implementation Mechanisms

None Cited.

Related Policies/Programs in Place

Montana Financial Incentives

- **Alternative Energy Investment Corporate Tax Credit (15-32-401)** - Commercial and net metering alternative energy investments of \$5,000 or more are eligible for a tax credit of up to 35% against individual or corporate tax on income generated by the investment.
- **Residential Alternative Energy System Tax Credit (15-32-201)** - Residential taxpayers who install an energy system using a recognized non-fossil form of energy on their home after 12/31/01 are eligible for a tax credit equal to the amount of the cost of the system and installation of the system, not to exceed \$500. The tax credit may be carried over for the next four taxable years.
- **Residential Geothermal Systems Credit (15-32-115)** - A resident taxpayer of Montana who installs a geothermal heating or cooling system in their principal dwelling can claim a tax credit based on the installation costs of the system, not to exceed \$1,500.
- **BEF - Renewable Energy Grant** - Using revenues generated from the sales of Green Tags, Bonneville Environmental Foundation (BEF), a not-for-profit organization, accepts proposals for funding for renewable energy projects located in the Pacific Northwest (OR, WA, ID, MT). Any private person, organization, local or tribal government located in the Pacific Northwest may participate. Projects that generate electricity are preferred. Acceptable projects include solar photovoltaics, solar thermal electric, wind, hydro, biomass and animal waste-to-energy.

¹² Another reference to this option noted by the TWG is Distributed Energy Generation, Benefits, Barriers and Best Practices, Report to the 60th Legislature Energy and Telecommunications Interim Committee, dated September 2006, prepared by Casey A. Barrs, and available at [http://leg.mt.gov/content/committees/interim/2005_2006/energy_telecom/staff_reports/DEG_consolidated_8-21-06%20\(2\).pdf](http://leg.mt.gov/content/committees/interim/2005_2006/energy_telecom/staff_reports/DEG_consolidated_8-21-06%20(2).pdf).

- **BEF - Solar 4R Schools** – This program began in 2002 to install small-scale solar systems at schools interested in increasing the visibility of renewable energy. BEF will generally completely fund or supply 1.1 kW system installations, fund up to 33% of other larger renewable energy projects, and provides curriculum modules developed for schools. The school agrees to own and maintain the solar system, provide access to the system, and implement an educational outreach strategy.
- **Corporate Property Tax Reduction for New/Expanded Generating Facilities (15-24-1402)** - Montana generating plants producing 1 MW or more by means of an alternative renewable energy source are eligible for the new or expanded industry property tax reduction. If approved, by the local government, the facility is taxed at 50% of its taxable value in the first five years after the construction permit is issued. Each year thereafter, the percentage is increased by equal percentages until the full taxable value is attained in the tenth year.
- **Generation Facility Corporate Tax Exemption (15-6-225)** - New electricity generating facilities built in Montana with a nameplate capacity of less than 1 MW and using an alternative renewable energy source are exempt from property taxes for 5 years after start of operation
- **Renewable Energy Systems Exemption (15-6-224 and 15-32-102)** - Montana's property tax exemption for recognized non-fossil forms of energy generation or low emission wood or biomass combustion devices may be claimed for 10 years after installation of the property. The exemption is allowed for single-family residential dwellings up to \$20,000 in value and for multifamily residential dwellings or a nonresidential structure up to \$100,000 in value.
- **Alternative Energy Revolving Loan Program (AERLP) (75-25-101)** - provides loans to individuals, small businesses, local government agencies, units of the university system, and nonprofit organizations to install alternative energy systems that generate energy for their own use. The program is funded by air quality penalties collected by the Department of Environmental Quality. In 2005, SB 50 amended the loan program, increasing maximum loan amount to \$40,000 (subject to available funds) and extending the repayment period to ten years. Interest rates are set annually and are fixed for the term of the loan. The rate for 2006 is 5.0%.

Montana Rules, Regulations and Policies

- **Interconnection Standards (69-8-604)** - Montana's net metering legislation, enacted in 1999, requires interconnected facilities to comply with all national safety, equipment and power-quality standards. NorthWestern Energy (Montana Power) has published a standard interconnection agreement for net-metered facilities; the agreement includes language on the technical requirements for interconnecting. Technical language mirrors the state law requirements with respect to national standards but also requires a manual, lockable, external disconnect switch. NorthWestern does not require system owners to purchase additional liability insurance, but encourages system owners to confirm with their insurance provider the limits of coverage applicable to interconnected systems.
- **Net Metering (69-8-601)** - allows customers of investor-owned utilities to net meter systems that generate electricity using solar, wind or hydropower systems up to 50 kilowatts (kW).

All customer classes are eligible, and no limit on enrollment or statewide installed capacity is specified. Utilities may not require customer-generators to comply with any additional standards or requirements beyond those established by the National Electric Code, National Electrical Safety Code, Institute of Electrical and Electronic Engineers (IEEE), and Underwriters Laboratories (UL). Net excess generation (NEG) is credited to the customer's next monthly bill. At the beginning of each calendar year, any remaining unused kilowatt-hour (kWh) credit accumulated during the previous year is granted to the utility.

- **Electric Cooperatives - Net Metering** - The Montana Electric Cooperatives' Association (MECA) developed and adopted a model Interconnection of Small Customer Generation Facilities policy in 2001. The model policy includes guidelines for net metering, which have been adopted in whole or part by most of the 26 electric cooperatives in Montana.

Type(s) of GHG Benefit(s):

- **CO₂**: By providing a financial incentive for renewable generation, more renewable facilities would be installed and more electricity from renewables would be generated. This very-low-carbon generation would displace generation from conventional fossil fuel generation leading to CO₂ reductions.
- **Black Carbon**: To the extent that generation from coal would be displaced by renewables, black carbon emissions would decrease.

Estimated GHG Savings and Costs Per Ton:

#	Policy	Scenario	Reductions (MMTCO ₂ e)*			NPV (2007– 2020) \$ millions	Cost- Effective- ness \$/tCO ₂
			2010	2020	Cumulative Reductions (2007 - 2020)		
ES-4	Incentives for Renewable DG						
ES-4	Incentives for CHP						

* - analyzed on the basis of **consumption-based emissions**, since this option reduces load, and does not directly affect decisions about new capacity additions in Montana.

Data Sources, Methods and Assumptions (for quantified actions):

a) Renewable Distributed Generation (customer-sited renewable energy)

- **Data Sources:**
- **Quantification Methods:**
- **Key Assumptions:**

- **Goals/Potential:** The following two sources provide potential targets/goals for rooftop solar photovoltaic (PV) systems.
 - Montana’s share of Million Solar Roofs initiative - 1500 systems by 2020, each system about 3 kW, so 4.5 MW by 2020.¹³
 - Montana’s share of WGA’s *Clean and Diversified Energy Initiative* target for 4,000 MW of distributed PV by 2015 – this is estimated at 40 MW by 2015.¹⁴
- **PV performance:** Average capacity factor of PV systems is conservatively assumed to be 25%.
- **PV Technology costs:** from Western Governor’s Association 2006 (WGA 2006) *Task Force Reports from the Clean and Diversified Energy Initiative*¹⁵, Energy Information Administration,¹⁶ or National Renewable Energy Laboratory.¹⁷;
- **Avoided costs:** See ES-1 above, also accounting for avoided transmission and distribution costs.
- **Avoided electricity emissions:** See description in the above “Approach” section on avoided emissions.

b) CHP

- **Data Sources:**

- The *Combined Heat and Power White Paper*, dated January, 2006, to the Clean and Diversified Energy Initiative of the Western Governors Association; and the *2003 Commercial Buildings Energy Consumption Survey Detailed Tables*, published by the US Department of Energy's Energy Information Administration.
- The report *A Balanced Energy Plan for the Interior West* from the Western Resource Advocates provides an alternative estimate for CHP potential in Montana.¹⁸

- **Quantification Methods:** Starting with an estimate for Montana’s share of CHP potential in the West, as provided in the “CHP White Paper” referenced above, assumptions regarding the penetration of and fuel shares for new CHP systems, and estimates of future capacity of CHP developed under the policy, are generated. Estimates of CHP cost and performance for different kinds of systems are then used to estimate the overall net GHG emissions reduction and net cost of the policy.

- **Key Assumptions:** Key assumptions are that CHP potential in Montana but the data sources are showing variation in this value 470 MW (per the WGA/CDEAC source above) or 1092

¹³ Personal communication, Pat Judge MEIC and Chris Daum, Oasis Montana, February 2007.

¹⁴ *Clean and Diversified Energy Initiative, appendix II*

¹⁵ <http://www.westgov.org/wga/initiatives/cdeac/index.htm>

¹⁶ <http://www.eia.doe.gov/oiaf/aeo/assumption/index.html>

¹⁷ http://www.nrel.gov/analysis/power_databook/

¹⁸ <http://www.westernresourceadvocates.org/energy/clenergy.php>

MW (per Western Resource Advocates); this potential grows with commercial and industrial loads; and the potential and can be realized at a rate of about 2-3% of total potential per year.. Gas-fired systems are assumed to dominate new CHP, but some biomass- and coal-fired capacity is also assumed. Systems are assumed to operate an average of 5000 hours per year (at full capacity), and 90 percent of co-generated heat is assumed to be usable (and displaces heat from purchased fuels).

- **Avoided costs:** See ES-1 above.
- **Avoided electricity emissions:** See description in the above “Approach” section on avoided emissions.

Key Uncertainties

None Cited.

Additional Benefits and Costs

None Cited.

Feasibility Issues

None Cited.

Status of Group Approval

Pending.

Level of Group Support

TBD

Barriers to Consensus

TBD

ES-5 Incentives for Advanced Fossil Fuel Generation and Carbon Capture and Storage (CCS), Including Combined Hydrogen and Electricity Production with Geological Carbon Sequestration

Policy Description

Advanced fossil technologies produce fewer CO₂ emissions per kWh as the result of more efficient generating technologies (supercritical coal, integrated gasification combined cycle, etc.) and/or carbon capture and sequestration or reuse (CCSR), either before or after fuel combustion.

Policies for advanced fossil technologies can include regulations or incentives to promote advanced technologies for new coal or natural gas plants. A technology regulation might require that new coal plants achieve a certain CO₂ emission rate. Incentives may be in the form of direct subsidies, assistance in securing financing and/or off-take agreements, or guarantee cost recovery for prudently incurred utility investments.

Policy Design

This policy option would:

- Directs DEQ or direct the State to enter into a regional collaborative effort to develop standards and protocols for CCSR.

There is ongoing discussion in the CCAC and TWG as to whether and how to proceed with the following. A “cross-option” CCSR discussion may be pursued as a way to resolve these and other questions.

- Strengthen the Major Facility Siting Act to enable eminent domain for pipelines to transport CO₂ and protect landowners with appropriate siting requirements.
- Provide tax exemptions for CCSR technologies/equipment (as in SB 105 or in Governor’s tax proposal). (*One TWG member notes the speculative nature of this technology will require tax incentives, others note that tax policy is only one of government’s tools in providing incentives.*)
- Establish moratorium on pulverized/fluidized-bed coal plants until post-combustion CCS is demonstrated to be technically and economically feasible, or establish moratorium period of 5-10 years.
- Create requirement that IGCC plants must sequester carbon within [3-5] years of initial operation.
- Direct state to assume liability for carbon capture and storage. (*A TWG member suggests that a liability fund be created with payments by CCS users, similar to Superfund, rather than leaving full liability to the State.*)

Goals: None yet specified. Quantification of this option will investigate at the potential emissions and cost consequences of implementing CCS for new facilities anticipated under the GHG forecast (and the high fossil scenario.)

Timing: TBD

Parties involved: TBD

Other: None Cited.

Implementation Mechanisms

None Cited.

Related Policies/Programs in Place

None identified.

Type(s) of GHG Benefit(s):

- CO2: Reductions in CO2 emissions can be achieved by encouraging more efficient generation and/or through carbon capture and storage.
- Black Carbon: Similarly, all other air emissions could decrease, especially with coal gasification and/or carbon capture and storage, since combustion is avoided.

Estimated GHG Savings and Costs Per Ton:

#	Policy	Scenario	Reductions (MMTCO ₂ e)*			NPV (2007– 2020) \$ Millions	Cost- Effective- ness \$/tCO ₂
			2012	2020	Cumulative Reductions (2007-2020)		
ES-5	Advanced Coal/Fossil Technologies	Reference Case					
ES-5	Advanced Coal/Fossil Technologies	High Fossil Case					

* - analyzed on the basis of **production-based emissions**, since the EPS is focused on load.

Data Sources, Methods and Assumptions (for quantified actions):

Absent a clear policy design for this options (so far), the quantification of this option is illustrative. We simply consider the possible costs and emissions savings associated with introducing CCSR technologies under the reference case and high fossil case scenarios, under the assumptions noted below.

- **Data Sources:** These are likely to include:

- The recently released MIT report, “The Future of Coal” (2007)¹⁹ provides estimates of costs and emissions savings from various coal technologies with and without carbon capture and storage.
- The IPCC Special Report on Carbon Dioxide Capture and Storage (2006)²⁰ which provides other estimates, including rough estimates of the costs of CO₂ transport and storage.
- EPA report, "Environmental Footprints and Costs of Coal-Based Integrated Gasification Combined Cycle and Pulverized Coal Technologies," July 2006, which contains cost and performance estimates for various coal plant types and CO₂ capture, accounting also for high elevation issues with IGCC as might be encountered in Montana.
- Advanced Coal Task force report and spreadsheets from Western Governor’s Association 2006 (WGA 2006) *Clean and Diversified Energy Initiative*²¹
- **Quantification Methods:** The following possibilities could be analyzed:
 - **New coal plants:** All new coal generation from [20xx] onwards would be provided by CCSR-capable technologies instead of conventional coal plants. If the requirement was set to begin in 2010, new coal capacity by 2020 would amount to about 400 MW in the reference case and 2,000 MW in the high fossil case.
 - **Existing coal plants:** All existing coal plants are retrofitted/rebuilt with CCSR technologies as of 20[xx]. (Note in some cases it may be as costly to retrofit as to rebuild, per MIT (2007) and others.)
- **Key Assumptions:** The key assumptions include:
 - **Projected levels of new coal builds.** See the inventory/forecast documentation. An implicit assumption is that support, incentives, and/or requirements for advanced coal and CCSR will not affect the overall amount of coal builds in Montana.
 - **Timing of carbon capture and storage.**
 - **Newly-built plants.** CCSR would commence at new coal plants as of [20xx or date of operation].
 - **Existing coal plants.** CCSR would commence at existing coal plants as of [20xx].
 - **Costs and operational characteristics of advanced coal and capture technologies.**

¹⁹ <http://web.mit.edu/coal/>

²⁰ <http://www.ipcc.ch/activity/srccs/index.htm>

²¹ <http://www.westgov.org/wga/initiatives/cdeac/index.htm>

- **Capital and O&M costs:** See above. Ranges of cost per tonne CO₂ avoided can be drawn from MIT, IPCC, and EPA studies noted above, or more detailed bottom-up calculations can be made based on technology cost estimates (for advanced vs. avoided conventional technologies), taking into account Montana-relevant factors (e.g. coal quality, elevation, etc.).
- **Fraction of CO₂ captured:** 90% assumed, as in MIT and other studies.
- **Capacity factor:** 85% capacity factor in all cases.
- **Costs of CO₂ transport and storage.** The IPCC report provides some rough cost ranges for storage and for transport as a function of distance and volume, which could suffice for a very broad estimate.
- **Costs and operational characteristics of avoided coal technologies.** If the bottom-up approach is chosen per above, Estimates can be drawn from EPA (2006) and EIA (AEO2006 or AEO2007), unless Montana-specific estimates are found and preferred.

Key Uncertainties

None Cited.

Additional Benefits and Costs

None Cited.

Feasibility Issues

None Cited.

Status of Group Approval

Pending.

Level of Group Support

TBD

Barriers to Consensus

TBD

ES-6 Efficiency Improvements and Repowering of Existing Plants

Policy Description

Efficiency improvements refer to increasing generation efficiency at power stations through incremental improvements at existing plants (e.g., more efficient boilers and turbines, improved control systems, or combined cycle technology). Repowering existing power plants refers to switching to lower or zero emitting fuels at existing plants, or for new capacity additions. This includes co-firing biomass at coal plants fuels or the use of natural gas in place of coal or oil. Policies to encourage efficiency improvements and repowering of existing plants could include incentives or regulations as described in ES-5 above, with adjustments for financing opportunities and emission rates of existing plants.

Policy Design

The TWG suggests that this option be made a lower priority for the time being, pending further consideration of the potential for the CCAC process to contribute to efficiency improvements. A TWG member noted that generation owners and operators are constantly reviewing options for improving the efficiency of generation, and suggested that State actions might do little to provide further incentives for (or reduce disincentives for) investments in repowering.

Goals: Under Development.

Timing: Under Development.

Parties involved: Under Development.

Other: None Cited.

Implementation Mechanisms

None Cited.

Related Policies/Programs in Place

None identified.

Types(s) of GHG Reductions

Under Development.

Estimated GHG Reductions and Costs (or Cost Savings)

Not Quantified.

Key Uncertainties

None Cited.

Additional Benefits and Costs

None Cited.

Feasibility Issues

None Cited.

Status of Group Approval

Pending.

Level of Group Support

TBD

Barriers to Consensus

TBD

ES-7 Demand-Side Management

(RCII TWG will take lead for analysis, with ES TWG providing review)

The option developed by the RCII TWG, RCII-1, uses the same policy design as the energy efficiency portion of ES-1 (see above).

ES-8 CO₂ tax

(To be considered jointly with RCI TWG.)

Policy Description

A CO₂ tax would be a tax on each ton of CO₂ emitted from an emissions source covered by the tax. A CO₂ tax could be imposed upstream based on carbon content of fuels (e.g. fossil fuel suppliers) or at the point of combustion and emission (e.g., typically large point sources such as power plants or refineries). Taxed entities would pass some or all of the cost on to consumers, change production to lower emissions, or a combination of the two. As the suppliers respond to the tax, consumers would see the implicit cost of CO₂ emissions in products and services, and would adjust their behavior to purchase substitute goods and services that result in lower CO₂ emissions. CO₂ tax revenue could go completely to state revenue and be used in a variety of ways such as income tax reduction or policies and programs to assist with CO₂ reductions. CO₂ tax revenue can also be directed to helping the competitiveness of industries or assisting communities most affected by the tax.

Various carbon tax policies in place are summarized in Appendix B.

Policy Design

A simple and largely qualitative comparison of national CO₂ tax and cap-and-trade (see ES-9) will be undertaken to better understand their different implications.

The TWG feels that the appropriate scale for implementing a CO₂ tax would be at the national level. One design element that the TWG may consider is a recommendation that Montana's representatives in the US Congress should be encouraged to work with colleagues toward establishment of a national carbon tax.

Some TWG members also suggest consideration of a small tax (such as in Boulder Colorado) to provide funding for some of the CCAC's strategies (e.g., education). *Note this may be considered under the cross-cutting TWG.*

(Note: Note that carbon tax is under consideration by the RCII TWG and that a combined volunteer group is being considered to explore this option as well as the cap-and-trade option below.)

Goals: None identified.

Timing: None identified

Parties Involved: Under Development.

Other: None Cited.

Implementation Mechanisms

Mechanisms for implementing a carbon tax might include:

- Offsets on income tax returns to help make the tax “revenue neutral.”
- Different tax configurations might be implemented.
- A carbon tax would likely be implemented at the fuel supplier level although other configurations are possible.

Related Policies/Programs in Place

None identified.

Types(s) of GHG Reductions

Under Development.

Estimated GHG Reductions and Costs (or Cost Savings)

Not quantified.

Key Uncertainties

None Cited.

Additional Benefits and Costs

Benefits

Carbon dioxide emissions reductions will typically be accompanied by reductions in the emissions of other air pollutants.

Costs

There is a concern that a Montana-only CO₂ tax would put the state at a competitive disadvantage for attracting and retaining businesses.

Feasibility Issues

None Cited.

Status of Group Approval

Pending.

Level of Group Support

TBD

Barriers to Consensus

TBD

ES-9 GHG Cap- and-Trade

Policy Description

A cap-and-trade system is a market mechanism in which GHG emissions are limited or capped at a specified level, and those participating in the system can trade permits (a permit is an allowance to emit one ton of CO₂). By allowing trading, participants with lower costs of compliance can choose to over-comply and sell their additional reductions to participants for whom compliance costs are higher. In this fashion, overall costs of compliance are lower than they would otherwise be.

For every ton of CO₂ released, an emitter must hold an allowance. Therefore, the number of allowances issued or allocated is, in effect, the cap. The government can give allowances away for free, auction them, or some combination of the two. Participants can range from a small group within a single sector to the entire economy. The compliance obligation can be imposed “upstream” (at the fuel extraction or import level) or “downstream” at points of fuel consumption.

Among the important considerations with respect to a cap-and-trade program are: the sources and sectors to which it would apply; the level and timing of the cap; how allowances would be distributed (e.g., whether load-based or generation-based, how new market entrants are accommodated, how leakage is addressed, etc.); **how allowances would be reduced over time**; what if any offsets would be allowed; over what region the program would be implemented (e.g., nationally, regionally, etc.); and whether compliance with the cap could be achieved given leakage from non participating states and coal-fired generation located on tribal lands that would not be subject to the state-imposed cap. Other issues to consider include which GHGs are covered; whether there is linkage to other trading programs; banking and borrowing; early reduction credit; what, if any, incentive opportunities may be included; use of any revenue accrued from permit auctions; and provisions for encouraging energy efficiency.

The principal example of a GHG cap-and-trade system in the US today is the Northeast States’ Regional Greenhouse Gas Initiative: <http://www.rggi.org/>.

Policy Design

The CCAC is [supportive] of the implementation of a GHG cap-and-trade system (or a CO₂ tax per ES-8) at the national level. It may also be desirable for Montana to participate in regional cap-and-trade program, such as the five-state initiative (Western Climate Agreement)²² currently under development.

Potential cap-and-trade configurations will be assessed in a general, non-quantitative fashion, recognizing that the large number of uncertainties regarding the many important design

²² http://www.governor.state.az.us/dms/upload/NR_022607_WesternClimateAgreementFinal.pdf

parameters (participating states, sector and source coverage, targets and timing, allocation methods, and rules regarding offsets, safety valves, and/or banking and borrowing, among others). The purpose of this assessment is to provide general input to the TWG process, not to define the details of a prospective regulatory program.

Cap-and-trade options should be explored on a regional basis (e.g., with West Coast and/or Intermountain states) as well, but not on a Montana-alone basis.²³ Such a system should:

- Cover electricity generation and other large point sources.
- (Possibly) credit all relevant GHG emissions reduction and sequestration measures, including carbon capture and storage. *(Note that the TWG is not agreed on this point. The maturity of geological sequestration technology as well as monitoring was questioned.)*

One design element that the TWG may consider is a recommendation that Montana should ask its congressional delegation to support cap-and-trade (or CO₂ tax, depending on the outcome of further deliberations) nationwide.

Goals: The analysis will consider the implications for Montana of:

- Participation in a national cap-and-trade system (configuration TBD)
- Participation in a Western regional cap-and-trade system (configuration TBD)

Timing: Under Development. CCAC notes that adequate “ramp up” time will be an important consideration.

Parties Involved: Under Development.

Other: None Cited.

Implementation Mechanisms

None Cited.

Related Policies/Programs in Place

None identified.

Types(s) of GHG Reductions

Under Development.

Estimated GHG Reductions and Costs (or Cost Savings)

Not Quantified.

Key Uncertainties

None Cited.

Additional Benefits and Costs

None Cited.

Feasibility Issues

²³ A model rule for application of a Cap-and-Trade system for the East Coast states is currently in place (www.rggi.org). Issues associated with Cap-and-Trade systems include distribution of allowances.

None Cited.

Status of Group Approval

Pending.

Level of Group Support

TBD

Barriers to Consensus

TBD

ES-10 Generation Performance Standards or GHG Mitigation Requirements for New (and/or Existing) Generation Facilities, with/without GHG Offsets

Policy Description

A generation performance standard (GPS) is a mandate that requires that load serving entities (LSE) to acquire electricity (e.g., in CA), or that power plant developers build and operate new generation (e.g., in OR and WA), with an emission rate (e.g., X lbs CO₂/MWh) below a specified mandatory standard. In some cases, GHG offsets or credits can be used for compliance (e.g., OR and WA). GHG offsets are GHG emission savings from project-based activities in sectors or regions not covered by the standard or regulations, which typically need to meet specific criteria laid out in the regulation.

A market-based variation of a GPS would allow generators with emission rates lower than the GPS to sell their extra “credits” to generators with emission rates higher than the GPS.

A third variation of a GPS is to establish the standard and allocate allowances based on that standard every year. In this variation, as electricity generation increases, plants would receive more permits. Utilities could trade permits in order to achieve the standard, but there would be no fixed cap on emissions. This variation provides a financial incentive (via the trading) for generators to reduce emissions so that they can sell unneeded permits to generators who have high emissions.

Various GPS policies in place are summarized in Appendix A.

Policy Design

The state would implement Greenhouse Gas Emission Performance Standards, and align these standards to the extent possible with those adopted in California and under consideration in Washington State. These standards would establish a maximum GHG emission rate for long-term financial commitments to electrical generating resources by load-serving entities, and would apply to both in-state and imported electricity (see table below, “Survey of Greenhouse Gas Standards in Other States”).²⁴

Another option is to establish a Carbon Dioxide Emission Standards for New Energy Facilities built in the state of Montana, similar to the standards adopted in Oregon and Washington (see table below). The CCAC indicates a preference for the GHG emission performance standards approach above, but suggests keeping OR/WA standards approach under consideration as well, potentially as a complementary measure.

Note that this option will complement and work with options ES-8 and ES-9.

Goals: Establish a GHG emissions performance standard that:

²⁴ A bill before the Montana Legislature follows the performance standards approach recently implemented in Oregon. The Oregon approach has been voluntarily adopted in the permitting of at least one recently-proposed generation facility in Montana.

- Applies to new long-term financial commitments to baseload electricity generation by load-serving entities.
- Is equal to or less than a new, combined-cycle natural gas power plant. (The value of 1100 lbs of CO₂e/MWh has been proposed for CA.)
- Ensures no reduction in energy supply reliability.
- Is based on net emissions from electricity production.
- Does not count CO₂ stored in geologic formations as emissions from the power plant.
- *Allows for added return where applicable (1/2-1%) for zero- or low-carbon generating resources.*

Timing: TBD (assume for now XXXX)

Parties involved: Under Development.

Other: None Cited.

Implementation Mechanisms

None Cited.

Related Policies/Programs in Place

None identified.

Type(s) of GHG Benefit(s):

- CO₂: A GPS program would directly target reductions CO₂ emissions.
- Black Carbon: To the extent that generation from coal and oil would decline under a GPS program, black carbon emissions would also decrease.

Estimated GHG Savings and Costs Per Ton:

#	Policy	Scenario	Reductions (MMTCO ₂ e)*			NPV (2007– 2020) \$ Millions	Cost- Effective- ness \$/tCO ₂
			2010	2020	Cumulative Reductions (2007-2020)		
ES-10	Generation Performance Standard	Reference Case					

* - analyzed on the basis of consumption-based emissions, since the GPS in its design above is focused on load.

Data Sources, Methods and Assumptions (for quantified actions):

- Data Sources:
- Quantification Methods: The analysis will compare the costs and CO₂ emissions of compliance with the GPS as defined above with the costs and CO₂ emissions of the reference case. It involves the following steps: (1) estimate the amount of new generation expected to be needed by load serving entities to meet load growth, retirements, or terminated contracts; (2) estimate the amount the likely mix of this new generation needed (based on the inventory/projections); (3) identify the likely amount of generation with emission rate exceeding the performance standard; 4) estimate the cost of (a mix of) alternative resources that can meet the standard.
- Key Assumptions:
 - Amount of load-serving generation likely to be replaced
 - Costs and emissions rate of avoided (coal) resources: The busbar cost (levelized c/kWh or \$/MWh) is based on the same assumptions for coal plants defined for option ES-5 above.

- Costs of alternative resources: The busbar cost (levelized c/kWh or \$/MWh) of alternative resources based on the same assumptions defined above for renewable energy sources (see ES-1) and coal plants with carbon capture and storage (ES-5). The cost of natural gas resources is estimated based on information from Energy Information Administration *Annual Energy Outlook 2006/7* or NWPCC New Resource Characterization for the Fifth Power Plan *Natural Gas Combined-cycle Gas Turbine Power Plants*²⁵.
- Replacement mix: The principal alternatives that meet the GPS are a) natural gas CC plants; b) renewable energy facilities; and c) coal with CCSR. The emissions savings and costs of the GPS policy will depend on the cost-competitiveness (and other factors) of these alternative, replacement resources, as illustrated in the table below. For the purposes of developing a single estimate, the following replacement mix is assumed:
 - 2010: 50% renewables and 50% natural gas,
 - 2020: 33% renewables, 33% natural gas, 33% coal CCSR.

Total Generation by Resource (GWh)

Alternative Resource	Busbar Cost (\$/MWh)	Incremental Cost (\$/MWh)	Emissions Rate (tCO ₂ /MWh)	Incremental Emission Savings (tCO ₂ /MWh)
Natural Gas				
Renewable Mix				
Coal CCSR				
“GSP Mix”				

Key Uncertainties

None Cited.

Additional Benefits and Costs

None Cited.

Feasibility Issues

None Cited.

Status of Group Approval

Pending.

Level of Group Support

TBD

²⁵ http://www.westgov.org/wieb/electric/Transmission%20Protocol/SSG-WI/pnw_5pp_02.pdf

Barriers to Consensus

TBD

ES-11 Methane and CO₂ Reduction in Oil and Gas Operations, Including Fuel Use and Emissions Reduction in Venting and Flaring

Policy Description

There are a number of ways in which methane (CH₄) and CO₂ emissions in the oil and gas industry can be reduced. Natural gas consists primarily of methane; therefore, any leaks during production, processing, and transportation/distribution should be addressed. In addition to reducing GHG emissions, stopping these leaks may be economically beneficial because it can prevent the waste of valuable product.

The EPA Natural Gas STAR program offers numerous methods of preventing leaks. These methods, called Best Management Practices (BMPs) and Partnership Reduction Opportunities (PROs), are divided by industry sub sector: production, processing, and transportation/distribution. Among the practices recommended are: *preventive maintenance*: (improving the overall efficiency of the gas production and distribution system), *reducing flashing losses* (*releases when pressure drops at storage tanks, wells, compressor stations, or gas plants*), and changing and replacing parts and devices to reduce leaks and improve efficiency, among others.

There are a number of ways in which CO₂ emissions in the oil and gas industry can be reduced by improving energy efficiency, including: (1) new efficient compressors, (2) optimize gas flow to improve compressor efficiency, (3) improve performance of compressor cylinder ends, (4) capture compressor waste heat, (5) replace compressor driver engines, and (6) waste heat recovery boilers.

Regulations, incentives, and/or support programs can be applied to achieve these reductions (see ES-5 for some examples).

Policy Design

Discussion of this policy is quite preliminary:

- Assist or require natural gas companies in the State to participate in EPA's Natural Gas Star program, and provide enforcement and verification of participation. Consider whether participation by smaller companies would be a significant burden and possibly provide incentives if needed. Apply penalties (fines) to companies whose equipment does not comply. (TWG member will be following up to assess current utility participation in Gas STAR.).²⁶

Goals: Under Development. The CCAC has indicated that it would like to see an emissions reduction goal for this sector.

Timing: Under Development.

Parties involved: Under Development.

²⁶ It was noted that technologies for detecting pipeline leaks are becoming available, though they are still quite expensive.

Other: None Cited.

Implementation Mechanisms

None Cited.

Related Policies/Programs in Place

- **EPA Natural Gas STAR program** – is a voluntary partnership with the EPA, which includes several Montana natural gas companies, encouraging companies across the natural gas and oil industries to adopt cost-effective technologies and practices that improve operational efficiency and reduce emissions of methane. Natural Gas STAR partners sign a Memorandum of Understanding (MOU) wherein they agree to evaluate the Program's recommended Best Management Practices (BMPs) for reducing methane emissions and implement them when cost effective for the company. Partners develop a customized Implementation Plan and submit Annual Reports showing emissions reductions undertaken.
- **Remote control of wells and capture of waste gas** – Many oil well operations in E. Montana are remotely controlled to save vehicle mileage and better prevent spills. Most waste gas is being captured rather than vented in state operations.

Type(s) of GHG Benefit(s):

- CO₂: CO₂ emissions would be reduced directly through the fuel use and flaring reductions.
- CH₄: Methane emissions would also be reduced, mostly through decrease venting and leak reductions.

Estimated GHG Savings and Costs Per Ton:

#	Policy	Scenario	Reductions (MMTCO ₂ e)			NPV (2007– 2020) \$ Millions	Cost- Effective- ness \$/tCO ₂
			2010	2020	Cumulative Reductions (2007-2020)		
ES-11		Reference Case					
ES-11		High Fossil Case					

Data Sources, Methods and Assumptions (for quantified actions):

- **Data Sources:** Capital cost and other information for individual technologies and practices are available at EPA’s Natural Gas Star website, <http://www.epa.gov/gasstar/techprac.htm#tabnav>

- **Quantification Methods:** GHG reductions would be based on a specified goal level if/as established. Note that GHG reduction technologies and practices cover a wide variety of actions, and the costs would vary significantly by site and application, and are thus difficult to consolidate.

- **Key Assumptions:**

Key Uncertainties

None Cited.

Additional Benefits and Costs

None Cited.

Feasibility Issues

None Cited.

Status of Group Approval

Pending.

Level of Group Support

TBD

Barriers to Consensus

TBD

ES-12 GHG Reduction in Refinery Operations, Including in Future Coal-to-Liquids Refineries

Policy Description

There are a number of ways in which CH₄ and CO₂ emissions can be reduced in the production of liquid fuels at oil refineries or coal-to-liquids plants. These options include various efficiency measures including enhanced combined heat and power along with carbon capture and storage. Coal-to-liquids (CTL) plants are energy-intensive, and produce about 10 times more CO₂ emissions than conventional oil refineries in order to produce liquid fuels; however, with carbon capture and storage (and co-production of electricity and liquid fuels) such emissions can be substantially reduced.²⁷ Regulations, incentives, and/or support programs can be applied to achieve these reductions (see ES-5 for some examples).

Policy Design

The following initial ideas are still under discussion (*no agreement yet*):

- CTL facilities should be required to capture and store CO₂ from the start of operations.
- CTL facilities should be required to co-fire some fraction of biomass.
- CTL facilities should not be permitted to operate in Montana.
- Any CTL plant should also be a poly-generation plant—should produce electricity along with fuel products.
- Improve maintenance at oil refineries and ensure that best practice is being followed (cross-cut with safety issues).

The CCAC expressed serious concerns about the emissions associated with CTL.

Goals: Under Development. The TWG will look at the emissions and emission reductions that might be achievable for CTL under different options (polygeneration, biomass blending, CCSR) for the high fossil scenario. The question of oil refinery emissions not discussed by the CCAC.

Timing: Under Development.

Parties involved: Under Development.

Other: None Cited.

Implementation Mechanisms

None Cited.

²⁷ International Energy Agency, 2006. *Energy Technology Perspectives*. Well-to-wheel GHG emissions from coal liquids are approximately twice those of conventional oil products. Cogeneration and carbon capture and storage can reduce those emissions to levels similar to, or slightly below, those of conventional oil products.

Related Policies/Programs in Place

None identified relating to GHG reduction in refinery operation, including future coal-to-liquids refineries.

Type(s) of GHG Benefit(s):

- CO₂: CO₂ emissions would be reduced directly through fuel use reductions
- CH₄: CH₄ could also be reduced due to process changes (e.g. leak reductions, as appropriate)

Estimated GHG Savings and Costs Per Ton:

#	Policy	Scenario	Reductions (MMTCO ₂ e)			NPV (2007– 2020) \$ Millions	Cost- Effective- ness \$/tCO ₂
			2010	2020	Cumulative Reductions (2007-2020)		
ES-12		Reference Case					
ES-12		High Fossil Case					

Data Sources, Methods and Assumptions (for quantified actions):

- Data Sources:
- Quantification Methods:
- Key Assumptions:

Key Uncertainties

None Cited.

Additional Benefits and Costs

None Cited.

Feasibility Issues

None Cited.

Status of Group Approval

Pending.

Level of Group Support

TBD

Barriers to Consensus

TBD

ES-13 CO₂ Capture and Storage or Reuse (CCSR) in O&G Operations, Including Refineries and Coal-to-Liquids Operations

Policy Description

Carbon capture and storage or reuse (CCSR) involves capturing carbon dioxide and either (1) sequestering it permanently in a geologically sound reservoir or (2) reusing it to aid in oil and gas extraction or as a feedstock for industrial processes, and perhaps eventually as a feedstock that when combined with water can be reformed into liquid fuels. Where excess CO₂ is found in some natural gas reservoirs – pipeline natural gas can contain only up to 2.5% CO₂ by volume, and some gas fields have a higher concentration – it is typically vented to the atmosphere in gas processing plants. Carbon can also be captured in the process of gasifying coal to liquid fuels. This process is well established in the chemical industry and forms the basis for Integrated Gasification Combined Cycle (IGCC) electricity generating plants.

Policies to encourage CCSR could include a state agency or department within an existing agency tasked with promoting CCSR, evaluation studies to identify geologically sound reservoirs, R&D funding to improve CCSR technologies, financial incentives to capture and store carbon or to capture and reuse it, and/or mandates – coupled with technical feasibility and cost and investment recovery mechanisms, if appropriate – to capture and store carbon or capture and reuse it.

Policy Design

The TWG suggests addressing oil and gas operations with incentives and/or requirements related to carbon capture and storage or reuse in a manner yet to be determined. CCSR requirements for oil and gas operations should be consistent with those for the electricity generation sector. See ES-5 and ES-12.

Goals: Under Development.

Timing: Under Development.

Parties involved: Under Development.

Other: None Cited.

Implementation Mechanisms

None Cited.

Related Policies/Programs in Place

None identified.

Type(s) of GHG Benefit(s):

- CO₂: If carbon were successfully stored in appropriate geological reservoirs, the net emission of carbon would be substantially reduced, if zero-carbon energy is used for the storage operations. If carbon were reused to make liquid fuels, then when those fuels were

combusted, there would be carbon emissions at a rate comparable to natural gas, if large sources of zero-carbon energy are available for the reforming processes. Reforming of CO₂ to liquid fuels is a theoretical technology at this time and no estimate of timing for potential commercial deployment is available.

Estimated GHG Savings and Costs Per Ton:

#	Policy	Scenario	Reductions (MMTCO ₂ e)			NPV (2007– 2020) \$ Millions	Cost- Effective- ness \$/tCO ₂
			2010	2020	Cumulative Reductions (2007-2020)		
ES-13		Reference Case					
ES-13		High Fossil Case					

Data Sources, Methods and Assumptions (for quantified actions):

Key Uncertainties

None Cited.

Additional Benefits and Costs

None Cited.

Feasibility Issues

None Cited.

Status of Group Approval

Pending.

Level of Group Support

TBD

Barriers to Consensus

TBD

Appendix A: Survey of Greenhouse Gas Standards in Other States

State	Start Date	GHG Emissions Performance Standard	Applicability	Additional information
Greenhouse Gas Emission Performance Standards (Long-term financial commitments to electrical generating resources) – “load-based”				
California: Senate Bill No. 1368 (approved Sep 2006)²⁸ CPUC interim opinion (Jan 2007)²⁹	2007	Equal to or less than a new, combined-cycle natural gas power plant. Interim rule: 1100 lbs of CO ₂ e/MWh	New long-term financial commitments to baseload electricity generation by load-serving entities. (Applies to in-state or imported electricity.)	Ensures no reduction in energy supply reliability Emissions based on net emissions from electricity production. CO ₂ stored in geologic formations shall not be counted as emissions from the power plant (interim opinion: for sequestration projects, lifetime emissions count, plan but immediate storage not needed) Allows for added return where applicable (1/2-1%) for zero- or low-carbon generating resources.
Washington: PSSB 2399 (in Senate consideration)³⁰	July 1, 2008 (if approved)	The lesser of 1100 lbs of CO ₂ e/MWh or emissions of a combined-cycle natural gas power plant with 100 units in operation for at least 3 years	New, long-term financial commitments to baseload electricity generation by IOU and consumer-owned utilities.	Ensures no reduction in energy supply reliability Emissions based on net emissions from electricity production. CO ₂ stored in geologic formations shall not be counted as emissions from the power plant.
Carbon Dioxide Emission Standards For <i>New</i> Energy Facilities – “facility-based”				
Oregon: HB 3283³¹	1997 Updated 2003	Meet emissions standard 17% better than the most efficient base-load gas plant currently operating in the U.S. (0.675 lb. CO ₂ per kWh)	New energy facilities	Compliance options: - implement offset projects directly - pay a fee of \$0.85 per metric ton CO ₂ using a qualified organization that purchases/manages offsets (below market cost of offsets).
Washington: HB 3141 & RCW 80.70.020, WAC 173-407	2003 Updated 2004	CO ₂ mitigation plan to offset 20% of CO ₂ equivalent emissions over a 30 year period	New energy facilities > 350 MW (EFSEC rules); 25-350 MW (Dept Ecology rules); or output increases at existing facilities	Compliance options: - implement offset projects directly - pay a fee of \$1.60 per metric ton CO ₂ using a qualified organization that purchases/manages offsets (below market cost of offsets).
Carbon Dioxide Emission Standards For <i>Existing</i> Energy Facilities – “facility-based”				
Massachusetts: Amendment to 310 CMR 7.29³²	2006 cap 2008 rate	Cap: Emissions cannot exceed historical emissions Rate: Emissions must not exceed 1800 lb CO ₂ /MWh	Six current power generation facilities in MA	Compliance may be met via emission reductions, avoided emissions, or sequestered emissions.

²⁸ http://www.energy.ca.gov/ghgstandards/documents/sb_1368_bill_20060929_chaptered.pdf

²⁹ http://www.cpuc.ca.gov/PUBLISHED/FINAL_DECISION/64072.htm

³⁰ <http://apps.leg.wa.gov/billinfo/summary.aspx?bill=6001>

³¹ <http://www.oregon.gov/ENERGY/SITING/docs/ccnewst.pdf> ;

Jurisdiction	Status: Start Date	Tax Rate - Applicability	Where tax applied	Use of Revenue
Finland¹	1990 Revised 1997 Revised 2002	1990 \$1.54 per ton 1993 \$3.00 per ton 1997-8 Electricity: \$0.007 per kWh Heating: \$22.53 per ton CO2 Natural gas: \$11.26 per ton CO2	1990 Fuels 1997 Electricity consumption not fuels Reduced for industry Exemption for international aviation, shipping and refineries	Reimbursement via lower payroll taxes
Norway²	1991 Revised 1999	Petrol: \$55.90 per ton CO2 Mineral Oil: \$30.16 per ton CO2, Oil and gas in North Sea: \$52.05 per ton CO2	Producers and importers of oil products Exemption for foreign shipping, fishing, external aviation	Reduce other taxes
Sweden³	1991 Revised 2004	CO2: \$100 per ton 2004 increases: Gasoline: \$0.02 per L Diesel: \$0.04 per L Vehicle Tax Electricity: \$0.002 per kWh (excludes industry)	Oil, coal, natural gas, liquefied petroleum gas, petrol, and domestic aviation fuel Reduced industrial rate Exemption for high-energy industries i.e. horticulture, mining, manufacturing and pulp/paper industry	Offset by income tax relief Est. revenue \$523 million
Denmark⁴	1992 Revised 1999	Commercial \$14.30 per ton CO2 Households \$7.15 per ton CO2	Buildings	Reallocated as subsidies for energy efficiency activities and voluntary agreements

Appendix B: Survey of Carbon Tax Programs

Germany⁵	1999 Revised 2000	1999 Gasoline: \$0.04 per L Heating fuel: \$0.03 per L Natural gas: \$0.02 per kWh Electricity: \$0.01 per kWh 2000-03 annual increases Gasoline: \$0.04 per L	Electricity, heating fuel, natural gas, gasoline	Tax breaks for commuters; Reduce labor costs via pension contributions
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³² http://trinityconsultants.com/State_Regulatory_News.asp?st=MA&n=313;
<http://www.mass.gov/dep/air/laws/ghgappb.pdf>

Australia: State of West Australia⁷	Under current consideration	\$19.58 per ton CO2		
Canada: Province of Quebec⁸	2006	To be determined by Quebec Energy Board \$1 Billion est. 6-yr revenue	Non-renewable fossil fuels sold in bulk to retailers	Green Fund: Public transportation, energy efficiency for buildings
		Electricity: \$0.003 per kWh		
Japan⁶	2001	Green taxation Subsidies for high efficiency automobiles	Vehicles	
UK	2001-	Electricity: \$0.0084 per kWh Coal and Natural gas: \$0.0029 per kWh Levy will rise with inflation annually beginning in 2007	Electricity generation includes nuclear Renewable exempt	Reduced National Insurance rate Fund for energy efficiency initiatives
Netherlands	2005	Fossil electricity: \$0.08 per kWh for small consumers Renewable exemption: \$0.04 per kWh Rates indexed to inflation.	Electricity and fuel consumption. Renewable sources with green certificate exempt.	Reduced income and corporate tax rates
City of Boulder, CO	Approved 2006 Start 2007 Expiration 2013	Electricity: (kWh) \$.0022 for residential \$.0004 for commercial \$.0002 for industrial use. Max increases: \$.0049 for residential \$.0009 for commercial \$.0003 for industrial use	Electricity use	Funding for city's Climate Action Plan: Programs to increase energy efficiency, renewable energy use, reduce motor vehicle emissions, and take further steps to meeting Kyoto protocol targets

- ¹ <http://www.norden.org/pub/ebook/2001-566.pdf>; 2 <http://www.regjeringen.no/en/ministries/fin/Selected>
3 <http://pubs.acs.org/hotartcl/est/98/dec/hanis>; 4 <http://www.norden.org/pub/ebook/2001-566.pdf>;
<http://www.iea.org/textbase/pamsdb/detail.aspx>; 5 <http://www.iea.org/textbase/pamsdb/detail.aspx?>
6 <http://www.iea.org/textbase/pamsdb/detail.aspx?mode=cc>; 7
<http://www.news.com.au/story/0,23599,21171914-2,00>; 8 <http://www.cbc.ca/news/background/kyoto/carbon-tax.html>