Energy Supply Technical Work Group
Summary List of Recommended High Priority Mitigation Options

September 20, 2007 – This version of the Options document includes feedback from the August 30th TWG meeting and September 7th CAT meeting. All options have been affirmed by the CAT except

ES-5 – CCSR, needs revisions to ensure that option recommendations do not overlap with SB6001

The table below indicates some of the key remaining issues. Highlights within the document also indicate sections where full TWG discussion and agreement have not yet occurred – please review and be prepared to discuss at the TWG meeting. Additionally, we have added some potential sources for cost and emission reduction information under Data Sources – again, please review these sources and provide any additional references to us.

#	Mitigation Option Name	Comments/ Areas for TWG review
ES-1	Grid-based renewable energy incentives and/or barrier removal (originally 2.2)	Should financial incentives be provided to meet I-937 requirements?
ES-2	Distributed renewable energy incentives and/or barrier removal (originally 2.3)	What is the appropriate definition for "distributed" for this analysis?
ES-3	Efficiency improvements at existing renewable and power plants (originally 2.9 and 3.3)	What are the best data sources for quantifying this option (eg energy efficiency potential studies)
ES-4	Technology Research & Development, plus Technology-Focused Initiatives (originally 1.6, 2.8, and 3.4)	Due to the long term and indirect nature of the GHG emission reductions from RD&D, quantifying the GHG reduction or cost-effectiveness of this option may not be appropriate.
ES-5	CCSR (including pre and post-combustion) incentives, requirements and/or enabling policies plus R&D (originally 5.1, 5.2, and 3.1a and b)	Ensure that option recommendations do not overlap with SB6001
ES-6	Transmission system capacity, access, efficiency, and Smart Grid (originally 6.1, 6.2, and 6.5)	Additional policy design elements have been added, also discussion needed on ability to share costs.

#	Mitigation Option Name	Comments/ Areas for TWG review
ES-7	Combined Heat and Power (CHP) and Thermal Energy Recovery and Use (originally 2.5)	Is SB6001 sufficient to ensure that future regulations will be based on useful energy output?
ES-8	*Incorporated into ES-5* (originally 3.1a)	

The following options received significant interest from the TWG but were not considered high priority. Suggestions for follow up for some of the options are provided as well.

Catalog #	Mitigation Option Name	Comments
1.7	Climate change education initiatives	TWG suggests that the CAT should develop over-arching education policy
2.4	Green power purchases and marketing	Keep at moderate priority
2.7	Renewable energy development issues	Keep at moderate priority, limited ability for state actions
2.10	Use carbon offsets markets to promote additional renewable energy development	Include in other discussions on market based mechanisms (cap and trade, carbon tax)?
4.5b	Coal-to-gas production	Keep at moderate priority
4.7	LNG policies and infrastructure	Possibly consider needs for overall natural gas supply policies

Note from TWG regarding future Natural Gas Prices and Supply:

Natural gas supply and price issues are not specifically addressed among the ES options, since direct opportunities for new GHG emission reduction initiatives appear somewhat limited. At the same time, it is important to recognize that if the availability of affordable natural gas supplies is limited, this could have negative consequence both for the state's economy as well as GHG emissions. It is recommended that complementary efforts be undertaken in other venues to address these concerns.

ES-1. Grid-based Renewable Energy Incentives and/or Barrier Removal

Based on ES Catalog Option 2.2

Mitigation Option Description

This policy option addresses the barriers to and possible incentives for expanding grid-based, or utility-scale, renewable resources. Renewable resources, be they grid-scale or small-scale, can provide an important contribution to achieving the overall emission targets for Washington State. "Barriers" in this context should be thought of as institutional barriers to developing cost effective renewable resources or actions that will lead to grid-scale renewable resource being more economic. Such institutional barriers may include wind integration, transmission policies, interconnection policies, or regulatory cost recovery policies, or economic policy drivers.

Policies that target non-or low-emission resources through financial incentives or command-control purchases should include financial safeguards to ensure that the most cost competitive resources are developed and that end-use customers are protected from paying unreasonable costs.

Mitigation Option Design

[input from August 30 TWG meeting] The policy's objective is to *add the maximum amount of feasible renewable generation to the Washington State grid, taking into account the economic, environmental impacts and system reliability constraints.* This option should remove any barriers in existing regulations that limit achievement of the goal. In addition, the option should consider financial incentives to activities that exceed any legal requirements (for example I-937) for grid-based renewables. (The TWG noted the challenges in determining exactly which incentives will lead to activities that exceed legal requirements).

Potential design elements are described below

Barrier Removal for meeting I-937:

Regulatory Uncertainty

Development Costs: Legislation requiring the WUTC to develop policies and procedures to provide guidance to utilities on how different types of prudently incurred development costs will be recovered in rates before utilities make such expenditures.

Research Development and Demonstration Costs: The WUTC could be required to establish policies, guidelines, and procedures for reviewing, approving, and establishing accounting treatment for utility proposed RD&D projects. The process could clarify how costs of prudently managed, utility proposed RD&D projects may be recovered.

Transmission Cost Barriers: The state could provide no-interest loans or loan guarantees to utilities and non-utility generators for upfront transmission charges.

Barriers to Non-Utility Generators: High interconnection costs, power dispatchability and regulatory barriers need also to be removed similar to OR Public Utility Commission ruling under UM 1129.

Transmission Siting Barriers: Ensure EFSEC has siting authority over some transmission and that projects are allowed to opt into EFSEC. [*TWG members noted that recent legislation may cover these concerns. In January 2006, EHSB 1020 passed* "Extending EFSEC Jurisdiction Over Transmission Lines".[1] *Further TWG discussion will determine if this legislation is sufficient]*

Avoided Cost Policies: When administratively determined avoided costs are used as the basis for acquiring grid-scale resources, such avoided costs should accurately reflect the full benefit marginal or incremental cost savings for particular resource types. When utilities use a competitive bidding process in lieu of administratively determined avoided costs for such resources, the WUTC (for IOUs) should ensure resource acquisition decisions accurately reflect costs and benefits savings from all non-utility generation, including renewable resources.

Incentives for exceeding I-937

Availability and Diversity of Resources: Legislative actions to target expanded sources of renewable resources and encourage investment and development of these resources. For example, new polices could expand the requirements for renewable resources and the definition of renewable to be more focused on non/low emitting resources. These targeted resources could include geothermal, solar, organic pulping by-products, tidal and ocean, and biomass, along with renewable resources from Canada or Southern Alaska. This can be accomplished in one of two ways. One would be to update the resource definitions and renewable targets in the RPS (I-937)—this would not represent a consensus recommendation by the TWG. A second way would be to add another layer to the existing legislation.

Incentives to directly support development of renewable resources, *which are in excess of I-937 (TWG members may differ on whether incentives can be applied to meet I-937).* This can be through some combination of tax supports to renewable developers, that may be bid into utility RFP's. The tax supports or other direct support could also be provided to utilities, that could be used for self-owned or non-utility renewable energy, which would help ensure energy and green attributes of such state-supported renewable resources stay in the state.

Exceeding RPS Targets: Legislation that explicitly allows utilities to use excess revenue cap capacity to invest in additional renewable resources. For example, utilities could be allowed to retain revenue from selling RECs generated/acquired in excess of those needed to comply with the RPS.

[1] http://www.leg.wa.gov/pub/billinfo/2005-06/Pdf/Bill%20Reports/Senate/1020-S.SBR.pdf

Incentives for Investor Owned Utilities: Utilities could be allowed to retain revenue from selling RECs generated/acquired in excess of those needed to comply with the RPS. This would provide positive incentives to comply with physical RPS targets early and in the long-term. Such an incentive could be coupled with the process described in "exceeding the RPS" to provide a cap on expenditures. Alternatively, utilities could be provided a rate of return kicker (or financial equivalent for purchases) for renewable resources. Washington State already provides that utilities may earn a higher return on equity for conservation investments. A comparable mechanism could be applied to renewable resources.[2] New legislation should not take away this type of option for policy makers and regulators to give as an incentive to utilities.

Policies/Strategies for Consumer Owned Utilities:

Examples have not yet been discussed by TWG but members acknowledged the need to consider these.

- **Goals:** *Add the maximum amount of feasible grid-based renewables, taking into account the economic, environmental impacts and system reliability*
- **Timing:**
- **Coverage of parties:**
- **Other:**

Implementation Mechanisms

Related Policies/Programs in Place

The Energy Independence Act (Initiative 937) passed by the state's voters in 2006 established renewable portfolio standards. Large utilities (25,000 customer and over) are required to obtain 15% of their electricity from new renewable resources, such as solar and wind, by 2020 (3% in 2012, 9% in 2016 and 15% in 2020). Additionally, utilities must undertake cost-effective energy conservation. The RPS affects 95% of the electric generation in the state.

See ES-2 below. See Senate Bill 6001 (April 2007), section 4d) and 4e),

Incentives for Non-Utility Generators—Combined Heat and Power incentives are discussed under ES-7

Type(s) of GHG Reductions

[2] For example, utilities could be allowed to earn at least 2% more on renewable resource rate base or equivalent expense, comparable to what was allowed at one time for conservation resources (One utility has recently applied to the UTC to capitalize a portion of their conservation expenditures. It is more common for utilities to expense their conservation costs). Applying this type of incentive for renewables was considered in the previous legislative session for SB6001, but was not included in the final version. Concerns regarding the incentive included (1) public utilities not having a similar incentive, (2) providing incentives for mandated renewable investments, and (3) whether the incentives could be applied to other non-renewable investments.

[Insert text here]

Estimated GHG Savings (in 2020) and Costs per $MtCO_2e$

- **Data Sources:**
  - Northwest Power Council 5th Power Plan (2005) and Biennial Monitoring Report (2007) – projections of costs and resource availability. http://www.nwcouncil.org/energy/powerplan/default.htm
  - Integrated Resource Plans from Utilities http://www.nwcouncil.org/energy/Biennial/(P4-3)IRP%20Status.doc
  - Union of Concerned Scientists. *The Washington Clean Energy Initiative: Effects of I-937 on Consumers, Jobs and the Economy.* http://www.ucsusa.org/clean_energy/clean_energy_policies/washington-clean-energy-i-937.html
- **Quantification Methods:**
- **Key Assumptions:**

Contribution to Other Goals

- **Contribution to Long-term GHG Emission Goals (2035/2050):**
- **Job Creation:**
- **Reduced Fuel Import Expenditures:**

Key Uncertainties

[Insert text here]

Additional Benefits and Costs

[Insert text here]

Feasibility Issues

[Insert text here]

Status of Group Approval

TBD

Level of Group Support

TBD

Barriers to Consensus

TBD

ES-2. Distributed Renewable Energy Incentives and/or Barrier Removal

Based on ES Catalog Option 2.3 and RCI Catalog Option 6.1

This option will be considered jointly with the RCI TWG group.

Mitigation Option Description

Distributed electricity generation sited at residences and commercial and industrial facilities, and powered by renewable energy sources (typically solar, but also wind, small hydroelectric power sources, or biomass or biomass-derived fuels), displaces fossil-fueled generation and avoids electricity transmission and distribution losses, thus reducing greenhouse gas emissions. This policy can also encourage consumers to switch from using fossil fuels to using renewable fuels in applications such as water, process, and space heating. Increasing the use of renewable energy applications in homes, businesses, and institutions in Washington can be achieved through a combination of regulatory changes and financial incentives.

The TWG has not yet agreed on the definition of Distributed Generation. Some TWG members suggested that this option should consider defining distributed generation according to RCW 19.285.030(9), i.e., an eligible renewable resource where the generation facility or any integrated cluster of such facilities has a generating capacity of not more than five megawatts. Other members suggest that larger units should also be included (up to 100 MW). Potential technologies include: solar photovoltaic systems, solar water heating/space heating systems, wind power systems, particularly for rural areas, biomass-fired generation, space, or water heating systems.

There are numerous barriers to distributed renewable energy, including inadequate information, institutional barriers, community barriers, limited number of qualified contractors, high technology costs 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 recognition for emissions reduction value provided also creates obstacles. Policies to remove these barriers could include: improved interconnection policies, improved rates and fees policies, streamlined permitting, recognition of the emission reduction value, financing packages and bonding programs, power procurement policies, education and outreach, etc.

Mitigation Option Design

Potential elements of this option could include [*these suggestions have not been fully discussed by the TWG and are subject to revision*]:

- Conduct analysis to determine availability of DG supply.
- The primary barrier to new small DG is the high initial cost which must be borne by the customer-generator. Mitigation could include: WA tax credits for commercial operations;

WA-supported no-interest loans to residential customers; and WA state rebates for the purchase of specified technologies. Tax credits and other mechanisms to make distributed renewable resources more economically viable are important to develop non-traditional resource alternatives. [From ES-7, Oregon's Business Energy Tax Credit (BETC) program provides a useful example for the State to consider. Other potential financial incentives to implement distributed renewables programs include:

- Siting Incentive Programs;
- Low-cost bonding or loan guarantee programs;
- Tax credits for investment in distributed renewables]
- Expanding incentives offered under the existing law to residential consumers to include commercial systems
- Increase utility rates of return for investments in distributed renewables

- Washington already has uniform interconnection standards for small DG resources and net-metering laws. The existing regulatory construct can discourage direct utility capital investment in DG; those barriers should be examined, at least. Other "incentives" aimed at increasing market penetration of DG and certain energy efficiency technologies would be more effectively targeted at utilities, rather than individual consumers; utilities could be encouraged to create the market if they (IOUs) have the proper incentives to do so.
- Efforts to simplify and standardize permitting for industrial and large commercial DG systems, as well as support for County and city land use prescreening efforts to facilitate siting.
- Interconnection standards are based on federal, state and industry safety requirements. High interconnection costs and regulatory access barriers can be shifted from the customer-generator to the general population with appropriate legislation.
- There is support among some members of the Energy Supply TWG to amend I-937 to include a broader variety of resources and waste-to-energy (WTE) as renewable fuels. I-937 proponents have concerns about opening up the initiative, in part because of the potential to undermine the original intent that now serves as a fundamental basis of GHG emission reductions in the energy supply sector. I-937 proponents also have concerns about air quality impacts of traditional methods of burning pulping liquors and even more so with WTE.
- Training/certification programs for installers/contractors
- Consider amending the net metering statute (RCW 80.60) to: (1) increase the size of qualifying [agricultural] systems from 100 kW to 200 kW (currently net metering is available generally up to 100 kW); (2) accelerate the timeline for increasing the cumulative generating capacity available to renewable net metered systems[3]; and (3)

[3] 80.60.020(1) says: "… On January 1, 2014, the cumulative generating capacity available to net metering systems will equal 0.5 percent of the utility's peak demand during 1996. Not less than one-half of the utility's 1996 peak demand available for net metering systems shall be reserved for the cumulative generating capacity attributable to net metering systems that generate renewable energy".

ensure a simplified process for customer-generators to utilize net metering. *[Note, as mentioned above, that the TWG has not yet agreed on appropriate size (kW) for this recommendation]*

- Consider requiring new connections representing a load greater than a certain threshold (x kW) to evaluate distributed generation options

- **Goals:** Overcome barriers posed by high up-front costs of distributed generation systems. Expand use of systems in Washington, and promote stronger market for Washington's solar energy industry. *Achieve XX% of identified [cost-competitive] distributed generation potential in Washington by 2020 or achieve XX aMW/BTU of [specific resource]*.
- **Timing:** Many of the incentives, including loan subsidies, could be implemented in the 2009 legislative session, when the next biennial budget is drafted by the legislature.
- **Coverage of parties:**
- **Other:**

Implementation Mechanisms

- State incentive funds and low or no interest loan programs subsidized by the state.
- Expansion and/or extension of tax incentives provided under SB 5101 (2005).

[*The following are from RCI TWG comments and have not been fully discussed by the Energy Supply TWG*]

- Encouraging the creation of and support for biomass fuels markets.

Related Policies/Programs in Place

In 2005, the Legislature enacted the Renewable Energy System Cost Recovery (RCW 82.16.110) and Tax on Manufacturers or Wholesalers of Solar Energy Systems (RCW 82.04.294). The legislation provides incentives for the purchase of locally-made renewable energy products and provides a preferential rate under the business and occupation tax. Furthermore, tax exemptions under RCW 82.08.02567 and RCW 82.12.02567 incent the purchase and use of machinery and equipment used directly to generate electricity using fuel cells, wind, sun, or landfill gas. Similarly, RCW 82.08.835 and RCW 82.12.835 incent the purchase and use of solar hot water systems. Other renewable energy incentive programs include the federal income tax credit of 30% for one year (max $2,000).

Incentive payments are provided by electric utilities to customers generating renewable energy (i.e., solar, wind) on their property. For example, the Chelan County PUD Sustainable Natural Alternative Power Producers Program encourages customers to install power generators such as solar panels and wind turbines and connect them to the PUD distribution system; Avista Utilities provides a production credit of 14 cents per kWh for one year; Bonneville Environmental Foundation Green buys "tags" for five cents per kWh for up to five years (see additional information at end of this document).

A statewide biomass inventory and assessment was completed in 2005 by the U.S. Department of Energy (DOE) and Washington State University (WSU). The inventory identified nearly 17 million dry weight tons of annually renewable biomass resources across the state, with woody biomass as the dominant resource. Estimates indicate this organic resource is capable of supplying -- through combustion and anaerobic digestion -- about 50% of Washington annual residential electrical needs. In 2006, the Washington legislature authorized the "Waste to Fuels Technology" project, a partnership between the U.S. DOE and WSU, to evaluate the potential energy production from biomass feedstock, identify specific bio-fuels recovery technologies, and assess market development economics for organic resources.

Executive Order 05-01 mandates 10% reduction in State Agency energy purchases from 2003 levels by 9/1/2009, including through use of renewable energy

Type(s) of GHG Reductions

[TWG has begun to provide input; to be discussed at next CAT meeting]

Estimated GHG Savings (in 2020) and Costs per $MtCO_2e$

PRELIMINARY RESULTS

			Reductions		($MMtCO_2e$)*		
	Policy	**Scenario**	**2012**	**2020**	**Cumulative Reductions (2007–2020)**	**NPV (2007–2020) $ millions**	**Cost-Effective-ness $/tCO_2$**
ES-2	Renewable DG	20 MW PV by 2020, 0.8% of homes with solar hot water by 2015, 30 MW of small wind by 2020	0.03	0.07	0.5	$34	$69

- **Data Sources:** Western Governors Association's *Clean and Diversified Energy Initiative*; EIA *Annual Energy Outlook 2007* assumptions; Energy Trust of Oregon *A Comparative Analysis of Community Wind Power Development Options in Oregon*.
- **Quantification Methods:** Starting with the goals for each technology (see below), assumptions regarding the annual penetration of new distributed systems are generated. Estimates of cost and performance for different kinds of renewable systems and costs/emissions of avoided electricity are then used to estimate the overall net GHG emissions reduction and net cost of the policy.
- **Key Assumptions:**
  - **Goals/Potential:** ***These goals reflect placeholder values and require TWG revision/affirmation***

    Goal for rooftop solar photovoltaic (PV) systems is 20 MW by 2020.

    Goal for Small Wind is 30 MW by 2020.

Goal for Solar Hot Water is to have systems installed in 0.8% of new homes by 2015, based on Western Governors' Association estimate of an achievable goal of 500,000 systems installed by 2015 for entire region. The WA fraction accounts for electricity use, solar insulation [the amount of sunlight/solar radiation], and population growth.

- **Technology costs:** from Western Governors' Association 2006 (WGA 2006) Task Force Reports from the Clean and Diversified Energy Initiative,[4] Energy Information Administration,[5]; and, Energy Trust of Oregon (Table G-4).[6]

Table . Costs for solar PV, solar hot water, and wind technologies.

Technology	Capital Cost ($/kW)	Capacity Factor	Project Life (Years)	Source/Notes
Solar PV	Residential: $4,904 (2012) $3,265 (2020) Commercial $2,464 (2012) $1,870 (2020)	20%	20	WGA Clean and Diversified Energy Initiative report on Solar, includes federal incentives
Solar Hot Water	$2,534 (2012) $2,200 (2020)	75%	20	EIA Annual Energy Outlook assumptions
Wind	$2,149 (2012) $1,194 (2020)	35%	20	Energy Trust of Oregon for 2020, 2010 rough estimate

- **Avoided costs:** $43.5/MWh Based on analysis from NW Power and Conservation Council.
- **Avoided electricity emissions:** 0.5 metric ton CO_2/MWh, placeholder value (reflecting largely avoidance of natural gas) awaiting further consultation with NW Power and Conservation Council and TWG as analysis proceeds.

See Appendix B: Further details on Quantification for Options

Contribution to Other Goals

- **Contribution to Long-term GHG Emission Goals (2035/2050):** Likely dependent on how key uncertainties noted below are resolved over time. Level of contribution to long term goals dependent on how broadly DG technologies are utilized, which are in turn highly dependent on per kW cost of systems.

[4] http://www.westgov.org/wga/initiatives/cdeac/index.htm

[5] http://www.eia.doe.gov/oiaf/aeo/assumption/index.html

[6] *A Comparative Analysis of Community Wind Power Development Options in Oregon* http://www.oregon.gov/ENERGY/RENEW/Wind/docs/CommunityWindReportLBLforETO.pdf

- **Job Creation:** Washington is home to many companies, such as RES and Xantrex, that manufacture solar energy and other DG system components. Expansion of the market for DG systems should help grow this fledgling industry in Washington and create more jobs in places like Moses Lake, Arlington and Vancouver.
- **Reduced Fuel Import Expenditures:**

Key Uncertainties

Growth in utilization of DG technologies will depend, in part, on new technologies, increased manufacturing efficiencies with existing technologies and increase in markets to drive economies of scale that will reduce system costs.

Additional Benefits and Costs

[Insert text here]

Feasibility Issues

Renewable Energy -- tapping local renewable resources such as bio-energy. including supplies in the NW and Canada.

- Bio-energy includes a range of biomass feedstocks and technologies for conversion of these materials into useful energy.
  - "Biomass" is a general term for organic materials, and encompasses woody materials such forest wood wastes, wood chips, urban waste wood (tree trimmings), sawmill residue, crop residues, organic portions of municipal waste. Encourage development of cellulosic ethanol via pro-active policies and incentives.
  - Increasing interest in bio-energy is driven by advances in technology, environmental benefits, energy supply and price stability, and the potential for significant spin-off employment in fuel procurement and processing.
  - For some biomass materials, using the biomass for energy also can eliminate a waste disposal and landfill saturation problem.
  - Biomass can be used directly to produce thermal energy and/or electricity. Liquid or gaseous fuels can be produced from biomass for combustion in reciprocating engines or gas turbines.
- Geothermal resources are found throughout most of the western continental U.S., Alaska, Hawaii, and, to a lesser degree, in areas of the south and east.
  - Power generation is only one aspect of geothermal resource development. Geothermal heating, especially when coupled with district energy systems, can contribute significantly to reduction in the use of conventional fuels.
  - There are 271 communities in 10 western states, including WA, with nearby geothermal resources that could provide a renewable source of heating. These cities represent a population of 7.4 million people.

Status of Group Approval

TBD

Level of Group Support

TBD

Barriers to Consensus

TBD

ES-3. Efficiency Improvements, Capacity Additions and Fuel Switching at Existing Renewable and Fossil Power Plants

Based on ES Catalog Options 2.9 and 3.3

Mitigation Option Description

Efficiency improvements refer to increasing electric generation output at existing projects through incremental improvements at existing renewable projects (e.g. hydro, biomass, solar or wind) and at existing fossil plants (e.g., more efficient boilers and turbines, improved control systems, or combined cycle technology). Efficiency improvements at existing projects include incremental operational and equipment changes that result in more electric energy output using the same amount of fuel.

Capacity additions refer to adding electric generation capacity to any existing renewable projects. Fuel switching refers to switching to lower or zero emitting fuels at existing fossil plants. This may include the use of biomass or natural gas in place of coal or oil. (repowering is not fuel switching)

All of these (efficiency improvements, capacity additions and fuel switching) are effective ways of achieving lower GHG emissions and should be encouraged as part of state policy (*See additional information at end of this document*). Policies to encourage improvements at existing plants could include: new policies and principles, new laws and regulations, market-driven incentives, and financial incentives.

Mitigation Option Design

Potential elements of this option could include [*these suggestions have not been fully discussed by the TWG and are subject to revision*]:

- Policies and Principles – establish policies and principles through the Governor that define and promote efficiency improvements at existing projects. Encourage optimal use of our existing resources and investments in new resources.

- Laws and Regulations – develop implementing legislation or guidelines that provide the necessary market-driven incentive to accomplish overall goal.
- Market-driven incentives – provide incentives through future environmental attributes market (e.g. renewable energy credits, green power, and carbon offsets) that encourage and reward the efficient use of our energy resources.
- Financial incentives – provide incentives through reduced taxes and low-interest loans and other financial incentives.
- Explicit credit for GHG emission reduction could be a part of the prudence decision-making process, which could then result in more such improvements occurring.
- Incentives should be provided using investment and production tax credits, government loan guarantees, low interest loans and grants. Oregon's Business Energy Tax Credit system works well to encourage renewable energy generation and energy efficiency projects at commercial sites and industrial plants.
- To address potential efficiency improvements at plants under federal authority, the regional Governors and state delegations could, working with BPA, secure federal funding to first study and identify the potential efficiency improvements in the Bonneville hydro system and then obtain funding for implementation.

- **Goals:** *Implement the achievable, [cost-effective] efficiency potential at Washington's existing power plants. Reduce GHG emissions by substituting higher GHG fuels with lower GHG fuels [goal framing TBD].*
- **Timing:** To establish policies on or before January 1, 2009.
- **Coverage of parties:**
- **Other:**

Implementation Mechanisms

Additional Design Considerations [these have not been fully discussed by the full TWG and are subject to revision]

- Focus on efficiency improvements, capacity additions and fuel switching at existing renewable and fossil facilities. This could also include co-firing with biomass
- Need to clarify financial incentives. Favor utilizing incentives where appropriate.
- Under I-937, a utility cannot count against the renewable energy standard RECs from a hydro upgrade made by a qualifying utility, or the output from a hydro upgrade made by a non-qualifying utility. [The previous sentence needs clarification, CTED notes that "Utilities get credit from incremental hydro improvements towards their RPS targets, when the hydro project is owned by a qualified utility)"].TWG members disagree on whether changes should be made within I-937 to address this restriction or new policy/legislation should be developed to encourage efficiency improvements at hydro plants.

- Establish market standards that prevent potential double-counting of renewable energy generation.
- Methods to recover capital expended on existing fossil-fueled resources while also facilitating a transition to lower GHG emitting resources could be explored.
- The eligible $/MWh for efficiency projects could be adjusted to reflect the value of avoiding GHG emissions during any pre-approval or prudence review.
- A system that incorporates changes in the Washington's B&O tax to provide tax incentive credits similar to BETC could provide the tipping-force to move GHG reduction projects forward.
- Need to ensure financial incentives are equally available to both private and publicly-owned utilities.
- Consider whether avoided GHG emissions attributable to efficiency improvements, capacity additions and fuel switching at existing plants prior to any mandate or that exceed an operating permit limitation could be creditable as early actions within the context of a regional mechanism to achieve GHG reductions.

Related Policies/Programs in Place

- Senate Bill 6001 (April 2007), sections 4c) and 11.
- Implementation of the Energy Independence Act (RCW 19.285)

Type(s) of GHG Reductions

[TWG has begun to provide input; to be discussed at next CAT meeting]

Estimated GHG Savings (in 2020) and Costs per $MtCO_2e$

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

Contribution to Other Goals

- **Contribution to Long-term GHG Emission Goals (2035/2050):**
- **Job Creation:**
    - Implementation of efficiency improvements will produce high-quality technical and trade jobs.
- **Reduced Fuel Import Expenditures:**

Key Uncertainties

[Insert text here]

Additional Benefits and Costs

[Insert text here]

Feasibility Issues

- The estimated percent of efficiency improvements needs to be confirmed. An energy audit of existing projects to identify operational and equipment efficiency improvements and to identify new generation resources needs to be completed. Potential energy savings (aMW) and expected costs associated with those savings needs to collected and compiled before informed decisions can be made.

Status of Group Approval

TBD

Level of Group Support

TBD

Barriers to Consensus

TBD

ES-4. Technology Research, Development & Demonstration and Technology-Focused Initiatives

Based on ES Catalog Options 1.6, 2.8, and 3.4.

Mitigation Option Description

Drive advances in technologies that would develop cleaner energy supplies and make existing fossil fuel energy sources less GHG emitting. Encourage deeper investments in implementation opportunities for these new technologies. Establish an emerging energy technology program to set the stage for wider-scale adoption of these emerging and break through clean energy and efficiency technologies.

Mitigation Option Design

- Establish an emerging energy technology program to help develop and deploy advanced technologies:
  - Provide opportunities and incentives to invest in, test, and deploy new technologies.
  - Promote research and development of cost-effective breakthrough technologies.
  - Support technology demonstration projects to help commercialize technologies that have already been developed but are not yet in widespread use.
- Criteria for the Program
  - Program investments must target efforts that reduce GHG, reduce energy imports and create clean energy jobs and economic development.
  - Increase collaboration between existing institutions for RD&D on technologies and support public and private partnerships. Create centers of technology excellence.
  - Use an open bidding procedure (i.e., driven by bids received rather than by a focused strategy to develop a particular technology).
  - [*TWG members indicated some concern that R&D may not lead to actual GHG emission reductions. Suggest reviewing the achievements of other R&D programs to better understand the key components of successful R&D programs and seek to include these elements*]
  - Could consider opportunities for private sector companies to provide funding for this program
- The emerging energy technology program should be inclusive of legitimate technologies that among others, result in:
  - Efficiencies in power generation, fuel transport and co-firing
  - Efficiencies in power use
  - Advance energy storage systems

  - Carbon capture, storage and reuse
  - Alternative clean energy development

- **Goals:**
  - Build on existing state partnerships and initiatives. $10 million Emerging Energy Technology fund for advanced clean energy technologies.
  - Shared funding partnership with state, federal, and private sector partners to ensure the most effective deployment of these technologies.

- **Timing:**
  - Establish funding in the 2008 legislative session. First RFP issued January 2009.

- **Coverage of parties:**
  - State agencies, Washington Universities, private companies, utilities, Federal laboratories

- **Other:**

Implementation Mechanisms

- State program that partners with all levels of government, utilities, energy suppliers, and technology development companies.

Related Policies/Programs in Place

See Senate Bill 6001 (April 2007), various sections.

Northwest Energy Technology Collaborative

Washington Technology Center

Washington State University Energy Extension Service

Community Trade and Economic Development - Energy Policy Division

Pacific Northwest National Laboratory

Type(s) of GHG Reductions

Carbon Dioxide

Methane

Sulfur hexafluoride

Estimated GHG Savings (in 2020) and Costs per $MtCO_2e$

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

Contribution to Other Goals

- **Contribution to Long-term GHG Emission Goals (2035/2050):**

- **Job Creation:**
- **Reduced Fuel Import Expenditures:**

Key Uncertainties

[Insert text here]

Additional Benefits and Costs

[Insert text here]

Feasibility Issues

[Insert text here]

Status of Group Approval

TBD

Level of Group Support

TBD

Barriers to Consensus

TBD

ES-5. Carbon Capture, Storage, and Re-use Incentives, Requirements and/or Enabling Policies and Research & Development (including pre-combustion technologies)

Based on ES Catalog Options 5.1, 5.2, and 3.1b.

Mitigation Option Description

Carbon dioxide (CO_2) capture and storage or reuse (CCSR) is a process consisting of the separation of CO_2 from industrial and energy-related sources, transport to a storage location and long-term isolation from the atmosphere. The CO_2 from large point sources can be compressed and transported for storage in geological formations, in the ocean, in mineral carbonates, or for reuse in industrial processes. Captured carbon can be reused for enhanced recovery of oil and gas extraction or as a feedstock for industrial processes. Technological and financial barriers exist to implementation of CCSR. While separation, capture and transport of CO_2 are mature technologies only three industrial-scale storage projects are currently in operation. Further R&D funding to improve CCSR technologies and evaluation studies to identify geologically sound reservoirs will be needed.

Key components of this option would include:

- Identify and develop pre-combustion and post-combustion carbon capture technologies
- Identify and develop potential carbon sequestration technologies reservoirs
- Use algal biomass to capture carbon dioxide from exhaust gases that has been absorbed in water, probably with sequestration or reuse of algal biomass
- Identify and develop CO_2 transmission and reuse technologies
- Identify and recommend policies for permanent CO_2 storage that consider the implications of future liability - including state permitting, issues regarding short and long term liability

For electricity generation, a key technology today appears to be Integrated Gasification Combined Cycle (IGCC) combined with carbon capture and storage (CCS) technology. A significant advantage for IGCC when compared to conventional pulverized coal with amine-based carbon capture is the reduced cost of capturing CO_2 from the process. Carbon capture technologies have the potential to remove approximately 90 percent of a coal plant's CO_2 emissions.[7]

See additional information provided at end of this document

Mitigation Option Design

[7] PacifiCorp's 2007 IRP at 98, located at http://www.pacificorp.com/Navigation/Navigation23807.html.

The key element of this option is an Executive Order or legislation directing state agencies to identify regulatory and legal barriers to the commercialization of CCSR projects. The final product could be a report to either the Governor or the legislature.

Feedback from the CAT: Senate Bill 6001 includes requirements on sequestration plans. The CAT directs the TWG to consider policy design elements that do not overlap with SB6001. (see SB 6001 excerpt below under Related Policies). The public will have the opportunity to provide input to SB6001 rule-making.

- CCSR raises new legal and regulatory risks associated with siting and permitting projects, CO_2 transportation, injection and storage.[8] These risks are not yet fully understood, nor are uniform standards or government regimes in place to address and mitigate them. Among the key questions to be addressed in the development of a consistent regulatory framework for CCS are: potentially applicable criminal and civil environmental penalties; property rights, including the passage of title to CO_2 (including to the government) during transportation, injection and storage; long-term CO_2 liability, insurance coverage for short-term CO_2 liability; the licensing of CO_2 transportation and storage operators, intellectual property rights related to CCS, and monitoring of CO_2 storage facilities.

- California recently adopted AB 1925, directing the California Energy Commission to recommend standards to accelerate the adoption of long-term management of industrial CO_2.[9] Washington should similarly develop guidelines for addressing the emerging legal and regulatory issues associated with carbon capture and sequestration. Among the options it should explore is that adopted by Texas, which transfers the title (and any liability post-capture) to CO_2 captured by CCS to the Railroads Commission of Texas.[10] New Mexico Governor Richardson's Executive Order 2006-69 required the New Mexico Energy, Minerals, and Natural Resources Department (EMNRD) to coordinate with a stakeholder group to explore and identify statutory and regulatory requirements needed to geologically sequester anthropogenic CO_2. The group recently published an interim report[11] that identifies the issues and challenges that must be addressed by potential statutory and regulatory changes, to identify questions, concerns and recommendations made by the stakeholder group, and to present preliminary findings and research to date for further policy development. A final

[8] Robertson, K., Findsen, J., Messner, S., Science Applications International Corporation. June 23, 2006. "International Carbon Capture and Storage Projects Overcoming Legal Barriers", prepared for the National Energy Technology Laboratory (see http://www.netl.doe.gov/energy-analyses/pubs/CCSregulatorypaperFinalReport.pdf)

[9] California AB 1925 (2006), located at http://www.leginfo.ca.gov/pub/05-06/bill/asm/ab_1901-1950/ab_1925_bill_20060926_chaptered.

[10] Texas H.B. 149 (2006).

[11] See, http://www.emnrd.state.nm.us/OCD/documents/InterimReportCO2Sequestration.pdf

report, with findings and recommendations, is due on December 1, 2007. The approach and process undertaken in New Mexico could be easily replicated in Washington.

[*Other Design Considerations – these have not been fully discussed by the TWG and are subject to revision:*

- *Consider modifying the traditional least cost/least risk regulatory standard for IOUs in order to advance the use of IGCC and other CCSR technologies.*
- *Washington could enact state or jointly advocate for federal tax incentives to encourage new IGCC and CCSR project development to serve Washington customers. The most effective combination of tax incentives for IOU development of CCSR technologies is a tax credit plus accelerated depreciation.*
- *Consider an Executive Order or legislation directing the Washington Utilities and Transportation Commission to implement changes to Washington's "used and useful" statute, mandating "pay as you go" cost recovery for IGCC and CCSR technologies, in order to advance their commercialization*
- *Consider whether avoided GHG emissions attributable to IGCC and CCSR technologies placed into operation prior to any mandate or that exceed an operating permit limitation should be creditable as early actions within the context of a state or regional mechanism to achieve GHG reductions.*
- *Verification and monitoring technologies and systems are needed*

- **Goals:**
- **Timing:**
- **Coverage of parties:**
- **Other:**

Implementation Mechanisms

[Insert text here]

Related Policies/Programs in Place

See Senate Bill 6001 (April 2007), sections 4b, 7 and 5

"**Sec. 5.** (1) Beginning July 1, 2008, the greenhouse gases emissions performance standard for all baseload electric generation for which electric utilities enter into long-term financial commitments on or after such date is the lower of:

(a) One thousand one hundred pounds of greenhouse gases per megawatt-hour; or

(b) The average available greenhouse gases emissions output as determined under section 7 of this act.

…

(7) The following greenhouse gases emissions produced by baseload electric generation owned or contracted through a long-term financial commitment shall not be counted as

emissions of the power plant in determining compliance with the greenhouse gases emissions performance standard:
(a) Those emissions that are injected permanently in geological formations;
(b) Those emissions that are permanently sequestered by other means approved by the department; and
(c) Those emissions sequestered or mitigated as approved under subsection (13) of this section.
(8) In adopting and implementing the greenhouse gases emissions performance standard, the department of community, trade, and economic development energy policy division, in consultation with the commission, the department, the Bonneville power administration, the western electricity coordination council, the energy facility site evaluation council, electric utilities, public interest representatives, and consumer representatives, shall consider the effects of the greenhouse gases emissions performance standard on system reliability and overall costs to electricity customers.
(9) In developing and implementing the greenhouse gases emissions performance standard, the department shall, with assistance of the commission, the department of community, trade, and economic development energy policy division, and electric utilities, and to the extent practicable, address long-term purchases of electricity from unspecified sources in a manner consistent with this chapter.
(10) The directors of the energy facility site evaluation council and the department shall each adopt rules under chapter 34.05 RCW in coordination with each other to implement and enforce the greenhouse gases emissions performance standard. The rules necessary to implement this section shall be adopted by June 30, 2008.
(11) In adopting the rules for implementing this section, the energy facility site evaluation council and the department shall include criteria to be applied in evaluating the carbon sequestration plan, for baseload electric generation that will rely on subsection (7) of this section to demonstrate compliance, but that will commence sequestration after the date that electricity is first produced. The rules shall include but not be limited to:
(a) Provisions for financial assurances, as a condition of plant operation, sufficient to ensure successful implementation of the carbon sequestration plan, including construction and operation of necessary equipment, and any other significant costs;
(b) Provisions for geological or other approved sequestration commencing within five years of plant operation, including full and sufficient technical documentation to support the planned sequestration;
(c) Provisions for monitoring the effectiveness of the implementation of the sequestration plan;
(d) Penalties for failure to achieve implementation of the plan on schedule;
(e) Provisions for an owner to purchase emissions reductions in the event of the failure of a sequestration plan under subsection (13) of this section; and
(f) Provisions for public notice and comment on the carbon sequestration plan.
(12)(a) Except as provided in (b) of this subsection, as part of its role enforcing the greenhouse gases emissions performance standard, the department shall determine whether sequestration or a plan for sequestration will provide safe, reliable, and

permanent protection against the greenhouse gases entering the atmosphere from the power 23 plant and all ancillary facilities.
(b) For facilities under its jurisdiction, the energy facility site evaluation council shall contract for review of sequestration or the carbon sequestration plan with the department consistent with the conditions under (a) of this subsection, consider the adequacy of sequestration or the plan in its adjudicative proceedings conducted under RCW 80.50.090(3), and incorporate specific findings regarding adequacy in its recommendation to the governor under RCW 80.50.100.
(13) A project under consideration by the energy facility site evaluation council by the effective date of this section is required to include all of the requirements of subsection (11) of this section in its carbon sequestration plan submitted as part of the energy facility site evaluation council process. A project under consideration by the energy facility site evaluation council by the effective date of this section that receives final site certification agreement approval under chapter 80.50 RCW shall make a good faith effort to implement the sequestration plan. If the project owner determines that implementation is not feasible, the project owner shall submit documentation of that determination to the energy facility site evaluation council. The documentation shall demonstrate the steps taken to implement the sequestration plan and evidence of the technological and economic barriers to successful implementation. The project owner shall then provide to the energy facility site evaluation council notification that they shall implement the plan that requires the project owner to meet the greenhouse gases emissions performance standard by purchasing verifiable greenhouse gases emissions reductions from an electric generating facility located within the western interconnection, where the reduction would not have occurred otherwise or absent this contractual agreement, such that the sum of the emissions reductions purchased and the facility's emissions meets the standard for the life of the facility.

Type(s) of GHG Reductions

[Insert text here]

Estimated GHG Savings (in 2020) and Costs per $MtCO_2e$

- **Data Sources:**
  - Pacificorp White Paper
  - Recently released MIT report, "The Future of Coal" (2007) [12] which 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)[13] which provides other estimates, including rough estimates of the costs of CO_2 transport and storage.

[12] http://web.mit.edu/coal/

- 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 CO_2 capture, accounting also for high elevation issues with IGCC as might be encountered in Washington.
- Advanced Coal Task force report and spreadsheets from Western Governor's Association 2006 (WGA 2006) *Clean and Diversified Energy Initiative*[14]
-

- **Quantification Methods:**
- **Key Assumptions:**

Contribution to Other Goals

- **Contribution to Long-term GHG Emission Goals (2035/2050):**
- **Job Creation:**
- **Reduced Fuel Import Expenditures:**

Key Uncertainties

[Insert text here]

Additional Benefits and Costs

[Insert text here]

Feasibility Issues

[Insert text here]

Status of Group Approval

TBD

Level of Group Support

TBD

Barriers to Consensus

TBD

[13] http://www.ipcc.ch/activity/srccs/index.htm

[14] http://www.westgov.org/wga/initiatives/cdeac/index.htm

ES-6. Transmission System Capacity, Access, Efficiency, and Smart Grid

Based on ES Catalog Options 6.1, 6.2, and 6.5.

Mitigation Option Description

This option comprises three main elements: 1) increasing transmission system capacity for, and access to the grid by, clean energy technologies[15]; 2) improving efficiency and reducing line losses in the electric transmission and distribution system; and 3) providing support to "smart grid"[16] technologies that optimize the electricity grid (and unlock additional renewable resource alternatives) through devices that help manage electricity demand and supply;

Mitigation Option Design

1. **Provide financial incentives and remove barriers for implementing smart grid technologies that reduce GHG emissions.** Incentives may be necessary to counter any additional risk of bringing new smart grid solutions on line; incentives must be comparable for private and public utilities, as well as relevant non-utility actors. Utility regulators and managers should work together to identify smart energy technologies with ratepayer benefits such as improved reliability and efficiency, and environmental benefits in terms of reduced or avoided GHG emissions. Any barriers to adoption of these technologies, including potential regulatory challenges of retiring resources that have not been fully depreciated or that are still operating cost-effectively, need to be addressed. (Note that option RCI-5 suggests pilot smart meter programs that could complement this option.)

2. Provide incentives and remove barriers to improving the efficiency of the T&D system and components and to reducing line losses. [17] Regulations, incentives, and/or support

[15] According to the Wind Integration Study conducted by the Northwest Power Planning and Conservation Council, transmission capacity currently available to Northwest is only sufficient to support anticipated wind project development through 2009. Additional transmission capacity will be needed to achieve the 6000 MW of wind envisioned in the Council's plan and to open up new areas for wind development, which could provide access to better wind resources, diversify wind production, and as a result, lower the costs of wind generation and integration. Although transmission is regulated at the federal level, state policies should encourage such investments. http://www.nwcouncil.org/energy/Wind/library/2007-1.pdf

[16] Smart Grid technologies can involve, for instance, devices that "turn off" non-essential power when demand, and subsequent electricity prices, are high. Also technologies are used to co-ordinate a range of small scale distributed generation (including electric vehicles) and/or intermittent power, such as wind. For a discussion of Smart Grid technologies, see "Poised for Profit in Clean Energy Report: Powering Up the Smart Grid" www.climatesolutions.org/pubs/pdfs/PoweringtheSmartGrid.pdf

[17] Utilities use a variety of components throughout the transmission and distribution system to reduce losses. Increasing the efficiency of these components can further reduce losses. Vermont State, for example, offers a rebate to encourage users to install energy efficient transformers.

programs can be applied to achieve greater efficiency of transmission and distribution system components. Utility regulatory commissions should encourage utilities to identify opportunities to optimize transmission and distribution networks to minimize line losses through the replacement of or additions to existing facilities. *Policies should be designed to ensure that costs and benefits are equitably shared by utilities and customers, and such that incentives for public and private utilities are comparable.* [TWG may not be in agreement over wording of last sentence]

3. **Develop and apply procedures** to ensure that utilities can fairly and transparently assess "non-wires options", such as distributed generation or demand management, that can avoid or otherwise free up transmission and distribution capacity. Place these "non-wires" technologies on a level playing field when considering upgrades in traditional pole and wire infrastructure. (see Related Policies/Programs in Place, below, for examples on current pilot programs)

4. To help implement the above goals,

- Examine the Oregon Public Utility Commission's UM1129 decision as a possible approach to achieving the above goals and consider how similar approach can be applied to public utilities. http://apps.puc.state.or.us/edockets/orders.asp?OrderNumber=07-360
- Designate staff to track and recommend emerging technologies of potential benefit to stakeholders and ratepayers including distributed generation, combined heat and power, load management and end-use efficiency.
- Place a priority, where appropriate, on employing smart grid technologies such as voltage reduction to optimize delivery networks for minimal line losses.
- Work with public utility organizations, clean energy advocates and Bonneville Power Administration to overcome obstacles to local generation created by interconnection rules and losses of BPA power allocations.

The following recommendations were not discussed at the Aug 30th TWG:

5. **Investigate products and policies that make better use of existing transmission lines and transmission corridors.** Conditional firm and voluntary economic re-dispatch, that could enable new wind or other low GHG projects to come on line before new transmission lines are constructed, or extend the time until transmission construction is required. *Opportunity exists to increase transmission line carrying capacity as much as threefold through the implementation of new construction and retrofit activities on the transmission grid including incorporating advanced composite conductor technologies, capacitance technologies, and grid management software. Policy measures could provide incentives to utilities to upgrade transmission systems and reduce barriers to siting of new transmission lines.*

6. **Increase the capability, and reducing the costs, of integrating intermittent resources in the grid.** The cost of wind integration services can be reduced through generally four types of actions: (1) developing more cooperation between regional utilities to spread the variability of

wind more broadly; (2) developing markets that will reward entities who choose to market their surplus flexibility; (3) making more low-cost flexibility such as that provided by hydroelectric resources available; and (4) development and application of new flexibility technologies. Achieving these goals will require coordinated actions similar to those required to establish the Pacific Northwest Coordination Agreement of the Columbia River Treaty. Specifically, the Council's integration plan suggests that the:

- "four Northwest state regulatory commissions to review and amend as necessary regulatory policies to remove barriers to more efficient use of transmission for wind and other renewable resources, … and the
- Northwest Power and Conservation Council, working with BPA and other interested organizations, should establish a Northwest Wind Integration Forum to facilitate implementation of the actions called for in this *Action Plan.*"

7. This option could also include **reductions in use and leakage of SF_6** from distribution system transformers, plus efficient transformers and other materials and equipment.

- **Goals:** TBD

- **Timing:**
- **Coverage of parties**
  - Electric Utilities
  - Utility and Transportation Commission
  - Bonneville Power Administration
  - Northwest Power and Conservation Council
  - Northwest Power Pool or other regional transmission authorities and regional control area operators.
  - Coordinate with:
    - Northwest Energy Technology Collaborative
    - Northwest Center for Electric Power Technologies
    - Western Regional Climate Action Inititive
    - Energy Facility Site Evaluation Council
- **Other:**

Implementation Mechanisms

Related Policies/Programs in Place

BPA NonWires Solutions – is a highly advanced effort to replace costly transmission line upgrades with smart energy technologies.

Pacific Northwest GridWise Testbed – intends to provide an institutional structure for developing and hosting smart grid demonstration projects.

WA CTED is reviewing best practices for investing in smart-grid technologies

Type(s) of GHG Reductions

There are emissions reductions related to improved operations of electric power generation and improved access for renewables.
(Depending on whether it's included here: Emissions of SF_6 related to electric power transmission and distribution from WA GHG inventory, currently about 0.3 MMtCO2e.

Estimated GHG Savings (in 2020) and Costs per $MtCO_2e$

- **Data Sources:**
  - Poised for Profit in Clean Energy Report: Powering Up the Smart Grid, by Patrick Mazza
  - Northwest Wind Integration Action Plan, conducted by the Northwest Power and Conservation Council: http://www.nwcouncil.org/energy/Wind/library/2007-1.pdf
  - Smart Meters: Commercial, Policy and Regulatory Drivers, by Gill Owen and Judith Ward, which reports on experience with smart meters in the UK, and reports one to several percent net savings in electricity consumption from implementation of smart meters, as well as peak reduction impacts. Dated March 2006, Published by Sustainability First, and available as http://www.sustainabilityfirst.org.uk/docs/smart%20meters%20pdf%20version.pdf
- **Quantification Methods:**
- **Key Assumptions:**

Contribution to Other Goals

- **Contribution to Long-term GHG Emission Goals (2035/2050):**
- **Job Creation:** The Poised for Profit II Partnership found at least 225 companies in the Northwest representing 14% of the $15 billion global smart energy market. Additionally, the high regional concentration of software, semiconductor and wireless companies could find new opportunities and innovation in the energy sector.
- **Reduced Fuel Import Expenditures:**

Key Uncertainties

[Insert text here]

Additional Benefits and Costs

- Could eliminate $46-$117 billion in US peaking infrastructure investments over the next 20 years. (Poised for Profit in Clean Energy Report: Powering Up the Smart Grid, Climate Solutions, pg 8)

- Improves reliability of power grid
- Reduces losses from power lines
- Improves ability to utilize waste heat from power generation.
- Improves utilization of renewable generation

Feasibility Issues

- Issues associated with "access" and "planning" are subject to FERC jurisdiction and may not be appropriate to explore in the CAT venue.
- Reliance on new technologies which require extensive field testing.
- Can create shift from centralized power production to localized power production.
- Can have disruptive impacts on traditional utility business models that base revenue flows on gross throughput. Regulatory and ratemaking framework could create disincentives for adopting new technologies.

Status of Group Approval

TBD

Level of Group Support

TBD

Barriers to Consensus

TBD

ES-7. Combined Heat and Power and Thermal Energy Recovery and Use

Based on ES Catalog Option 2.5.

Mitigation Option Description

Combined heat and power (CHP) and thermal energy recovery and distribution can reduce GHG emissions by increasing the overall efficiency of fuel use, by reducing energy losses (where facilities are located near heat and power demands). These emissions benefits can be particularly significant where CHP and thermal facilities utilize low GHG fuels and feedstocks (e.g. biomass resources such as organic pulping byproducts). There are opportunities to recover thermal energy from CHP, industrial or municipal waste heat or renewable energy sources.[18] District energy systems provide a key infrastructure for conveying this "recycled" energy from the sources to energy consumers.

Policies can be adopted to encourage cost-effective CHP and waste heat recovery ("recycling") by ensuring that the full cost (including related electric energy transmission and distribution infrastructure costs plus transmission losses) of the alternative technology generation (typically a combined cycle plant) is compared to the cost of generating electricity at a CHP site (with the cost of heat sales to the thermal energy consumer covering any additional capital and operating expenses of the CHP project).

Mitigation Option Design

Recommended policies to promote CHP and thermal energy use, and ensure equitable comparison with electricity-only technologies, include:

1. Incentives to encourage, new CHP facilities, as well to expand and/or repower existing facilities. [*Current avoided costs are too low to incent CHP – TWG members are in discussion on wording of this sentence]*. The state should specifically consider establishing CHP tax credits under existing B&O tax system or form other sources to provide investment incentives. These incentives should be equally accessible to public as well as private power suppliers. Oregon's Business Energy Tax Credit (BETC) program provides a useful example for the State to consider.[19] Other potential financial incentives to implement CHP programs include:

[18] A variety of industries, such as pulp and paper mills, saw mills, steel mills, and aluminum smelters, alternative fuel generation plants, cement plants and other facilities, produce waste heat at temperatures suitable for building heating. Additionally, municipal operations produce byproduct energy in the form of landfill gas (which can be combusted in CHP engines or turbines) or sewage effluent (which can be converted to usable heat with heat pumps).

[19] For example, in Oregon there is a $20 million per project tax incentives program established under BETC system. Tax credits can be sold to third parties, enabling public utilities to take advantage of the program as well. Examples

- Siting Incentive Programs;
- Low-cost bonding or loan guarantee programs;
- Tax credits for investment in CHP;

2. **Amended procedures for streamlined permitting of CHP and thermal energy recovery facilities, without compromising other environmental goals**. (Seek input from air agencies on this and the following recommendation.)

3. *When regulating air emissions and GHGs (including GHG trading under a cap and trade program) consider* ***basing requirements on useful energy output rather than fuel input, so as to capture the benefits of higher end-use efficiency****. [TWG members are discussing whether the performance standard used in SB6001 is sufficient to override the need for this point]*

4. Financial incentives to implement district energy thermal distribution infrastructure, waste heat recovery and renewable thermal energy systems through a variety of programs including:

- Property owner incentives to join waste heat based district heating systems;
- Low-cost bonding or loan guarantee programs;
- Tax credits for *investment* in thermal energy projects, and/or for *production* of recycled energy;
- Incentives for buildings to connect to district energy systems established to use or convert to renewable energy or recover waste energy; and
- Incentives to upgrade existing steam district energy systems to hot water district energy distribution to enhance system performance and improve efficiencies.
- Encouragement of public/private partnerships for thermal energy transmission and distribution infrastructure installation.

5. Pro-active information/education/outreach communications are needed to address the importance of removing barriers to optimizing existing and CHP generation and district energy development. We need to overcome real or perceived barriers about such important issues as avoided cost barriers, regulatory barriers, lack of integrated community energy planning, and lack of financial sector misunderstanding of these systems.

- **Goals:** The goal will be expressed as an achievable fraction of technical or economic potential (see below).
- **Timing:**
- **Coverage of parties:**
- **Other:**

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of incentives for CHP for avoided cost calculations include: Thermal efficiency - $7/MWh; GHG savings of 1092 pounds of CO2 - $ 8/MWh; T&D incremental cost savings plus 8% loss - $ 10/MWhn; Credit for not needing hydro backup compared with wind- $12/MWh; Renewable fuel credit - $ 10/MWh; System security distributed energy credit – $5/MWh; Avoided fuel (natural gas price risk adjustment) UM 1129 (Oregon State Ruling)

Implementation Mechanisms

State wide IRP used to determine potential for CHP.

The following suggestions are from the RCI TWG:

- Training/certification of installers/contractors
- Creation/support of markets for biomass fuels
- Leveraging of attractive financing arrangements, tax benefits such as the existing sales and use tax incentive for machinery and equipment used for cogeneration facilities (RCW 82.08.02565[20] and RCW 82.12.02565[21]) and other incentives to promote CHP technologies.

Net-metering, rates, and interconnection issues:

- Removing high interconnection cost and regulatory access barriers similar to OR Public Utility Commission ruling under UM 1129.
- Increasing the current net-metering cap from 25 kW to 1 MW, and allow aggregation if appropriate in commercial and/or agricultural applications.

Permitting and siting

- Supporting county and city land use prescreening efforts to support siting.

Government lead-by-example:

- Addressing lack of funding for design of CHP and waste heat utilization systems associated with state facilities and university campuses.

Waste heat capture/recycling:

- A Washington State inventory of waste heat resources, evaluating the full renewable thermal energy potential in the State
- Incentives for new or existing waste heat generators to (re)locate adjacent or close by to heat users

Related Policies/Programs in Place

PURPA, 1978.
B & O Taxes.
Business Energy Tax Credits (BETC) in Oregon.

The Washington UTC has an interconnection standards process underway with provisions for comments

[20] http://apps.leg.wa.gov/RCW/default.aspx?cite=82.08.02565

[21] http://apps.leg.wa.gov/RCW/default.aspx?Cite=82.12.820

Senate Bill 6001 includes language to recognize the output of cogeneration, which could be modified for other policy design elements:
Section 5 (6) The department shall establish an output-based methodology to ensure that the calculation of emissions of greenhouse gases for a cogeneration facility recognizes the total usable energy output of the process, and includes all greenhouse gases emitted by the facility in the production of both electrical and thermal energy. In developing and implementing the greenhouse gases emissions performance standard, the department shall consider and act in a manner consistent with any rules adopted pursuant to the public utilities regulatory policy act of 1978 (16 U.S.C. Sec. 824a-3), as amended.

Senate Bill 6631 – Thermal Energy Companies – Exemption from Utilities and Transportation Commission Authority.

House Bill 114 – Regulation of District Heating Systems and Services

Chapter 35.97 RCW – Heating Systems

UM1129 Oregon Public Utilities Commission final order issues August 20th, 2007
http://apps.puc.state.or.us/edockets/orders.asp?OrderNumber=07-360

Types(s) of GHG Reductions

By recovering waste heat and reusing it, the equivalent amount of new fossil-based energy will be displaced resulting in a more energy efficient energy production program and significantly less GHG production per MWh generated.

Estimated GHG Savings (in 2020) and Costs per $MtCO_2e$

PRELIMINARY RESULTS – SEE APPENDIX B FOR MORE DETAILS

			Reductions		($MMtCO_2e$)*		
	Policy	**Scenario**	**2012**	**2020**	**Cumulative Reductions (2007–2020)**	**NPV (2007–2020) $ millions**	**Cost-Effective-ness $/tCO_2$**
ES-7	CHP	2,847 MW by 2020	0.35	1.3	7.6	$445	$59
	Thermal Energy Recovery and Use	TO BE COMPLETED					

- **Data Sources:**

RCW 82.35, which expired in 1984, included tax credits for CHP facilities. Reports may be available on the approach for the credits and on their impacts on CHP uptake.

CHP market potential

- **Combined Heat and Power in the Pacific Northwest: Market Assessment** This 2004 report provides: 1) A comprehensive review of current CHP capacity in the Pacific Northwest including a database by each state; 2) A review of the economic and technical market potential for additional CHP; 3) A review of barriers and incentives to CHP; and 4) Recommended actions to increase CHP deployment.
  http://www.chpcenternw.org/NwChpDocs/Chp_Market-Assessment_In_PNW_EEA_08_2004.pdf
- **Washington State CHP Technical Potential (2002-2022) MW:**

	Existing Facilities	New Facilities	Total	Economic Potential
Large Industrial	1,230	57	1,287	High
On-Site *Export*	*360* *870*	*57* *N/A*	*417* *870*	
Small Industrial	745	304	1,049	Low to Moderate
Commercial	2,885	2,473	5,358	Low
Resource Recovery	27		27	Moderate to High

Estimated Economic Potential (using 10-year payback):

731 MW (Business as Usual assumptions – current cost and performance specs, $3-4 /kW/month CHP Stand-by charges, no financial incentives)

2,847 MW (Accelerated Case assumptions – 2020 cost and performance specs, no stand-by charges, financial incentives equal to about 15% of capital costs)

Source: *Combined Heat and Power in the Pacific Northwest: Market Assessment* (Energy and Environmental Analysis Inc. 2004)

Northwest Power Council 5th Power Plan – estimates potential for CHP but need to consider the impacts of incentives and barrier removal on the CHP projections.

Technical Market Potential for CHP in the Pacific Northwest. This is an overview of CHP market potential by sectors.
http://www.chpcenternw.org/NwChpDocs/CHP_Market_Potential_in_PNW_Eng_Int_ORNL_rpt_07_2003.pdf

CHP

- **Quantification Methods :** Starting with an estimate for Washington's share of CHP potential in the Pacific Northwest, as provided in the *Market Assessment* report (Energy and Environmental Analysis Inc. 2004) 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 the CHP potential in Washington, the analysis is based on a potential of 2,847 MW (per the *Market Assessment* source above)[22]; 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.

Table Technology characteristics of new CHP equipment.

Technology	Capital Cost ($/kW)		Fraction of New CHP capacity	
	2012	2020	2012	2020
Natural Gas	$932	$840	100%	100%
Biomass	$1,182	$1,030	0%	0%
Coal	$932	$840	0%	0%

Source: Energy and Environmental Analysis, Inc for Oak Right National Laboratory (2004) *Combined Heat and Power in the Pacific Northwest: Market Assessmen*t, based on a 5MW gas turbine; biomass assumed to be $250 higher; coal assumed to be equal to gas turbine

- **Avoided costs and emissions:** See ES-2

Waste Heat Recovery Market Potential

- Turbosteam looked at the waste heat potential of just 5 key waste heat potentials in a number of states including Washington. This report reviews the potential for generating electricity from waste heat processes and determined that 235 MW and 1553 GWh's annually could be achieved by 2020. This would result in an annual reduction of almost one million tCO2e. (Turbosteam Corporation 161 Industrial Blvd. Turners Falls, MA 01376)

  SEE WORKSHEET POSTED ON ENERGY SUPPLY TWG WEBSITE FOR AUGUST 30TH MEETING http://www.ecy.wa.gov/climatechange/cat_twg_energy.htm

- There does not appear to be a similar comprehensive analytical study of all the waste heat potential not used for electricity generation in Washington.

Other potential data sources

- Western Governor's Association 2006 (WGA 2006) *Task Force Reports from the Clean and Diversified Energy Initiative,*[23] Energy Information Administration,[24]; and, Energy Trust of Oregon.[25]

[22] An alternate estimate of CHP potential is 1092 MW from a 2004 analysis by the Western Resource Advocates, *A Balanced Energy Plan for the Interior West*. http://www.westernresourceadvocates.org/energy/clenergy.php
[23] http://www.westgov.org/wga/initiatives/cdeac/index.htm
[24] http://www.eia.doe.gov/oiaf/aeo/assumption/index.html

- **Additional Assumptions:**

CHP is typically 1/3 more efficient than conventional stand-alone generating systems, where electric energy is generated and transmitted long distances from a centrally located generation facility. On-site CHP equipment is used to meet process system requirements, heating and cooling loads. The most efficient CHP systems provide generation efficiencies of 70-80%, a dramatic improvement over conventional power generation that currently averages 31% nationwide with associated reductions in GHG emissions. In addition, transmission and distribution infrastructure costs plus transmission losses are generally eliminated with CHP because these facilities are located on-site at the load centers.

Natural gas fuel savings for CHP include a an estimate by the California Cogeneration Council (testimony before the California Energy Commission) that 5,000 MW's of new CHP would reduce California's natural gas demands by 9%. The thermal efficiency for a CHP plant can be as high as 89%, significantly better than the 57% thermal efficiency associated with generating plant with a stand-alone steam boiler. [Need to check the above assumptions with the 2004 CHP report]

Contribution to Other Goals

- **Contribution to Long-term GHG Emission Goals (2035/2050):**
- **Job Creation:**
- **Reduced Fuel Import Expenditures:**

Key Uncertainties

No significant CHP capacity has been built during the past 15 years due to a number of important economic and policy barriers that need to be overcome:

- Dispatchabilty control by utilities can be a concern for the plant owner. Mutually agreeable dispatch protocols should be negotiated between the plant owner and the host utility.
- Grid interconnection standards and associated costs should be streamlined by Washington State where applicable.
- High transaction costs associated with CHP 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.
- Consistent, long term clear incentives supporting CHP and waste energy recovery.

Need for a pro-active public information campaign to educate and inform the public of the benefits of CHP to Washington and the NW economy.

Additional Benefits and Costs

[25] *A Comparative Analysis of Community Wind Power Development Options in Oregon* http://www.oregon.gov/ENERGY/RENEW/Wind/docs/CommunityWindReportLBLforETO.pdf

[Insert text here]

Feasibility Issues

Local opposition to siting of facilities in areas where CHP would work - relatively high density areas with large thermal load needs

Status of Group Approval

TBD

Level of Group Support

TBD

Barriers to Consensus

TBD

ES-8. Advanced Fossil Fuel Generation and Pre-Combustion Sequestration Technologies

Based on ES Catalog Option 3.1a.

Based on TWG suggestions at the latest TWG meeting, this option is now being incorporated into ES-5.

APPENDIX A

ADDITIONAL INFORMATION FOR SPECIFIC OPTIONS PROVIDED BY TWG MEMBERS

ES-2. Distributed Renewable Energy Incentives and/or Barrier Removal

PSE offers two incentive programs that provide ongoing, annual benefits. Net Metering (Schedule 150) allows the energy produced by a customer's renewable-energy system to offset the customer's usage of PSE-provided electricity over the course of a year at the retail rate of ~9 cents per kWh. For months in which a customer's self-generated renewable energy exceeds the amount of PSE electricity consumed, that excess production is rolled over to offset PSE power usage in other months. Typically, high summer production of renewable energy can offset high winter usage of PSE-provided power. In addition to Net Metering, PSE elected to create a separate incentive program as authorized by State Senate Bill 5101 (2005) and Washington Administrative Code 458-20-273. PSE provides all of the consumer benefits allowed under the state law. The PSE program (called the Renewable Energy Advantage Program under Schedule 151) provides a payment for Production Metering. The purpose of this program is both to encourage small-scale renewable-energy generation and to induce in-state production of renewable-energy system components. The Production Metered payments to customers can range from 12 cents/kilowatt hour (kWh) to 54 cents/kWh if the parts of a particular renewable energy system were manufactured in Washington. The law set an annual cap of $2,000 in incentive payments per installation.

ES-3. Efficiency Improvements, Capacity Additions and Fuel Switching at Existing Renewable and Fossil Power Plants

- In Washington State, the overall energy load was approximately 9,500 aMW and the overall energy generation was 11,000 aMW. Approximately 70 percent of the energy generation was from non-emitting resources and 30 percent was from natural gas and coal. If existing projects were able to increase energy generation by approximately 10 percent through efficiency improvements, an additional 1,100 aMW would be available to replace the use of fossil fuels. This is equivalent to about 10,000,000 MWh – enough power to serve about 1,000,000 homes annually.
- In the Pacific Northwest, there are more than 20 projects currently being built and expected to be completed in the next two years. These projects total over 2,500 MW of capacity of which 1,300 MW is wind and other renewable generation. Many NW utilities (including all utilities operating in Washington) are in the process of developing integrated resource plans to evaluate their power needs for the next 10 to 20 years. Additional non-emitting or low-emitting generation resources from existing projects need to be encouraged.

- Although Washington State gets about 30 percent of its energy from GHG emitting resources, there are ways to reduce GHG emissions by switching high-emission fuels to other fuels sources or cleaner fuel types.

ES-5. Carbon Capture, Storage, and Re-use Incentives, Requirements and/or Enabling Policies and Research & Development (including pre-combustion technologies)

A broad regulatory framework is required that supports the identification, development and deployment of technologies that capture, sequester or reuse CO_2. For Washington State, and the USA, to achieve CO_2 goals a multi sector approach is required, but within the electricity supply sector three technologies are emerging as near term scalable technologies.

- **Pre and Post CO_2 Combustion Capture**
    - Technologies
- Do not try to pick a single winning technology. It is important to create a framework in which industry will invest in a broad range of low emitting technologies. It will take a sum total of all technologies to achieve long-term CO_2 reduction roles
- Proper incentives allow and encourage industries to take early risks inherent in new technologies. A broad range of incentives should be pursued which will apply to different technologies, and technologies at different stages of deployment.
- In the absence of long-term clarity, higher emitting generation will likely continue to be built, and may face extraordinary environmental costs later in life. Effort must be made to avoid stranding assets due to the financial implications on utility companies and the end customers.
- Current and new policies must be able to adapt to the latest changes, and continue to adapt as technology continues to be developed and implemented. Failure to do so is likely to stall, if not impede, the construction of billion of dollars of productive infrastructure in the US.
- Three technology branches appear to offer the best near-term solution to low-GHG emitting base load electricity:
    - Ultra supercritical [*coal-fired generation*] with carbon capture
    - IGCC [*integrated gasification combined-cycle plants using coal, sometimes with biomass co-firing*] with carbon capture
    - Nuclear [*power*] *[TWG members are not in agreement about including nuclear power here]*
- The net reduction of emissions to the atmosphere through CCSR depends on the fraction of CO_2 captured, the increased CO_2 production resulting from loss in overall efficiency of power plants or industrial processes due to the additional energy required for capture,

transport and storage, any leakage from transport and the fraction of CO_2 retained in storage over the long term. The most viable of these technologies today appears to be Integrated Gasification Combined Cycle (IGCC) combined with carbon capture and storage and reuse (CCSR) technology. There are also emerging CCSR technologies that show promise for capturing carbon emissions from traditional pulverized coal fired boilers. These emerging technologies include chilled ammonia scrubbing and oxy-fuel combustion. Carbon capture technologies have the potential to remove approximately 90 percent of a coal plant's CO_2 emissions.

- R&D for the CCSR technologies is also vital for their larger scale commercialization. R&D funding can also be made available to CCSR technologies 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 these technologies.
- The important role of advanced clean coal technology is recognized in the Western Public Utility Commissions' Joint Action Framework on Climate Change, signed on December 1, 2006 by the Washington, Oregon, California and New Mexico public utility commissions.[26] The Framework's Statement of Shared Principles includes five principles, the second of which is "Development and use of low carbon technologies in the energy sector." The third of six Action Items is: "Explore ways to remove barriers to development of advanced, low-carbon technologies for fossil fuel-powered generation capable of capturing and sequestering carbon dioxide emissions."

- **CO_2 Storage**
  - Technologies
  - Liability
- There are significant legal barriers to carbon sequestration related to environmental and other legal liability and property rights. Many of these fall into areas traditionally governed by state law and, hence, must be addressed if carbon sequestration is to become reality in the state.
- Avoided GHG emissions attributable to CCS equipment placed into operation prior to any mandate or that exceed an operating permit limitation should be creditable as early actions within the context of a regional mechanism to achieve GHG reductions
- Emphasize the need for Washington to support near term CCS demonstration projects (Similar to the arguments in the PacifiCorp white paper).

[26] Western Public Utility Commissions' Joint Action Framework on Climate Change (December 1, 2006), located at http://www.puc.state.or.us/puc/news/2006/2006026jointaction.

- Washington's large basalt formation may hold significant CO_2 sequestration capacity. Developing a carbon sequestration industry in Washington will bring long-lasting benefits. Industries created around reusing CO_2 should also have a high priority.
- There are significant technological challenges associated with post-combustion capture. Consequently, if this technology is going to emerge it will require much broader support than simply a state-led initiative.

Estimate of Mitigation Option Costs and Benefits for Washington Energy Supply GHG Analysis

ES-2 Distributed renewable energy incentives and/or barrier removal

Date Last Modified: *12/09/2007* *G. Powell*

Key Data and Assumptions	2012	2020/all	Units
First Year Results Accrue		2009	
Option Design Elements:			
Target Year for Reaching Solar Hot Water (SHW) Implementation Level		2015	
Fraction of additional existing Washington Homes with Solar HW by Target Year		0.8%	
Using the Western Governor's Association estimate of 500,000 systems installed by 2015 for entire region. The WA fraction was estimated using same fraction as used for WGA estimates of Solar PV by state (accounting for electricity use, solar insolation, and population growth).			
Target Year for Reaching Distributed Wind Generation Implementation Level		2020	
Additional WA Distributed WindGeneration Achieved by Target Year		30.00	MW
*Placeholder for now (See **Note 7** for WA specific information)*			
Target Year for Reaching Solar PV Implementation Level		2020	
Additional WA Solar PV Achieved by Target Year		20	MW
*Placeholder for now (See **Note 9** for WA specific information)*			
Avoided Electricity Cost		$43	$/MWh
Weighted average over total 2007-2020 electricity savings for this policy in each sector. See common assumptions ("Common Factors" worksheet in this workbook).			
Avoided Natural Gas Cost		$7.5	$/MMBtu
See common assumptions ("Common Factors" worksheet in this workbook)			
Avoided LPG Cost		$11	$/MMBtu
See common assumptions ("Common Factors" worksheet in this workbook)			

Results	2012	2020	Units
Savings due to Implementation of ES-2 Programs			
Electricity			
TOTAL Reduction in Electricity Sales (savings from SWH/CHP plus electricity output from CHP/Solar PV and landfill gas/biomass/biogas systems)	58	156	GWh (sales)
Reduction in Generation Requirements	46	114	GWh (generation)
Gross GHG Emission Savings	0	**0.06**	$MMtCO_2e$
Natural Gas			
Net Change in Gas Use (negative values denote increased use)	99	181	Billion BTU
Net GHG Emissions (negative values denote increased emissions)	0.01	0.01	$MMtCO_2e$

Summary Results for ES-2 (DG)	2012	2020	Units
Total for Policy (Electricity, Natural gas, LPG, Oil, Landfill Gas, Biomass, Biogas)			
GHG Emission Savings	**0.03**	**0.07**	$MMtCO_2e$
Net Present Value (2007-2020)		**$34**	$million
Cumulative Emissions Reductions (2007-2020)		**0.5**	$MMtCO_2e$
Cost-Effectiveness		**$68.95**	$/tCO_2e$

Other Data, Assumptions, Calculations	2012	2020/all	Units

Residential Sector Water Heating

Number of Total Housing Units in Washington (thousand)	2,956,453	3,210,585	

Table 1: Annual Estimates of Housing Units for the United States and States: April 1, 2000 to July 1, 2006 (HU-EST2006-01)
Source: Population Division, U.S. Census Bureau
Release Date: August 15, 2007

Assumes 2005 ratio of new homes to increase in population holds through 2020.

Fraction of Additional Housing Units Solar Water Heat through Program	0.4%	0.8%	
See assumptions above			
Fraction of Housing Units Using Non-Solar Water Heat In Absence of Program			
Fraction Using Electricity	42.0%	42.0%	
Fraction Using Natural Gas	58.0%	58.0%	
Fraction Using LPG	0.0%	0.0%	
Fraction Using Solar (alone or with back-up, before policy)	0.0%	0.0%	

Rough Estimates using NW region mix for new houses, From NW Alliance Water Heater Market Study, nwalliance.org/research/reports/06-158.pdf

Use of Electricity and Other (non-solar) Energy Sources per (non-solar) Household in Absence of Program			
Electricity	4,000	3,810	kWh
Natural Gas	17.96	17.27	MMBtu
LPG	17.96	17.27	MMBtu

Value for 2010 assumes 4000 kWh per HH using electricity for water heat, which is a rough estimate pending receipt of state-specific data. Estimates for gas and lpg base on average EF of .93 for Electricity, .7 for Natural Gas/LPG. Value in 2020 assumes a 5% reduction in energy intensity

Additional Households Using Solar HW Under Program (thousand)	12.7	24.1	
Fraction of household hot water needs provided by solar HW units	75.0%	75.0%	

Placeholder Assumption--Back-up fuels used for water heating in housing units with solar water heating are assumed to be distributed based on the pre-Policy fractions given above. (placeholder based on report for Environment Canada)

Savings of Electricity and Other (non-solar) Energy Sources Due to Program			
Electricity	15.8	28.9	GWh
Natural Gas	0.099	0.181	TBtu
LPG	-	-	TBtu
Capital Cost of Solar Water Heater	$2,534	$2,200	

Assumption used in EIA's Annual Energy Outlook 2007. http://www.eia.doe.gov/oiaf/aeo/assumption/pdf/residential.pdf

Implied Cumulative Additional Annualized Capital Costs for Residential Solar Hot Waters Installed as a Result of Policy (thousand 2005 dollars)	$ 2,182	$ 3,601	

Factors for Annualizing Capital Costs (Residential Solar Hot Water Systems)		
Interest Rate (real)	7%	/yr
Economic Life of System	20	years
Implied Annualization Factor	9.44%	%/yr
Marginal Federal Tax Rate, Residential	28%	

Intermediate Results: Residential SWH Program

Reduction in Electricity Sales from SWH Program: Residential	16	29	GWh (sales)
Reduction in Generation Requirements	17	31	GWh (generation)
GHG Emission Savings	**0.01**	**0.02**	$MMtCO_2e$

Economic Analysis (for Electricity Savings due to SWH Program)

Net Present Value (2007-2020)	2	$million
Cumulative Emissions Reductions (2007-2020)	0.1	$MMtCO_2e$
Cost-Effectiveness	**$14.09**	$/$tCO_2e$

Natural Gas

Savings due to Implementation of SWH Program

Reduction in Gas Use	99	181	Billion BTU
GHG Emission Savings	0.05	0.10	$MMtCO_2e$

Economic Analysis (for Gas Savings due to SWH Program)

Net Present Value (2007-2020)	**$1.2**	$million
Cumulative Emissions Reductions (2007-2020)	0.84	$MMtCO_2e$
Cost-Effectiveness	**$1.46**	$/$tCO_2e$

LPG

Savings due to Implementation of SWH Program

Reduction in Gas Use	0	0	Billion BTU
GHG Emission Savings	0.00	0.00	$MMtCO_2e$

Economic Analysis (for LPG Savings due to SWH Program)

Net Present Value (2007-2020)	0	$million
Cumulative Emissions Reductions (2007-2020)	0.000	$MMtCO_2e$
Cost-Effectiveness	**#DIV/0!**	$/$tCO_2e$

Distributed Wind Generation

Washington Potential for Distributed Wind		30	MW
*Placeholder for now (See **Note 7** for WA specific information)*			
Estimated Future Washington Potential for Distributed Wind	10	30	MW
Potential assumed to scale with forecast commercial plus industrial electricity sales.			
Fraction of Potential Installed Under Program (Cumulative)	100.0%	100.0%	
MW Wind Installed Under Program (annual installations)	3	3	MW
Average full-capacity-equivalent hours of operation for New CHP units:	3,066	3,066	
(Assumption based on capacity factors of :)	35.0%	35.0%	
Placeholder, from Energy Trust Oregon 2004 report by Wiser et al., based on 1.5MW system. See Note 4.			
Implied Cumulative Distriubuted wind Electricity Output (GWh)			
Wind	**31**	**92**	

Inputs to Cost Estimates for Distributed Wind Systems

Estimated Average Installed Capital Costs by System Type ($2005/kW)			
Wind	$ 2,388	$ 1,194	$/kW
Placeholder, from Energy Trust Oregon 2004 report by Wiser et al., based on 1.5MW system. See Note 4.			
Factors for Annualizing Capital Costs (all plant types)			
Interest Rate		8%	/yr
Economic Life of System		20	years
Implied Annualization Factor		10.19%	%/yr
Estimated Average Non-fuel Operating and Maintenance Costs by System Type ($/MWh)			
Wind	$ -	$ -	

Intermediate Results for Cost Estimates

Total Capital Costs for New Systems (thousand 2005 dollars)		
Wind	**$ 5,373**	**$ 2,985**
Annualized Capital Costs for All Systems (thousand 2005 dollars)		
Wind	**$ 2,341**	**$ 5,625**
Annual Non-Fuel Operating and Maintenance Costs for All Systems (thousand 2005 dollars)		
Wind	**$ -**	**$ -**
Total Non-Fuel Costs for All Systems (thousand 2005 dollars)		
Natural Gas	**$ 2,341**	**$ 5,625**

Intermediate Results: Distributed Wind

Electricity

TOTAL Reduction in Electricity Sales (electricity output from wind generation)	31	92	GWh (sales)
Reduction in Generation Requirements	33	99	GWh (generation)
Gross GHG Emission Savings	**0.02**	**0.05**	$MMtCO_2e$

Total for Distributed Wind Program

Net Present Value (2007-2020)	**$9**	$million
Cumulative Emissions Reductions (2006-2020)	0.3	$MMtCO_2e$
Cost-Effectiveness	**$28.90**	$/$tCO_2e$

Solar Photovoltaics (PV)

Total Additional Capacity of PV Built under Program	6.7	20.0	MW
Annual Additional Capacity of PV Built under Program	1.7	1.7	MW
Fraction of Additional Capacity As			
Residential PV Systems	20%	20%	
Commercial PV Systems	80%	80%	
Average Capacity of Solar PV System Installed on Homes (kW)	**3.00**	**3.00**	
*Assumption, consistent with capacity assumption used in Source in **Note 2**.*			
Average Capacity of Solar PV System Installed on Commercial Buildings (kW)	**20.00**	**20.00**	
*Assumption, roughly consistent, per square foot of floor area, with capacity assumptions for new and existing residential buildings used in Source in **Note 2**. See also **Note 6** for calculation of average floor area of commercial builidngs.*			
Number of Homes Installing Solar PV Systems Annually	**111**	**111**	
Total Number of Homes with Solar PV Systems Installed under this Option, 2009 to 2020: 1,333			
*Note that a cummulative ~4,300 solar PV systems by 2020 is considerably less, on a per-capita basis, than the 1.2 million solar homes by 2020 used in an estimate of solar PV contributions to GHG emissions reduction in California (see **Note 2**).*			
Implied number of Commercial Solar PV Systems Added Annually	**67**	**67**	
Calculated based on target capacity and capacity-per-building assumption above.			
Total Annual Residential Solar PV Capacity Installed on Homes (MW)	**0.33**	**0.33**	MW
Total Annual Commercial Solar PV Capacity Installed (all Buildings) (MW)	**1.33**	**1.33**	MW
Estimated Annual Total Solar PV Installed Under Policy by Year (MW)	**1.67**	**1.67**	MW
Estimated Cumulative Total Solar PV Installed Under Policy by Year (MW)	**6.67**	**20.00**	MW
Average full-capacity-equivalent hours of operation for Solar PV Systems:	**1,752**	**1,752**	
Based on WGA report for Solar--See Note 4.			
(Assumption based on capacity factors of :)	20.0%	20.0%	
Implied New Solar PV Output, Cumulative Systems (GWh)	**11.68**	**35**	GWh

Inputs to Cost Estimates for Solar PV Systems (Data from Source in *Note 3*)

Capital Costs for PV Systems for Homes			
Total System - $/kW	**$ 4,904**	**$ 3,265**	
Total System - $	**$ 14,712**	**$ 9,795**	
*WGA report, See **Note 1,** assume additional decrease in cost after 2015 at half the rate of decrease from 2010 to 2015*			
Commercial System Capital costs/kW Relative to New Residential			
Total System - $/kW	**$ 2,464**	**$ 1,870**	
Total System - $	**$ 49,280**	**$ 37,400**	
*WGA report, includes Federal incentives, See **Note 1,** assume additional decrease in cost after 2015 at half the rate of decrease from 2010 to 2015*			
Solar PV Operating and Maintenance (O&M) Costs ($/MWh)	$ 10.00	$ 5.00	
WGA report,			
Federal Solar Tax Credits: Residential Sector--See ***Note 3***	0%	0%	
Federal Solar Tax Credits: Commercial and Industrial Sectors--See ***Note 3***	0%	0%	
already accounted for in capital costs			

Factors for Annualizing Capital Costs (Residential PV Systems)		
Interest Rate	7%	/yr
Economic Life of System	20	years
Implied Annualization Factor	9.44%	%/yr
Marginal Federal Tax Rate, Residential	28%	
Factors for Annualizing Capital Costs (Commercial PV Systems)		
Interest Rate	8%	/yr
Economic Life of System	20	years
Implied Annualization Factor	10.19%	%/yr
Reduce Captial Costs for Solar Tax Credits and Federal Mortgage Deductions?	**NO**	

Intermediate Results for Solar PV System Cost Estimates

Total Capital Costs for New Systems (thousand 2005 dollars) Before Tax Credits		
Systems for Residences	$ 1,635	$ 1,088
Systems for Commercial Installations	$ 3,285	$ 2,493
Annualized Capital Costs for All Systems (thousand 2005 dollars)		
Systems for Residences	$ 680	$ 1,647
Systems for Commercial Installations	$ 1,440	$ 3,699
Annual Operating and Maintenance Costs for All Systems (thousand 2005 $)	$ 93	$ 175

Intermediate Summary Results for Solar PV Generation Program

Total Electricity Output	11.7	35.0	GWh (sales)
Reduction in Generation Requirements	13	38	GWh (generation)
Gross GHG Emission Savings	0.01	0.02	$MMtCO_2e$
Total Cost (net of value of electricity output)	$ 2	$ 4	$million
Net Present Value (2007-2020)		$18	$million
Cumulative Emissions Reductions (2006-2020)		0.1	$MMtCO_2e$
Cost-Effectiveness		$146.24	$/tCO_2e$

NOTES AND DATA FROM SOURCES

Note 1:

From Western Governor's Association, Clean and Diversified Energy Initiative
Solar Task Force report http://www.westgov.org/wga/initiatives/cdeac/index.htm

Table 1. Current and Projected Levelized Cost of Energy for PV Systems

	Residential Systems (no incentives)			Commercial Systems (w/ ITC and MACRS)		
Year	2005	2010	2015	2005	2010	2015
Interest Rate (real) (i) *	4.0%	4.0%	4.0%	5.0%	5.0%	5.0%
System Lifetime (n)	25	30	30	25	30	30
Capital Recovery Factor (CRF)	0.064	0.058	0.058	0.071	0.065	0.065
System Selling Price ($/Wdc)	7.30	5.17	3.89	6.00	4.41	3.60
AC-DC Conversion Efficiency (%)	91%	94%	97%	93%	95%	97%
AC Equiv. System Price ($/Wac)	8.02	5.50	4.01	6.45	4.64	3.71
Fed ITC Rate (at permanent 10% level)	-	-	-	10%	10%	10%
Value of Fed ITC	-	-	-	0.65	0.46	0.37
Sys Cost after Fed ITC	-	-	-	5.81	4.18	3.34
Fed Accelerated Depreciation (Net Present Value)**	-	-	-	34%	34%	34%
Value of Fed Acc Dep. (basis = .95*system cost)	-	-	-	2.08	1.50	1.20
Final Cost ($/Wac) (ICC)	8.02	5.50	4.01	3.72	2.68	2.14
Capacity Factor (CF)	21%	21%	21%	18.5%	18.5%	18.5%
O&M	0.02	0.01	0.005	0.02	0.01	0.005
Levelized Cost of Energy (LCOE) (cents/kWh)* **	**29.9**	**18.3**	**13.1**	**18.3**	**11.8**	**9.1**

* These are real interest rates (i.e., adjusted for inflation and tax benefits) not nominal interest rates.
** Based on MACRS rates from IRS Publication 946, Table A-2 (assuming investment is made in 1st quarter of the year).
*** The LCOE values were calculated using the standard formula for amortization of cost over time, assuming the system is financed through a loan matched to the lifetime of the system.
LEC = (ICCx1000xCRF)/(CFx8760)+O&M, where
ICC = Installed Capacity Cost ($/Wp),
CRF = Capital Recovery Factor = (i*(i+1)^n)/((i+1)^n-1),
CF = Capacity Factor,
O&M = Operation and Maintenance ($/kWh),
i = interest rate,
n = system lifetime (i.e, how many years to amortize cost of system over).

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Note 2:

Source: Worksheet "Solar Homes Summary table.xls", with calculations in support of the California Million Solar Homes Initiative, authored by XENERGY, Inc., and provided by M. Lazarus. Selected annual data provided.

Note 3:

A description of the new Federal Solar Tax Credits for businesses and residences
as contained in the Energy Policy Act of 2005 (EPAct 2005) (see, for example,
http://www.seia.org/getpdf.php?iid=21) provides for 30% (of system cost) tax credits for solar PV investments by businesses in 2006 and 2007, reverting to 10% thereafter. For residences, the credit in 2006 and 2007 is 30% with a "cap" of $2000, reverting to zero after 2007.
See also, for Example,
http://www.sdenergy.org/uploads/PV-Federal%20Tax%20Credits%20Summary%206-01-04%20FINAL.pdf.

Note 4:

Information from a report prepared for the Energy Trust of Oregon, prepared by
Mark Bolinger, Ryan Wiser, Tom Wind, Dan Juhl, and Robert Grace (2004)
A Comparative Analysis of Community Wind Power Development Options in Oregon
http://www.oregon.gov/ENERGY/RENEW/Wind/docs/CommunityWindReportLBLforETO.pdf

Note 5:

Source: International Energy Agency (IEA), TRENDS IN PHOTOVOLTAIC APPLICATIONS
Survey report of selected IEA countries between 1992 and 2004. Report #IEA-PVPS T1-14:2005.
Page 18.
"Indicative costs" in 2004 in USD per kWp (assumedly DC output) for on-grid PV systems in the US:

<10 kW	7000 to 10,000
>10 kW	6300 to 8500

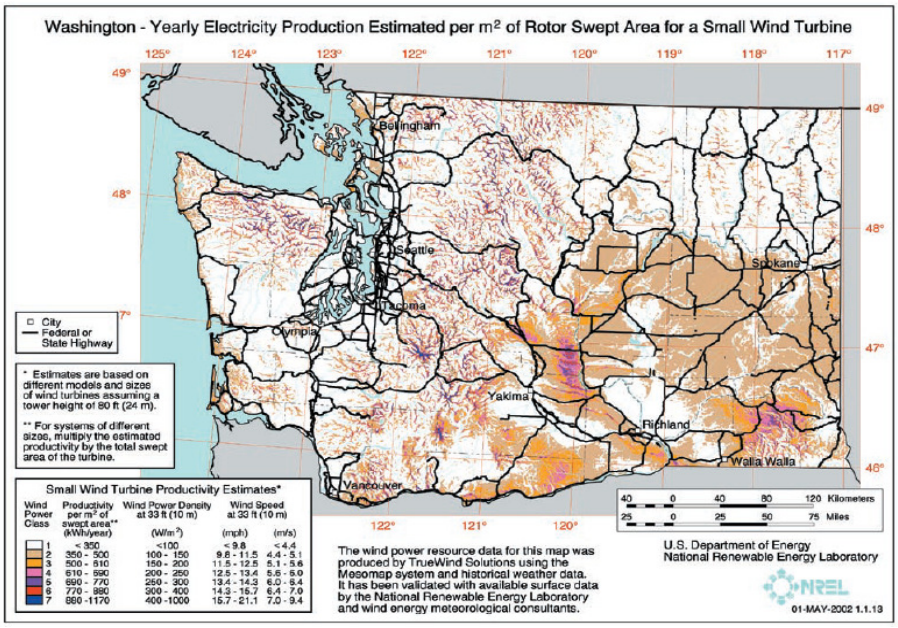
In EIA Projections of Renewable Energy Costs, presented in "Forum on the Economic Impact Analysis of NJ's Proposed 20% RPS" by Chris Namovicz of the USDOE EIA (Energy Information Administration), dated February 22, 2005, and available as http://www.eia.doe.gov/oiaf/pdf/rec.pdf, a wind power average cost of
6000 dollars/kW is provided for a 25 kW Commercial system, or
8200 dollars/kW for a 2 kW Residential system, with
"Large potential for cost reduction".

Note 6:

An older (1997) US DOE document OVERVIEW OF PHOTOVOLTAIC TECHNOLOGIES
(available as http://www.eere.energy.gov/ba/pdfs/pv_overview.pdf) suggests that even early solar PV systems had O&M costs of under $ 0.005 per kWh, which in 2005 dollars would be: $ 0.0059 per kWh.

Note 7:
Small Wind Potential in WA:

Source: http://www.eere.energy.gov/windandhydro/windpoweringamerica/pdfs/small_wind/small_wind_wa.pdf



Source: http://www.awea.org/smallwind/documents/AWEA_SWT_Market_Study_6-05.pdf
Home and Farm Wind Energy Systems: Reaching the Next Level
AWEA Global Small Wind Industry Market Study Confirms Need for Level Playing Field: June 2005

30 MW of small wind capacity installed in US between 1990 - 2004.
Small wind companies project growth targets of 18-21% by 2010, 107 MW by 2010.

Source: Renewable Energy Atlas of the West: http://www.energyatlas.org/PDFs/LowRes/atlas_state_WA.pdf
Total WA wind potential: 62 million MWh/yr

Source: WA Governor's Report: Wind Supply Task Force http://www.westgov.org/wga/initiatives/cdeac/Wind-full.pdf
240 MW wind capactiy installed in WA as of 2004

Wind Potential in WA: 1,050 MW by 2015 under scenario 1

Scenario 1. Wind development that is either in progress or can be reasonably assumed to occur based on existing plans with minimal new transmission additions. Evidence from prior work on the ability of new transmission tariffs and related policy implementation was assumed to help stimulate wind additions. This represents a near-term goal.

Note 8:
Water Heater Fuel Sources

DOE, AEO 2007:

Residential Fuel Source for Water Heaters in the West:
Electricity: 15 million homes: 64%
Natural Gas: 7.9 million homes: 33%
LPG: 0.7 million homes: 3%

Source: http://nwalliance.org/research/reports/06-158.pdf
Northwest Energy Efficiency Alliance Proprietary
Water Heater Market Study
Retrofit water heaters: 57% electric and 43% natural gas
New construction water heaters: 48% electric and 52% natural gas

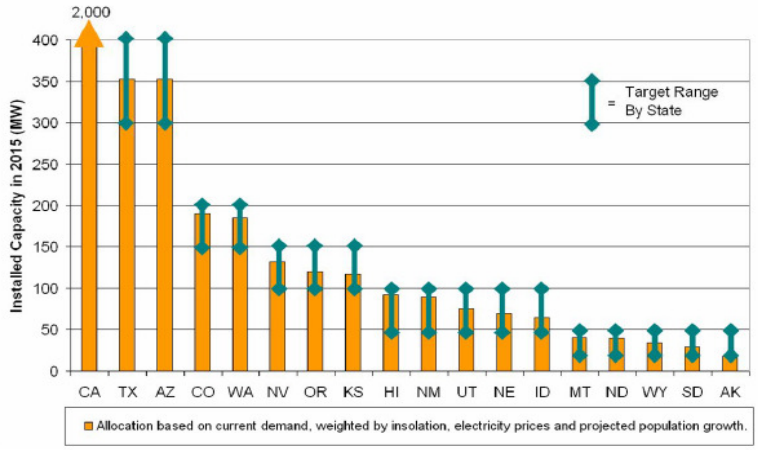
Note 9:
Distributed Solar PV

Source: http://www.westgov.org/wga/initiatives/cdeac/Solar-full.pdf
Western Governor's Report:

By 2015:
4,000 MW of distributed solar PV

WA potential:
Based on current demand, weighted by the amount of sunshine, electricity prices and projected population growth
WA installed capacity in 2015 184 MW +- 10 MW

Figure II-1. Weighted Allocation of Installed Capacity in WGA States (Total = 4GW in 2015)



Source: NREL

State	Electricity Demand (TWh)[1]	Initial Share	Solar Insolation (kWh/kW)[2]	Insolation Multiplier	Average Electricity Price 2003 (¢/kWh)[3]	Electricity Price Multiplier 2003	Population 2005 (million)[4]	Population 2015 (million)[4]	10 Year Population Growth Index	Population Growth Multiplier	Final Share[5]	Final Allocation (MW)	
WA	79.7	17.3%	1139	0.72	5.9	0.94	6.205	6.951	1.12	1.03	11%	184	

Source: PV Grid Connected Market Potential under a Cost Breakthrough Scenario: The Energy Foundation: Sept 2004
http://www.ef.org/documents/EF-Final-Final2.pdf

2025 Technical Ultimate Potential (MWp)					
State	Residential Total	Commercial Total	Total	% share of U.S Total	% share of Residential
Washington	13,337	11,297	24,633	2%	54%

Note 10
Solar Hot Water

Source: http://www.westgov.org/wga/initiatives/cdeac/Solar-full.pdf
Western Governor's Report:

By 2015:

500,000 solar hot water systems could be installed providing the equivalent of 2,000 MW generating capacity and 15 billion ft^3 of natural gas

As an example, Hawaiian Electric Company's Energy Solutions Solar Water Heating Program has grown to over 3,000 systems per year since its inception in 1996

European countries have also instituted a series of very successful incentive programs for solar water and space heating systems, enabling them to make significant progress and poising them for continued growth. Incentive programs are quite modest in countries with the most active solar water heating programs with rebates ranging from $300 to $1400 per system depending on size. Many of these countries have substantially less solar resource than that available in the Western US, yet they have more aggressive solar thermal programs. A subset of seven European Union countries[40] together installed approximately 250,000 solar thermal systems in 2003, or 875 MW_{th} equivalent.[41] Austria alone (population of 8.1 million) has an existing installed solar thermal generating capacity of 1,469 MW_{th}, equal to all of the installed solar thermal capacity in the entire US (population 294 million). Israel, with the population roughly equivalent to Arizona, is home to 5 percent of the world's solar water heating deployments. By contrast, the US solar thermal market for water heating has been stagnant for a number of years at around 8,000 systems.

WGA goal		
	500000	systems for entire WGA region
scale this goal to Washington based on the ratio used for PV in WGA report, see Note 9		
WGA goals for Solar PV		
WGA region	4000	MW
WA	184	MW
WA's fraction	5%	
WA Solar Hot wa	23000	systems
	3,066,505	number of WA households in 2015
	0.8%	Fraction of homes in 2015

Estimate of Mitigation Option Costs and Benefits for Washington Energy Supply GHG Analysis

ES-7 Combined Heat and Power (CHP) and thermal energy recovery and use

Date Last Modified: *18/09/2007* *G. Powell*

Key Data and Assumptions	2012	2020/all	Units

Total Remaining Estimated CHP Potential in WA as of 2004

2,847 MW (See ***Note 1***)

From the Combined Heat and Power in the Pacific Northwest: Market Assessment, dated August 2004, to the Oak Ridge National Laboratory (http://www.chpcenternw.org/NwChpDocs/Chp_Market-Assessment_In_PNW_EEA_08_2004.pdf)

First Year Results Accrue		2009	
Fuel Costs	2012	2020/all	Units
Natural Gas (Commercial and Industrial, Delivered)		$7.5	$/MMBtu
PLACEHOLDER for now			
Biomass		$3.2	$/MMBtu
PLACEHOLDER for now			
Oil		$12.5	$/MMBtu
PLACEHOLDER for now			
Coal		$0.7	$/MMBtu
PLACEHOLDER for now			
Avoided Electricity Cost		$43	$/MWh
Estimate derved from NWPCC data from RTF analysis, same source as marginal CO2 emission rate for electricity reductions, this is the average of the marginal dispatch costs for 2010, 2015, and 2020			
NEED TO CHECK THAT NWPCC VALUES ARE REAL 2005$			
Avoided electricity emissions rate	0.50	0.50	tCO_2/MWh
Placeholder for now			

Summary Results	2012	2020	Units
Total for Policy (All Fuels)			
Total Net GHG Emission Savings	0.34	1.3	$MMtCO_2e$
Net Present Value (2007-2020)		$445	$million
Cumulative Emissions Reductions (2007-2020)		7.6	$MMtCO_2e$
Cost-Effectiveness		$59	$/tCO_2e$

Other Data, Assumptions, Calculations	2012	2020/all	Units
Fraction of Washington's Remaining Existing CHP Potential Tapped per Yea	2.0%	3.0%	
Rough estimate to be refined in consultation with TWG. Fractions of remaining potential tapped in each year are assumed to be beyond "baseline plus existing policies" levels, and thus due to CAT policies.			
Annual Growth in CHP Potential	1.0%	0.7%	
Rough estimate based on consideration of growth in electricity use in the commercial and industrial sectors.			
Estimated CHP Potential by Year (MW)	3,062	3,266	*MW*
Potential shown above grows at the rate shown above.			
Estimated CHP Installed Under Policy by Year (MW)	61	98	*MW*
Average full-capacity-equivalent hours of operation for New CHP units:	6,000	6,000	
(Assumption, from NREL Power Technology Energy Databook)			
Fraction of New CHP Capacity/Energy Fueled With:			
Natural Gas	100%	100%	
Biomass	0%	0%	
Petroleum	0%	0%	
Coal	0%	0%	
(Assumptions)			
Implied Annual New CHP Capacity by Fuel (MW)			
Natural Gas	61	98	
Biomass	-	-	
Petroleum	-	-	
Coal	-	-	
Implied Cumulative New CHP Capacity by Fuel (MW)			
Natural Gas	241	917	
Biomass	-	-	
Petroleum	-	-	
Coal	-	-	
Implied Cumulative New CHP Electricity Output by Fuel (GWh)			
Natural Gas	1,447	5,500	
Biomass	-	-	
Petroleum	-	-	
Coal	-	-	
Average Net Heat Rate by Fuel (Btu Fuel Input/kWh Electricity Output)			
Natural Gas	10,000	10,000	
Biomass			
Petroleum	13,000	13,000	
Coal	12,000	12,000	
Implied Fuel Input by Fuel (Billion Btu)			
Natural Gas	14,471	55,004	
Biomass			
Petroleum	-	-	
Coal	-	-	
Usable Cogenerated Heat Output as a Fraction of Fuel Energy Input			
Natural Gas	40%	40%	
Biomass	40%	40%	
Petroleum	40%	40%	
Coal	40%	40%	
Implied Usable Heat Output by Fuel (Billion Btu)			
Natural Gas	5,788	22,002	
Biomass			
Petroleum	-	-	
Coal	-	-	

Other Data, Assumptions, Calculations	2012	2020/all	Units
Fraction of Usable Heat Output Replacing Space/Water/Process Heat Use	90%	90%	
(Assumption)			
Fraction of CHP Heat Output Displacing Thermal Energy Produced Using			
Natural Gas	100%	100%	
Biomass	0%	0%	
Coal	0%	0%	
Electricity	0%	0%	
Oil	0%	0%	
Assumptions: See Note 2			
Net Efficiency of Displaced Boiler/Heater Thermal Energy Produced Using			
Natural Gas	85%	85%	
Biomass	80%	80%	
Coal	80%	80%	
Electricity	92%	92%	
Oil	80%	80%	
Assumptions			
Net Displaced Fuel Use (Billion Btu)			
Natural Gas	**6,129**	**23,296**	
Biomass	-	-	
Coal	-	-	
Electricity (MWh)	-	-	
Oil	-	-	
Inputs to Cost Estimates for CHP Systems			
Estimated Average Installed Capital Costs by System Type ($2005/kW)			
Natural Gas	$ 932	$ 840	
Biomass	$ 1,182	$ 1,090	
Coal	$ 932	$ 840	
Source: Combined Heat and Power in the Pacific Northwest: Market Assessment, based on 5MW turbine; Biomass system assumed $250 higher than gas turbine; Coal system assumed equal to gas turbine			
Factors for Annualizing Capital Costs (all plant types)			
Interest Rate		8%	/yr
Economic Life of System		20	years
Implied Annualization Factor		10.19%	%/yr
Estimated Average Non-fuel Operating and Maintenance Costs by System Type ($/MWh)			
Natural Gas	$ 5.00	$ 6.00	
Biomass	$ 3.00	$ 4.00	
Coal	$ 12.00	$ 14.00	

Intermediate Results for Cost Estimates

Total Capital Costs for New Systems (thousand 2005 dollars)

Natural Gas	$ 55,941	$ 82,309
Biomass	$ -	$ -
Coal	$ -	$ -

Annualized Capital Costs for All Systems (thousand 2005 dollars)

Natural Gas	$ 22,723	$ 82,585
Biomass	$ -	$ -
Coal	$ -	$ -

Annual Non-Fuel Operating and Maintenance Costs for All Systems (thousand 2005 dollars)

Natural Gas	$ 7,235	$ 33,002
Biomass	$ -	$ -
Coal	$ -	$ -

Total Non-Fuel Costs for All Systems (thousand 2005 dollars)

Natural Gas	$ 29,958	$ 115,587
Biomass	$ -	$ -
Coal	$ -	$ -

Total Gross Fuel Costs for All Systems (thousand 2005 dollars)

Natural Gas	$ 108,218	$ 411,338
Biomass	$ -	$ -
Coal	$ -	$ -

Total Fuel Cost Savings from Displaced Heating Fuels for All Systems (thousand 2005 dollars)

Natural Gas	$ 45,833	$ 174,214	
Biomass	$ -	$ -	
Coal	$ -	$ -	
Electricity	$ -	$ -	*included below*
Oil	$ -	$ -	

Results	2012	2020	Units
Electricity			
TOTAL Reduction in Electricity Sales (electricity output from CHP plus avoided electricity use in boilers/space heaters/water heaters)	1,447	5,500	GWh (sales)
Reduction in Generation Requirements	1,560	5,916	GWh (generation)
Gross GHG Emission Savings	**0.78**	**2.96**	$MMtCO_2e$
Natural Gas			
Net Change in Gas Use (negative values denote increased use)	-8,342	-31,708	Billion BTU
Net GHG Emissions (negative values denote increased emissions)	**-0.44**	**-1.68**	$MMtCO_2e$
Biomass			
Net Change in Biomass Use (negative values denote increased use)	0	0	Billion BTU
Net GHG Emissions (negative values denote increased emissions)	**0.00**	**0.00**	$MMtCO_2e$
		0	dry tons
Coal			
Net Change in Coal Use (negative values denote increased use)	0	0	Billion BTU
Net GHG Emissions (negative values denote increased emissions)	**0.00**	**0.00**	$MMtCO_2e$
Oil			
Net Change in Oil Use (negative values denote increased use)	0	0	Billion BTU
Net GHG Emissions (negative values denote increased emissions)	**0.00**	**0.00**	$MMtCO_2e$

NOTES AND DATA FROM SOURCES

Note 1:

From *Combined Heat and Power in the Pacific Northwest: Market Assessment*
Task 1 - Final Report. Submitted to Oak Ridge National Laboratory
This report can be found at:
http://www.chpcenternw.org/NwChpDocs/Chp_Market-Assessment_In_PNW_EEA_08_2004.pdf
Accelerated Case assumptions – 2020 cost and performance specs, no stand-by charges,
financial incentives equal to about 15% of capital costs

Note 2:

Natural gas - cell AJ53 of SEDS workbook
Coal - cell AQ53 of SEDS workbook
Electricity - to be confirmed
Oil - pet. coke, pentanes plus, residential fuel, still gas, napthas, unfinished oils - cells AK53 to AP53 of SEDS workbook