

White Paper

# Issues and Options for Benchmarking Industrial GHG Emissions

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## A Note from the Department of Ecology

Last year, Governor Christine Gregoire issued an Executive Order on Washington's Leadership on Climate Change that directed this agency to work with businesses and other interested stakeholders to develop greenhouse gas (GHG) benchmarks. It called for us to support the use of benchmarks in any federal or regional GHG cap and trade program as a basis for distributing emissions allowances and as a means to recognize and reward those businesses that have made investments that have reduced GHG emissions. The Order also directed us to develop benchmarks that could be suitable for use as state emission standards.

As we talked to stakeholders prior to starting the project, we quickly realized that we were not alone in having only a basic understanding of GHG benchmarks and benchmarking. Therefore, we designed a two-phase process. Phase I focused on educating all of us on the issues and options for developing GHG emission benchmarks, while Phase II will address the actual development of benchmarks for selected industries or activities.

This White Paper represents the culmination of work under Phase I. To develop it, we contracted with the Seattle office of the Stockholm Environment Institute (SEI), a widely-respected international organization with two decades of experience on energy and climate analysis. SEI partnered with Ross & Associates Environmental Consulting, Ltd. to organize stakeholder interactions and facilitate public events, and with the Öko Institute to bring lessons and technical expertise from their cutting edge benchmarking work in Europe.

Phase I began with a scoping memo, which provided background information, a workplan, and a timeline for the project, followed by a public webinar in February to discuss the scope and goals of the benchmarking effort. For the following three months, we and SEI spoke with, and received input from a variety of stakeholders as the first draft of the White Paper was coming together. In early May, SEI issued the draft version of the White Paper for public review. Two weeks later, we co-hosted an all-day symposium in Seattle with the Western Climate Initiative to present and discuss benchmarking issues with over 100 industry and government stakeholders from Washington State and across North America. We were delighted to have a diverse group of speakers from industry associations, academia, national and international research organizations, and local businesses. The symposium provided a unique opportunity for stakeholders and experts to share experiences with benchmarking, and ideas and perspectives on the role of benchmarks in addressing industrial greenhouse gas emissions. This final White Paper incorporates feedback from the symposium as well as from numerous stakeholders who submitted written comments.

Throughout this work, I have been deeply impressed and gratified by the level of industry and other stakeholder engagement, and the valuable insights and suggestions they have made. Representatives of the following companies and organizations provided comments on earlier drafts of this White Paper: Alcoa, Ash Grove Cement Company, Cardinal Glass, Cement Association of Canada, Cogeneration Coalition of Washington, Holcim, Kaiser Aluminum, Kimberly Clark, Lafarge Cement, Longview Fibre, National Council for Air and Stream Improvement, Northwest Food Processors Association, Northwest Pulp and Paper Association, Nucor Steel, Solvay Chemicals, TransCanada, and Weyerhaeuser. Their comments and

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suggestions provided important observations and insights specific to particular industries and greatly improved the final White Paper.

I would also like to thank the presenters and attendees at the benchmarking symposium held in Seattle, Washington on May 19, 2010, and to the Western Climate Initiative for co-hosting it. A report summarizing the presentations and dialogue is available at the Ecology benchmarking website: <http://www.ecy.wa.gov/climatechange/GHGbenchmarking.htm>.

Finally, I would like to thank Michael Lazarus and Pete Erickson from SEI as well as Bill Ross and Amy Wheelless with Ross and Associates. Their professionalism and organizational skills were unparalleled. They kept the project on track and on budget, and this White Paper is a testament to their good work. I would also like to thank the Energy Foundation for providing additional support for SEI's research efforts.

We will soon begin building on the Phase I findings to design a path forward for the development of benchmarks, and to develop specific recommendations on their appropriate use. The final section of this White Paper offers some very useful ideas on next steps. We are taking these ideas into consideration, and welcome input from citizens, businesses, and organizations across the State.

I look forward to working with our state's leading industries and other stakeholders to deliver on the Governor's leadership in tackling one of the great challenges of our time.

Janice Adair, Special Assistant to the Director  
Washington Department of Ecology

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## Executive Summary

Industrial activity remains a cornerstone of modern economies, as well as a major source of emissions of heat-trapping greenhouse gases (GHGs). Industrial processes and energy use account for a over a fifth of greenhouse gas emissions globally and in Washington State. A handful of energy-intensive industries – including (but not limited to) aluminum, cement, pulp and paper, petroleum refining, and steel – account for a large share of these industrial emissions are therefore central to tackling climate change. Most of these industries have facilities here in Washington State and operate in highly competitive international markets.

State and federal policymakers are considering a range of approaches to address GHG emissions from industrial activity including:

- **Voluntary performance goals**, in which participating companies commit to achieving a particular emissions benchmark by a particular year;
- **Regulation of GHG emissions through a cap-and-trade program**, along with free allocation of emissions allowances to industry sectors in proportion to output based on an emissions performance benchmark; and
- **Regulatory GHG performance standards**, where individual facilities are required to meet an emissions performance standard.

A common theme to all three such approaches is the use or development of GHG benchmarks, which enable the assessment of GHG emissions performance across facilities or against a common standard.

With this range of possible purposes in mind, Washington Governor Gregoire, in Executive Order 09-05, directed the Washington State Department of Ecology to develop GHG emissions benchmarks for industry. GHG benchmarks enable the assessment of GHG emissions performance across facilities or against a common standard, and are often expressed as quantities of GHGs released per ton of product output. Governor Gregoire directed the Department of Ecology to develop these benchmarks in consultation with industry and other interested stakeholders and to deliver them by July 1, 2011.

This *White Paper* presents Phase I of the Department of Ecology's research into GHG benchmarks. The paper explores several technical issues and options to be considered in developing benchmarks, including how to define the product or sector being benchmarked, how to establishment measurement protocols and boundaries, whether to establish benchmarks at average or better-than-average performance levels, and an initial assessment of possible data sources. Ecology may consider these factors as it proceeds to Phase II, which could involve the development of benchmarks and will involve developing specific recommendations on their appropriate use in achieving the state GHG emission reduction targets.<sup>1</sup>

Key findings of this *White Paper* include:

- **The availability of more comprehensive production, energy, and emissions data would greatly assist the development of greenhouse gas benchmarks.** Data from state and federal mandatory reporting rules on GHGs are likely to provide the best source of data for benchmarking. However, these data will not be available until autumn of 2010 at the earliest. In the meantime, data from existing government surveys (e.g., the U.S. Energy Information Administration) or industry groups (e.g., the Cement Sustainability Initiative) may be useful.
- **Developing meaningful benchmarks will require GHG performance data from more than just Washington State.** Washington has only a handful of facilities in key industrial sectors, and so a broader geographic cohort of facilities will be needed – across the Western Climate Initiative (WCI), the U.S., or

<sup>1</sup> Washington's targets are to reduce the state's overall GHG emissions to 1990 levels by 2020, 25% below 1990 levels by 2035, and 50% below 1990 levels by 2050, as specified in Revised Code of Washington (RCW) 70.235.020 (2008): <http://apps.leg.wa.gov/RCW/default.aspx?cite=70.235.020>

North America – to establish robust and useful benchmarks. Broadening the geographic cohort could also help reflect the relative performance of Washington industries and potentially bring opportunities for Washington industry to be a leader in advancing approaches to address greenhouse gas emissions.

- **Resolution of key issues in benchmark development depends on the policy context.** Even as they may be able to rely on similar underlying data, benchmarks developed for voluntary, cap-and-trade, or regulatory policy approaches may differ significantly. For example, in a voluntary or (especially) regulatory program, individual facilities would commit (or be required) to meet a particular emissions benchmark. As a result, the ambition, or level, of the benchmark would directly determine GHG emissions from the sector. By contrast, in a cap-and-trade program, benchmarks are used to help compensate facilities for the cost of emissions allowances and do not directly set the level of emissions in any given sector. Accordingly, the choice about how ambitious to make the benchmark is very different in voluntary or regulatory programs as compared to cap-and-trade. Other key issues also differ by policy context.

The finding that benchmark development depends on policy context has important implications for Ecology's path forward. Ecology may need to decide whether to:

- **Cover all the bases with a comprehensive effort** that would involve developing benchmarking data and methodologies, and constructing proposed benchmarks, that are appropriate for all three policy contexts. This path would maintain maximum flexibility and include the greatest possible share of industrial GHG emitters in the state, but would require significant resources.
- **Alternatively, choose more focused paths** and identify particular combinations of policy context, sectors, and unresolved benchmarking issues where the agency believes it could yield significant emissions and/or economic benefit for Washington industry. For example, if regulatory performance standards (whether federal or state-based) are perceived as a feasible or likely near-term policy approach, then Ecology could choose to develop methodologies for benchmark development in those sectors that represent the greatest opportunity for cost-effective emission reductions in Washington state, since the level of the benchmark will directly drive emission reductions in a given sector (by determining the allowable level of plant emissions).

"Sweet spots" may also be possible, such as development of a benchmark for a particular industrial process that applies across sectors (and, potentially, across policy contexts, too). For example, a benchmark on heat production could apply to the handful of industrial sectors for which heat (as produced in a boiler) is an important intermediate product.<sup>2</sup>

In moving ahead with benchmark development, Ecology may wish to partner with other interested jurisdictions (e.g., the Western Climate Initiative, Midwest Greenhouse Gas Reduction Accord, or Regional Greenhouse Gas Initiative) – as well as the US EPA, industry associations, and expert groups – to develop a critical mass of data, methodological expertise, and potential policy applications.

Ecology's work under Governor Gregoire's Executive Order 09-05 brings the opportunity to significantly advance a transition to a low-carbon economy in Washington's industrial sector. Several choices on policy context, benchmarking methodology, and sectors remain before benchmarks can be delivered to the Governor by July 1, 2011. This paper helps lay groundwork for the Department of Ecology and other interested stakeholders to develop partnerships, policy approaches, and initiatives to address industrial greenhouse gas emissions in Washington State and beyond.

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<sup>2</sup> The production of heat, intermediate "product", is a significant source of emissions in several sectors, including pulp and paper, chemicals, food processing, and petroleum refining. One downside of a benchmark on an intermediate product such as heat is that it would not incent the efficient use of the intermediate product in creating a final product.

## 1. Introduction and Context

Industrial activity remains a cornerstone of modern economies, as well as a major source of emissions of heat-trapping greenhouse gases (GHGs). Industrial processes and energy use account for 20% of direct greenhouse gas emissions globally (Metz et al. 2007) and in Washington State (Center for Climate Strategies 2007). Many industries, such as aluminum production, are highly reliant on electricity use; when the emissions associated with generating electricity for industry are included, the share rises to a quarter of global emissions, and an even larger share of energy-related CO<sub>2</sub> emissions. A handful of energy-intensive industries – iron and steel, aluminum, chemicals, petroleum refining, minerals (e.g., cement, lime, and glass), and pulp and paper – account for over 80% of global industrial energy use, and a large majority of industrial GHG emissions (Metz et al. 2007).

These same industries could also play central roles in a transition to a low-carbon economy. Aluminum can reduce transportation energy needs by “lightweighting” vehicles. New transportation and energy infrastructure, from public transit systems to wind turbines, may require significant amounts of steel and cement, even as this new infrastructure helps reduce emissions from vehicles and electricity generation. Advanced low-emissivity (“low e”) glass is a key component of ultra-low energy buildings. Sustainably harvested forest products offer the potential for carbon sequestration in the built environment as well as a low-carbon energy source. In short, a few key energy and GHG emissions intensive industries – most of which are represented here in Washington State and operate in a highly competitive international markets – are central to tackling climate change.

With these considerations in mind, state and federal policymakers are considering a range of approaches to address GHG emissions from industrial activity. Approaches under consideration for emissions-intensive industry sectors include voluntary agreements or incentives, inclusion of industry in an economy-wide cap-and-trade program, and direct regulation through performance standards. A common theme to all three such approaches is the use or development of GHG benchmarks, which enable the assessment of GHG emissions performance across facilities or against a common standard.

GHG benchmarks are typically expressed as a quantity of emissions per unit of output, as in the following simple equation, and may in some contexts be called *emissions intensity*.<sup>3</sup>

$$GHG \text{ Benchmark} = \frac{\text{Emissions (tons CO}_2\text{e)}}{\text{Unit of Output (tons, \$, or other metric)}}$$

Policymakers can use GHG benchmarks in any of at least three policy approaches:

- **Voluntary performance goals**, in which participating companies commit to achieving a particular emissions benchmark by a particular year;
- **Allocation of allowances in a cap-and-trade program**, where emissions allowances are freely allocated to industry sectors based on a benchmark level of emissions performance and in proportion to the output of each facility;<sup>4</sup> and
- **Regulatory GHG performance standards**, where individual facilities are required to meet an emissions performance standard that may be set using a benchmark approach.<sup>5</sup>

With this range of possible purposes in mind, Washington Governor Gregoire issued Executive Order 09-05 in 2009, directing the Washington State Department of Ecology to develop emission benchmarks in consultation with industry and other interested stakeholders to be delivered to the Governor, per the Executive Order, by July 1, 2011. Specifically, the Executive Order calls for the Director of the Department of Ecology to:

<sup>3</sup> A common unit of emissions benchmarks is kilograms of carbon dioxide equivalent per ton of material processed or produced.

<sup>4</sup> For example, H.R. 2454 in the 111<sup>th</sup> Congress (the “Waxman-Markey” bill) included a rebate to certain energy intensive and trade-exposed sectors based on the average level of emissions per unit of output in the sector.

<sup>5</sup> Other approaches to setting emissions performance standards also exist, such as defining particular technologies that must be installed.

“In consultation with business and other interested stakeholders, develop emission benchmarks, by industry sector, for facilities the Department of Ecology believes will be covered by a federal or regional cap-and-trade program. The Department of Ecology shall support the use of these emission benchmarks in any federal or regional cap-and-trade program as an appropriate basis for the distribution of emission allowances, and as a means to recognize and reward those businesses that have invested in achieving emission reductions. These benchmarks shall be based on industry best practices, reflecting emission levels from highly efficient, lower emitting facilities in each industry sector. The benchmarks shall be developed to allow their application as state-based emissions standards, should they be needed to complement the federal program, or in the absence of a federal program.”

## Benchmark Basics

Industry efforts to compare and track GHG emissions performance have been underway for several years. Many global and North American industry associations have collected data from member companies on greenhouse gas emissions and production and distributed corresponding greenhouse gas intensity statistics. For example, the petroleum industry has been engaged for more than 20 years in benchmarking the dozens of processes that occur in petroleum refineries. Petroleum industry actors have compiled a global database of energy use, and have developed a widely adopted benchmarking approach.<sup>6</sup> Other industry associations in other sectors – both globally and regionally – have also developed greenhouse gas intensity metrics, or benchmarks.<sup>7</sup>

Approaches to benchmarking can vary substantially by sector. Some sectors (e.g., cement) have processes and products that are relatively simple and uniform. In such sectors, the task of defining which emissions to include – and what products and/or processes to benchmark – can be relatively straightforward. In other sectors, the task can be much more difficult. For example, the wide variation among facilities in the petroleum refining sector, including the presence of dozens of unique processes, makes the task of developing benchmarks challenging and time-consuming.<sup>8</sup> Regardless, an important consideration in developing benchmarks is to balance the need to obtain emissions and production data from a large enough group of facilities to be representative against the need for each benchmark to be consistent with the circumstances of the facilities it is intended to help assess.<sup>9</sup>

Figure 1 below presents a hypothetical benchmarking curve of emissions intensity data for a fictional industry sector.<sup>10</sup> In this chart, each individual facility, knowing its emissions intensity, could compare its emissions performance (kg CO<sub>2</sub>e/ton) to each other facility anonymously, as well as to the average intensity (displayed here as a red horizontal line). Facilities with emissions intensities below the red line are outperforming the average, while facilities with emissions above the red line are underperforming the average and emitting more emissions per each ton of product.

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<sup>6</sup> The benchmarking approach developed for the refinery industry by Solomon Associates, Inc. has been widely adopted among the world’s refineries and is also likely to form the basis for the European Union’s approach to benchmarking refineries in the third phase of its Emissions Trading Scheme, discussed in greater detail later in this paper.

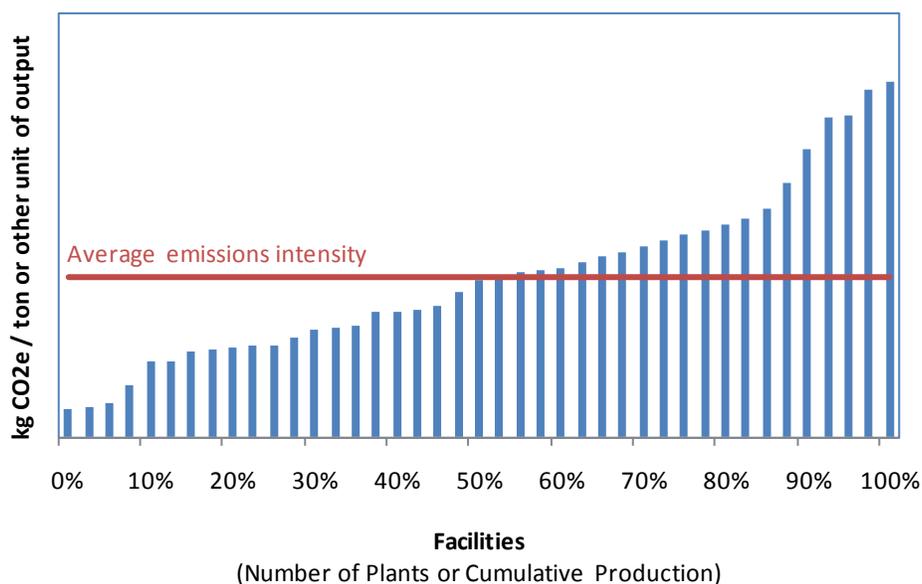
<sup>7</sup> Several industry efforts rely, and have contributed to, the Greenhouse Gas Protocol of the World Business Council for Sustainable Development and the World Resources Institute. In addition, the US EPA ENERGY STAR program for industry uses Census Bureau and industry-provided data to develop energy benchmarks called Energy Performance Indicators. Facilities that score in the top 25% energy efficiency are eligible to be awarded the ENERGY STAR label by EPA.

<sup>8</sup> The petroleum industry has developed a proprietary and relatively involved benchmarking approach over the course of three decades..

<sup>9</sup> Current industry efforts have tended to use kg CO<sub>2</sub>e as the numerator of the benchmark (and participated in collaborative exercises to establish protocols, such as the GHG Protocol, for measuring such emissions) and tons of product (usually an output, but sometimes an input, as for refining) as the denominator. Industry associations are much less uniform, however, concerning the level of ambition of the benchmark. A common approach employed by several industry associations is to report average greenhouse gas intensity metrics for their respective members.

<sup>10</sup> Curves like that presented in Figure 1 are common in developing benchmarks for energy and emissions. For example, US EPA develops similar curves in its ENERGY STAR Energy Performance Indicators for Industry, including in spreadsheet tools made freely available on its website, [www.energystar.gov](http://www.energystar.gov).

Figure 1. Hypothetical Benchmark Curve: Comparing Facility Emission Intensities in a Given Sector or Subsector<sup>11</sup>



Benchmarks need not be set at the average emissions intensity, however. A benchmarking curve (and its underlying data) can also be used to develop more ambitious benchmarks. For example, a benchmarking curve can be used to understand the best achieved level of emissions performance (i.e., the column furthest to the left in the chart above), to set a goal for a specified improvement over the current average (e.g., a 20% improvement in emissions intensity by a certain year), or to select a definition of top-performing plants (e.g., the plants in the top 25<sup>th</sup> percentile of performers). As we discuss in Section 3, setting the ambition of a benchmark – whether average, better-than-average, or top-performing – becomes particularly important in regulatory systems for reducing greenhouse gases, including both cap-and-trade and performance standards approaches.

## Roadmap of the White Paper

In this *White Paper*, we discuss issues and options for developing emissions benchmarks, starting with a brief summary of the possible policy approaches in Section 2. We then provide an assessment of key issues and options for developing benchmarks in Section 3, including a discussion of how the issues and options may differ for three commonly applied policy approaches. We include a discussion of considerations specific to several industrial sectors (e.g., aluminum, cement, steel) in Section 4.<sup>12</sup> In Section 5, we assess possible paths forward for Washington State in developing benchmarks to fulfill Governor Gregoire’s Executive Order.

This *White Paper* and the associated GHG benchmarking symposium on May 19, 2010 mark the first phase of the Department of Ecology’s research and stakeholder consultation on benchmarking. The second phase will entail the development of recommendations on industry benchmarks and their appropriate use in achieving the state GHG emission reduction targets: to reduce emissions to 1990 levels by 2020, 25% below 1990 levels by 2035, and 50% below 1990 levels by 2050.<sup>13</sup>

<sup>11</sup> In this chart, each vertical bar represents an individual facility, with facilities organized from least emissions intensive on the left to most emissions intensive on the right. The horizontal (x-axis) can be defined simply as the cumulative number (or percent) of facilities, the cumulative production, the cumulative emissions, or the cumulative energy, depending on the intent of the benchmarking curve. The curve here is depicted as if the axis is cumulative share of facilities, which, if all the facilities produced the same quantity of output, would also equal cumulative production.

<sup>12</sup> Because Washington State has already established a electricity generaion performance standard benchmark in (1,100 lb CO<sub>2</sub>e per MWh) per WAC 173-407-130, this paper does not discuss the electricity sector in depth.

<sup>13</sup> As specified in Revised Code of Washington (RCW) 70.235.020 (2008): <http://apps.leg.wa.gov/RCW/default.aspx?cite=70.235.020>

We intend the primary audience for the *White Paper* to be policymakers, industries to which GHG benchmarks may apply, and other interested stakeholders. While we place a particular focus on the needs and opportunities with respect to Washington State, much of the discussion may also apply to broader policy dialogues and decisions in the Western Climate Initiative and U.S.

## 2. Summary of Current Policy Approaches

Broadly speaking, greenhouse gas benchmarks are metrics that enable the assessment of GHG emissions performance across facilities or against a common standard. Benchmarks have been used in each of three leading policy approaches to reducing industrial GHG emissions: voluntary performance goals, cap-and-trade programs, and emission performance standards. This section describes these policy approaches and how benchmarks have been developed and applied in each approach.

### Voluntary Performance Goals

Voluntary industry efforts to benchmark and reduce greenhouse gas emissions have been underway for several years at international, national, and local levels. For example, major players in the global cement industry, organized as the Cement Sustainability Initiative, contribute data on emissions released per ton of cement (or clinker, a key component) to a third-party database so that they may compare their performance against other plants, or against an average or high-performing plant (CSI 2009).<sup>14</sup> Similarly, the international aluminum industry collects and shares data on emissions of perfluorocarbon (PFC), a highly potent greenhouse gas, and has recently pledged to reduce PFC emissions by at least 50% by 2020 as compared to 2006 (International Aluminum Institute 2009).

Voluntary programs may take one of several forms (Lyon 2003):

- initiatives undertaken by industry alone (e.g., self-regulation), such as the goals announced by the Cement Sustainability Initiative and the PFC reduction goals of the International Aluminum Institute;
- negotiated agreements between government and industry, such as the US EPA's Climate Leaders program; or
- public voluntary programs (e.g., ENERGY STAR) in which governments provide technical assistance and publicity to companies that adopt and meet certain goals.

Table 1 provides a summary of examples of the latter two types of voluntary programs recently active in the U.S. Benchmark methodologies in these programs have varied widely.

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<sup>14</sup> CSI members contribute individual facility data to a database operated and maintained by an independent third party. Participants are allowed to see their own data (to confirm accuracy and analyze company performance), and view global and regional aggregated data for all the other participants. Doing so allows comparisons and statistical analysis of the aggregated performance for a number of parameters including CO<sub>2</sub> emissions, energy use, electricity use, etc. CSI has found that the use of an independent third party is an essential ingredient to allow participation consistent with typical anti-trust rules. In addition, the data collected are at least one year old to further minimize the inadvertent disclosure of competitive information."

**Table 1. U.S. Government Programs with Voluntary GHG or Energy Performance Goals**

Program	Type of Goal	Sample of Participating Organizations with Facilities in Washington State	Benchmark Methodology
US DOE Climate VISION	Sector-wide improvement in energy or emissions intensity relative to value in some base year	<ul style="list-style-type: none"> <li>▪ American Chemistry Council</li> <li>▪ American Forest and Paper Association</li> <li>▪ American Iron and Steel Institute</li> <li>▪ Portland Cement Association</li> </ul>	Unclear. Appears to be defined by each participating industry association. <sup>15</sup> Not a true benchmark since no comparison between facilities, though progress tracked in terms of emissions (or, in some cases, energy) per unit of physical or economic output.
US EPA Climate Leaders	Company-specific absolute GHG reduction that significantly outperforms a pre-defined sector benchmark <sup>16</sup>	<ul style="list-style-type: none"> <li>▪ Alcoa</li> <li>▪ Ash Grove Cement</li> <li>▪ Boeing Company</li> <li>▪ ConAgra</li> <li>▪ Kimberly-Clark Corporation</li> <li>▪ Lafarge North America</li> <li>▪ Saint-Gobain Containers</li> <li>▪ Tyson Foods</li> <li>▪ Wafertech LLC</li> </ul>	EPA calculates benchmark based on current and projected future GHG intensity of sector based on Department of Energy and Bureau of Labor Statistics data and models.
US EPA ENERGY STAR	Depends on individual facility. Facilities that are in the top 25 <sup>th</sup> percentile nationally for energy performance receive the ENERGY STAR label / designation	<ul style="list-style-type: none"> <li>▪ Ash Grove Cement</li> <li>▪ ConAgra</li> <li>▪ Simplot</li> </ul>	EPA conducts a statistical analysis to determine energy use per normalized facility; specific benchmark value not available.
US EPA Performance Track (no longer active) <sup>17</sup>	Depends on individual facility. GHG reduction goals were common as are goals to reduce energy use by at least 10%.	<ul style="list-style-type: none"> <li>▪ Wafertech LLC</li> </ul>	Unclear. Appears to have been defined or negotiated by each participating facility. <sup>18</sup>
Northwest Food Processors Association and US DOE partnership	Reduce industry-wide energy intensity by 25% in 10 years and 50% in 20 years	49 facilities in Oregon and Washington (facility names and locations undisclosed)	Still under development. Completed energy audits and tested baseline methodologies in 2009.

Europe also has significant experience with voluntary GHG reduction goals particularly those agreements negotiated between governments and industries. For example, the German government and industrial sector organizations agreed to emission reduction targets in 2000.

Belgium and the Netherlands have also developed voluntary industrial covenants. These countries negotiated reduction targets with industry on a company level. By 2012, companies are to achieve an energy efficiency target comparable to the 10% most efficient installations worldwide. The companies must enact energy efficiency plans, which are subject to external verification, and report their progress annually. Table 2 summarizes the German, Dutch, and Flemish voluntary industry benchmarking programs.

<sup>15</sup> Per [www.climatevision.gov](http://www.climatevision.gov).

<sup>16</sup> From 2002 to 2009, goals could be absolute or intensity-based.

<sup>17</sup> EPA's Performance Track program operated between 2000 and 2009.

<sup>18</sup> The EPA Performance Track program concluded in 2009. Methodology details could not be located on the EPA website.

**Table 2. European Government Programs with Voluntary GHG or Energy Performance Goals**

Program	Type of Goal	Sample of Participating Organizations	Benchmark Methodology
Voluntary commitment of German industry of 9 <sup>th</sup> November 2000	Sector-wide improvement in emissions intensity relative to historic emissions / specific emissions depending on sectors	<ul style="list-style-type: none"> <li>▪ Federation of German Industries</li> <li>▪ Steel Industry</li> <li>▪ Chemical Industry</li> <li>▪ Power production</li> </ul>	Not technically benchmarks, since sector-wide goal relative to historic emissions. Emission reductions are not reported on a company level, but by the sector organization.
Energy Efficiency Benchmarking Covenant (Dutch Benchmarking Committee 1999)	Company-should reach the energy efficiency of the best international standard (defined as energy efficiency of the top 10 %)	<ul style="list-style-type: none"> <li>▪ Netherlands Chemical Industry Federation</li> <li>▪ Netherlands Iron and Steel Producing Industry Association</li> <li>▪ Non-Ferrous Industry Association</li> <li>▪ Petroleum Industry Association</li> </ul>	<ul style="list-style-type: none"> <li>▪ Determination of the best international standard regarding energy efficiency.</li> <li>▪ Companies draw up energy efficiency plans.</li> <li>▪ Checked by independent authority. Annual reporting of companies to competent authority.</li> </ul>
Flemish Energy Benchmarking Covenant (Flemish Benchmarking Commission 2010)	As in the Netherlands	As in the Netherlands	As in the Netherlands

Voluntary approaches have generally been perceived as being more acceptable to industry actors than regulatory or even market-based approaches to reducing greenhouse gases. Analyses of the success of voluntary environmental programs, however, have found that in general they have not and cannot attain levels of emissions reduction comparable to market-based or regulatory approaches (Lyon 2003; Morgenstern and Pizer 2007). When voluntary efforts have failed to meet their goals, some governments have pursued other policy approaches. For example, in the German voluntary program described above, when GHG reduction targets were not met in 2003 and 2004, Germany introduced a more ambitious cap into its cap-and-trade program in 2006 (German Federal Ministry of the Environment 2006). Despite their limitations, voluntary programs can help build technical capacity and early action towards eventual transition to a more comprehensive policy approach.

## Market-Based Approaches

A cap-and-trade program is a market-based program to limit greenhouse gas emissions. These types of programs are being implemented in the U.S. East Coast and Mid-Atlantic states through the Regional Greenhouse Gas Initiative (RGGI), in Europe, through the EU Emission Trading System (EU ETS), and in the state of New South Wales, Australia through its Greenhouse Gas Abatement Scheme. The Western Climate Initiative, which comprises four Canadian provinces and seven U.S. states including Washington, is currently developing the detailed design for a regional cap-and-trade system, as are the states involved in the Midwest Greenhouse Gas Reduction Accord (MGGRA).

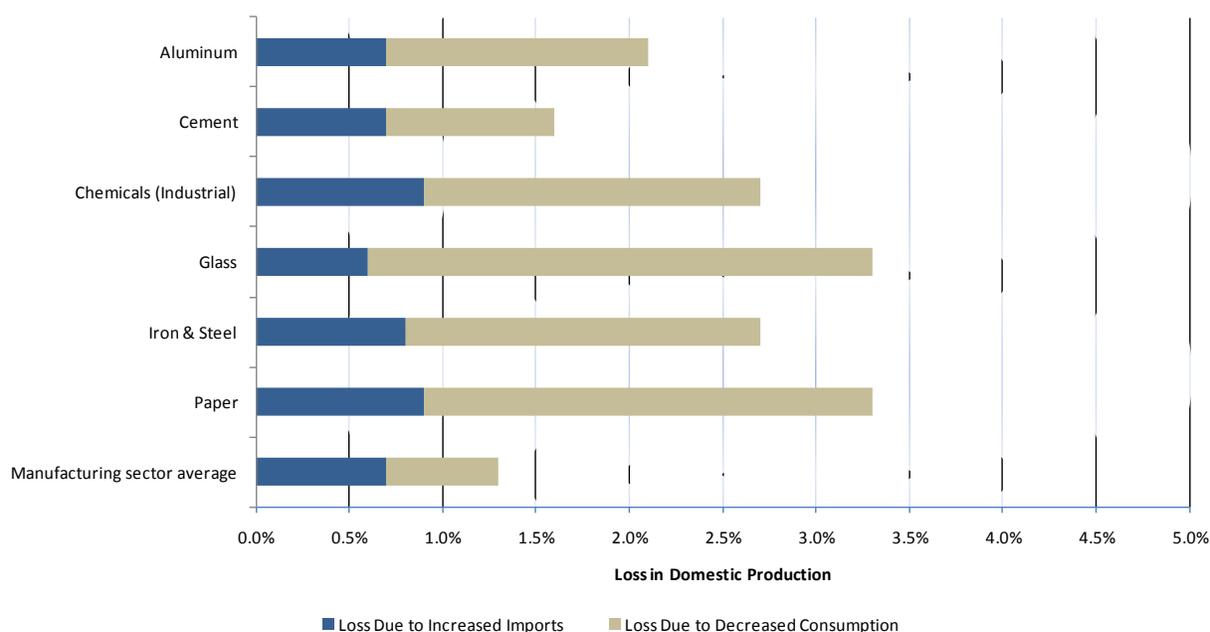
At the national level, proposed federal legislation that would establish a cap-and-trade system for large GHG emitters has been under consideration for many years, including the *American Clean Energy and Security Act*, which passed out of the House of Representatives in June 2009. . While the RGGI system currently covers only electric generators, most of the other GHG cap-and-trade programs proposed or underway also include large industrial sources.

Some industries – particularly those that are energy-intensive and sell their products in highly global markets – have raised concerns that a cap-and-trade program could disproportionately increase their costs and, in turn, potentially impact their competitiveness in the global marketplace. Furthermore, if implementation of a cap-and-trade program led industry to relocate its activities or investments to other regions or countries without comparable greenhouse gas regulations, emissions “leakage” could occur, compromising the environmental

effectiveness of the greenhouse gas cap.<sup>19</sup> For example, recent economic modeling suggests that unless some counteracting policy was implemented, a cap-and-trade program on greenhouse gases in the U.S. could lead to declines in domestic production of between 0.5% and 1.0% for several industrial sectors due to international competition (Aldy and Pizer 2009). This shift of production to other countries would also result in increased emissions in those countries and possibly to increased global emissions if the emissions intensity of production in that other country was higher than in the U.S.

Economists have developed predictions of competitiveness impacts for several energy-intensive sectors. We display one such set of predictions in Figure 2, which indicates that a \$15 carbon price in 2012 is predicted to lead to a 0.5-1.0% loss of domestic production in favor of foreign imports in some industry sectors. Economists also predict that a cap-and-trade program would decrease consumption of these energy-intensive goods, since some fraction of the carbon price could be expected to be passed on to consumers. As displayed in Figure 2, reduced consumption is expected to have a greater effect on industry production levels than is increased competition from foreign imports, with total impacts from both increased competition and decreased consumption less than 3% in most sectors.

**Figure 2. Predicted Impacts on Industrial Production Resulting from a \$15 per ton CO<sub>2</sub> Allowance Price in 2012 without Output-Based Rebates (Aldy and Pizer 2009)**



As seen in Figure 2, economists expect the effects of increased costs on domestic production to vary by industry. Among the factors that help explain these differences are (US EPA, US EIA, and US Treasury 2009) are:

- Production cost advantages: differences among countries in terms of access to inexpensive raw materials, highly skilled or low-cost labor, or advanced technologies that may provide cost advantages greater than any increased cost of production resulting from the cap-and-trade program;

<sup>19</sup> Emissions “leakage” would occur if implementation of a greenhouse gas policy (e.g., cap-and-trade legislation) were to induce industry sectors to replace domestic production with imports or to relocate production to foreign countries. If that were to occur, emissions would increase in the other country, resulting in emissions “leaking” from the domestic to the foreign country (Dröge et al. 2009)

- Large, fixed, capital investments: the extent to which increased production costs in the US might influence where new manufacturing facilities are located; and
- Transportation costs: the degree to which transportation costs for inputs and outputs influence the competitive position of the industry.

### Benchmark-based Allowance Allocation in Proposed U.S. Cap-and-trade Legislation

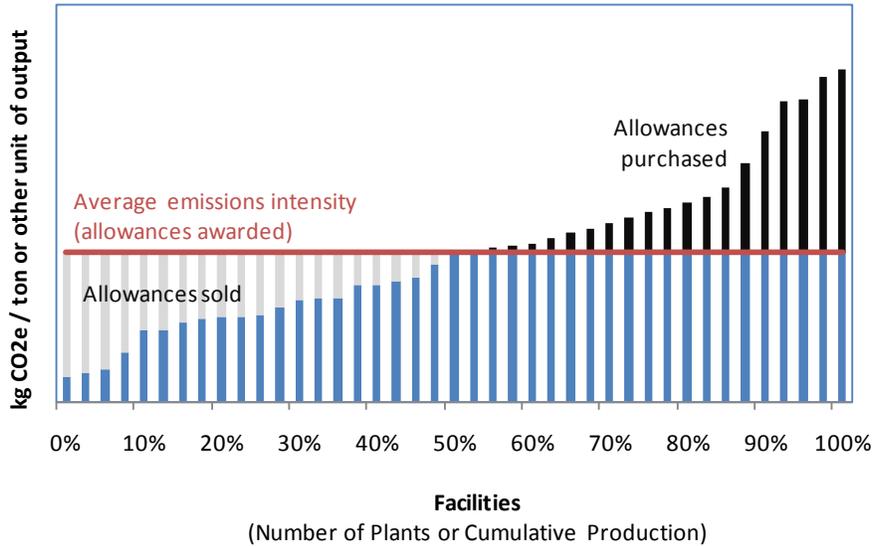
To help address concerns regarding industrial competitiveness, some observers have suggested that emissions allowances, the tradable commodity in a cap-and-trade system, be freely allocated to emissions-intensive, trade-exposed (EITE) industries. The *American Clean Energy and Security Act* (i.e., “Waxman-Markey”), which passed out of the U.S. House of Representatives as H.R. 2454 in June 2009, provides for allowances to EITE industries on the basis of a benchmark emissions level defined as the sector’s average direct emissions per unit of production output.<sup>20</sup> Allowances are also rebated for indirect emissions (i.e., emissions released to produce purchased electricity or heat) based on a similar sector-average calculation.<sup>21</sup> Each individual facility in an EITE sector would receive free allowances based on the facility’s output times the average emissions intensity of the sector (the benchmark).<sup>22</sup> Facilities with an emissions intensity below the average (more efficient or lower emitting facilities) would receive more allowances than they would need to cover their emissions and would therefore have extra allowances to sell. As shown in Figure 3, facilities with emissions above the average (less efficient or higher emitting facilities) would need to purchase allowances.

<sup>20</sup> See Section 761, page 1081, of H.R. 2454 as passed by the House of Representatives. In H.R. 2454, benchmarks are called “carbon factors.” A similar approach to benchmarking was included in the Kerry-Boxer bill passed out of committee in the U.S. Senate in fall, 2009.

<sup>21</sup> Direct emissions are those released by sources owned or controlled by an entity, for example by the combustion of fossil fuels to fuel a boiler or the release of CO<sub>2</sub> from limestone calcinations at a cement kiln. Indirect emissions are those released as a consequence of the activities of an entity that occur at sources not owned or controlled by the company (WBCSD and WRI 2004). The most commonly tracked source of indirect emissions is grid electricity production.

<sup>22</sup> The Waxman-Markey and Kerry-Boxer bills include allowance rebates to energy-intensive, trade-exposed (EITE) industry. EITE eligibility is determined according to criteria of energy or greenhouse gas intensity and trade intensity. Energy intensity is equal to a sector’s energy expenditures divided by the dollar value of its shipments; GHG intensity is calculated the same way except that GHGs are monetized at \$20/ton. Any sector that has an energy or GHG intensity of 20% or more is automatically an EITE industry. Otherwise, sectors that have an energy/carbon intensity greater than 5% and a trade intensity (defined as the sum of the value of imports and exports divided by sum of value of shipments and imports) greater than 15% are considered EITE. The actual benchmark value is calculated as the average direct and indirect emissions per unit of output (tons or a similar physical measure of output) for all entities in each eligible sector over the prior four years. Eligible entities are awarded allowances based on this benchmark multiplied by the average output in the two years preceding the allowance distribution. For further details on how EITE sectors are defined, benchmarks calculated, and allowances allocated, see EPA, EIA and Treasury (2009), Schneck, Murray, Mazurek and Boyd (2009b), Tonkonogy (2009), or Bradbury (2009), or Section 764 of the final version of H.R. 2454 as passed by the House of Representatives in June 2009.

Figure 3. Simplified Diagram of Benchmark-based Allowance Allocation to EITE Industry Sectors in H.R. 2454 for a Given Sector or Subsector

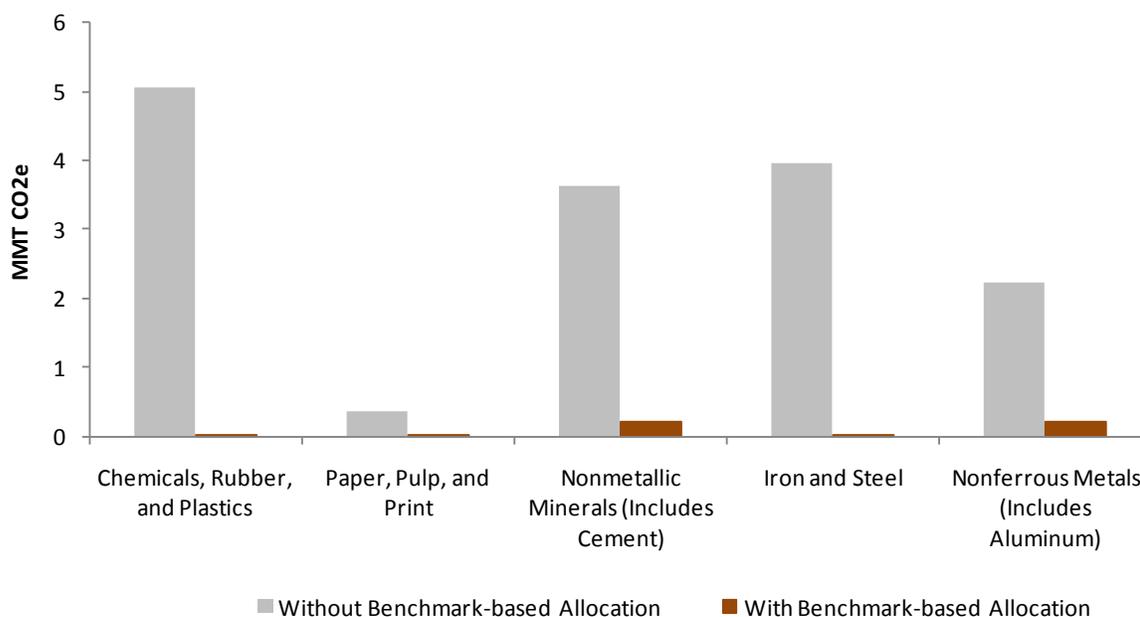


Economic modeling suggests that such output-based, or benchmarking, approaches to freely allocating allowances can effectively address industry competitiveness concerns, negating the potential impacts discussed above and summarized in Figure 2 (US EPA, US EIA, and US Treasury 2009; Fischer and Fox 2007; Fischer and Fox 2009). Analyzing the EITE provisions of H.R. 2454, a U.S. interagency report found that the free, output-based allocation of allowances based on average sector emissions intensity “can eliminate almost all – and, in some cases, potentially more than all – of those cost impacts, as well as the resulting changes in net imports and emissions leakage” (EPA, EIA, and Treasury 2009).

Figure 4, below, displays results from the interagency study for five industrial sectors. Without the benchmark-based allocation (and companion free allowance allocation to electricity and natural gas local distribution companies), emissions leakage to developing countries is predicted to be many millions of tons of GHGs.<sup>23</sup> With the allocation, this leakage is predicted to be almost completely eliminated.

<sup>23</sup> The authors of the U.S. interagency report focused on leakage to developing countries based on the assumption that other major OECD trading partners (e.g., Canada, Mexico, Europe) would adopt comparable regulations, minimizing risks of leakage to and from these countries.

Figure 4. Estimated Emissions Leakage to Developing Countries from U.S. Energy-intensive Trade-Exposed Industries under H.R. 2454 without and with Benchmark-based Allowance Allocation (US EPA, US EIA, and US Treasury 2009)<sup>24</sup>



Despite the apparent benefits of free allocation of allowances via output-based benchmarks, tradeoffs do exist. In particular, freely allocating allowances to industry can substantially diminish the price signal to firms to reduce GHG emissions, the central goal of the cap-and-trade program (Schneck et al. 2009; Matthes et al. 2008). Freely allocating allowances also foregoes the opportunity to use that allowance value for other uses, such as support for low income consumers, investments in clean energy technology, deficit reduction, or workforce training (US EPA, US EIA, and US Treasury 2009; Zabin, Buffa, and School 2009)<sup>25</sup>.

As an example of a benchmark-based allocation to an energy-intensive, trade-exposed industry, consider the cement sector. H.R. 2454 calls for emissions benchmarks to EITE sectors to be calculated “every 4 years, using an average of the four most recent years of the best available data” (Waxman and Markey 2009, 1111). Table 3, below, shows estimated emissions and production data for the U.S. cement industry for the four most recent years for which data are available as of the writing of this *White Paper*. The table includes both direct and indirect emissions for the cement sector as calculated by EPA, EIA, and Treasury in their Interagency Report (2009) from the national U.S. GHG inventory and the Energy Information Administration’s Manufacturer Energy Consumption Survey. These underlying data sources – and the subsequent calculations in the Interagency Report – are calculated at an aggregate sector level and include significant assumptions and uncertainties. Nevertheless, we use these data here to provide a numerical example based on publicly available information. Actual benchmark development would likely require facility-level data to increase accuracy and enable construction of benchmark curves (as in Figure 1) or other statistics that would enable comparison across facilities.

Using the requirements in H.R. 2454 and these data, we estimate that the benchmark for direct emissions (i.e., process CO<sub>2</sub> and combustion-related GHGs) for the U.S. cement sector would therefore be approximately 0.78 tCO<sub>2</sub>e per metric ton of cement produced.<sup>26</sup> The calculation of indirect emissions intensity would be a more

<sup>24</sup> The Waxman-Markey bill also includes free allocation to electricity and natural gas local distribution companies (LDCs) that would benefit energy-intensive and trade-exposed industries. In Figure 4, these LDC allocations are included in the results labeled “with benchmark-based allocation” and not in the results labeled “without benchmark-based allocation.”

<sup>25</sup> In addition, some legal analysts have raised concerns that freely allocating allowances to trade-exposed industries could constitute “actionable subsidies” under the World Trade Organization’s Agreement on Subsidies and Countervailing Measures (Parker and Grimmett 2010)

<sup>26</sup> Note that this benchmark calculation is denominated in metric tons of cement per the specifications of H.R. 2454 (page 1092). However, many stakeholders and analysts have recommended that benchmarks be based instead on clinker, the key, energy-intensive component of

complicated calculation involving national average energy intensity multiplied by the GHG-intensity of each facility's electricity supply and is not displayed here.

**Table 3. Sample Benchmark Calculation for Cement Sector under Waxman-Markey (H.R. 2454)**

Year	GHG Emissions (MtCO <sub>2</sub> e)					Cement Production Million Metric Tons <sup>29</sup>	Direct Emissions Intensity tCO <sub>2</sub> e per ton of cement
	Process <sup>27</sup>	Combustion <sup>28</sup>	Total Direct	Indirect <sup>28</sup>	Total Direct + Indirect		
2005	46	32	77	8	85	99	0.78
2006	47	31	78	8	85	98	0.79
2007	45	30	75	7	82	95	0.78
2008	41	27	68	7	74	86	0.78
<b>Direct Emissions Benchmark (Average over Four Years):</b>							<b>0.78</b>

Under a cap-and-trade program with benchmark-based allocation similar to H.R. 2454, each individual facility would receive an allocation of allowances equal to its level of production (averaged over the two years preceding the distribution) multiplied by this direct emissions benchmark. For example, suppose that allowances were to be distributed in the year 2012, that the benchmark value was 0.78 tCO<sub>2</sub>e per ton of cement (as in Table 3), and cement production at a cement production facility averaged 400,000 metric tons in 2010 and 2011 (the two years preceding the distribution in 2012). This cement facility would therefore receive an allowance allocation as follows:

$$\text{Benchmark value (0.78 tCO}_2\text{e/ton cement)} \times \text{Production (400,000 tons)} = \text{Allocation (312,000 allowances)}.$$

The number of allowances allocated (312,000) may be more or less than the actual emissions released by the plant. If more, then the facility would have extra allowances to sell or bank for future use; if less, it would have to buy additional allowances.<sup>30</sup> For example, suppose that this cement facility emitted 350,000 tCO<sub>2</sub>e of emissions in 2012. With a free allocation of 312,000 allowances, the facility would need to purchase the remaining 38,000 allowances from the cap-and-trade market (or else reduce emissions by a corresponding amount). If, on the other hand, the facility emitted 300,000 tCO<sub>2</sub>e, then the facility would have an extra 12,000 allowances to sell or bank for use in future years.<sup>31</sup>

The benchmark-based allocation for indirect emissions would be similar. Under H.R. 2454, the indirect emissions benchmark is calculated as the sector-wide average electricity intensity multiplied by an entity-specific electricity emissions factor. Using national (rather than facility-specific) data, this value would be expected to average about 0.08 tCO<sub>2</sub>e per ton of cement (i.e., 7 MtCO<sub>2</sub>e divided by 86 million tons in 2008 per Table 3). The allocation is then calculated by multiplying by the production level (in this example, 400,000 tons).

In addition to proposed federal climate legislation, the State of California has adopted legislation that authorized the implementation of a cap-and-trade program. Its state-appointed Economic and Allocation Advisory

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cement. Note also that data points in Table 3 are taken from public sources and in some cases are estimated. Since these may not be the exact same data sources or years ultimately used under any U.S. climate legislation, this calculation is approximate and for demonstration purposes only.

<sup>27</sup> Process emissions from cement production are taken from EPA's *Inventory of Greenhouse Gas Emissions and Sinks: 2000-2008* (2010c).

<sup>28</sup> Combustion and indirect emissions for the cement sector in 2006 are taken from US EPA, US EIA, and US Treasury (2009). Emissions for 2005, 2007, and 2008 are estimated here by SEI based on adjusting the 2006 values based on estimated annual energy intensity improvements for the U.S. cement industry reported in Dutrow et al (2010).

<sup>29</sup> Per the USGS Annual *Mineral Commodity Summary*: <http://minerals.usgs.gov/minerals/pubs/commodity/cement/mcs-2010-cemen.pdf>. Cement production here includes cement produced using imported clinker.

<sup>30</sup> Most cap-and-trade programs under consideration allow for entities to use offset credits in lieu of allowances for a fraction of their compliance obligations. Offsets are verified GHG reductions from uncapped sectors (e.g., agriculture, forestry) or regions (e.g. developing countries) that can be used for compliance with the cap.

<sup>31</sup> Note that since the allocation is based on production in the two years prior to the distribution, an increase in production in the year of the distribution would not be figured into the allocation and could leave even the average producer with fewer allowances than emissions in that year. Similarly, a decline in production would result in too many allowances.

Committee recently recommended output-based free allocation, which would require the development and use of benchmarks to the extent needed for the purpose of addressing emissions leakage associated with energy-intensive trade-exposed industries (EAAC 2010).<sup>32</sup>

## Benchmark-based Allowance Allocation in the European Union

Benchmarks will be the basis for distributing free allowances to industry in the upcoming third phase of the European Union's Emissions Trading System, which begins in 2013. The EU-ETS Directive, adopted in late 2008, sets the broad framework for establishing these benchmarks. The Directive specifies that the benchmarks be based on "the average performance of the 10% most efficient installations in a sector or sub-sector" in the years 2007 and 2008 (European Union 2008).<sup>33</sup>

The EU will decide on final benchmark values for the EU-ETS in 2010. In order to facilitate the development of these benchmarks, the European Commission has developed a set of benchmarking criteria. For example, the criterion "one product, one benchmark" means that among facilities that produce the same product, there will be no disaggregation according to technology, process, fuel choice, or age of facilities. Prior to 2012, the EU will decide on the measure of physical output to use in conjunction with these benchmarks in order to determine the number of allowances each facility will receive.<sup>34</sup>

## Emissions Performance Standards

While EPA and many stakeholders have expressed a preference for a market-based approach to reducing greenhouse gases (e.g., cap-and-trade), regulatory emissions performance standards continue to be considered and advanced as a "backstop" policy, should market-based approaches fail to be implemented (Alsalam 2009; Richardson, Fraas, and Burtraw 2010). In particular, EPA's December 2009 finding that greenhouse gases "endanger both the public health and the public welfare of current and future generations" may ultimately require EPA to regulate greenhouse gases from industrial facilities and other stationary sources under the Clean Air Act (Richardson, Fraas, and Burtraw 2010; US EPA 2009b). Accordingly, below we briefly describe possible means of developing and applying greenhouse gas emissions performance standards in a regulatory context.

Broadly speaking, regulations on GHG emissions from stationary, industrial facilities could be developed using one of two approaches. The first approach is to identify particular, sector-specific emissions benchmarks in terms, such as of tons CO<sub>2</sub>e per unit of output, that must not be exceeded. This approach has already been taken in Washington State for baseload electric generation, per Senate Bill 6001 in 2007, which imposed an emissions performance standard (a benchmark of 1,100 pounds CO<sub>2</sub> per megawatt hour) that has to be met by all qualifying facilities. The second approach is to define a particular set of technological controls – such as best available control technology (BACT) – that must be implemented by a specific facility. These approaches are not mutually exclusive. For example, a BACT may be defined as a specific technology based on that technology's ability to meet a particular emissions benchmark. Below we discuss the possible development and application of the GHG benchmark-based approach under EPA's existing permitting systems. Box 1 describes the relationship of how this process could require a technology-specific approach under determinations of BACT.

Section 111 of the Clean Air Act authorizes EPA to set New Source Performance Standards (NSPS) for emissions from *new* or substantially modified sources based on best demonstrated technology (Alsalam 2009; Nordhaus

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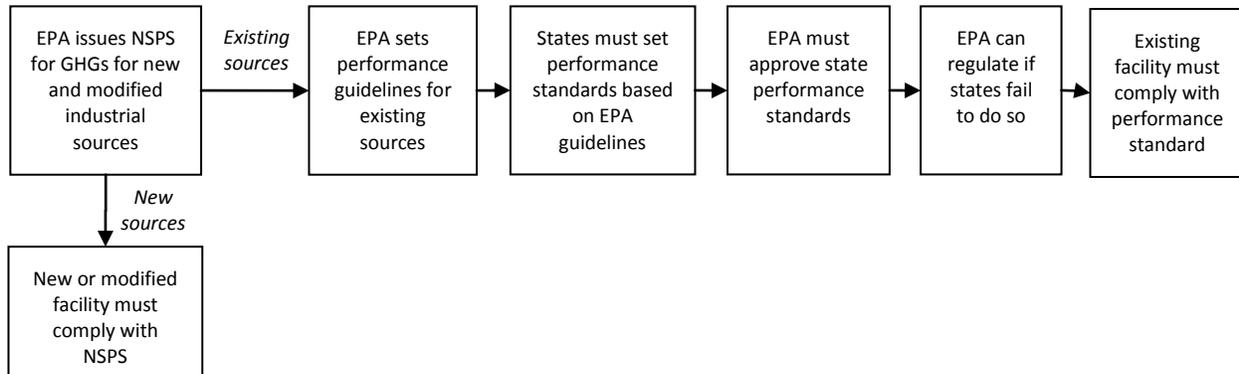
<sup>32</sup> In addition, the Portland Cement Association (PCA) has proposed that California adopt a "Cement Intensity Factor" as a tradable performance standard (Portland Cement Association 2009). Under a tradable performance standard, plants with performance less than the carbon intensity factor would generate a tradable credit, while plants with performance above the carbon intensity factor would have to purchase credits (Fischer 2003). In the absence of a cap, however, overall emissions could rise over time under a tradable intensity standard approach, if and as production increases.

<sup>33</sup> This level of ambition of the benchmark was agreed very early in the process. Since that time, the debate has focused on key methodological issues.

<sup>34</sup> In the EU, benchmarks will be in units of emissions per physical output (e.g., tons) and calculated based on performance of the 10% most efficient installations in 2007 and 2008 (European Union 2008). To translate this benchmark into an annual allocation of allowances, the benchmark must be multiplied by annual physical output. The rules for calculating physical output have not yet been agreed. The current proposal is use average production from 2005 to 2008 as the basis for "physical output."

2007; Parker and McCarthy 2009). Section 111(d) also authorizes EPA to require states to regulate emissions from certain kinds of *existing* sources (covering non-criteria, non-hazardous air pollutants) for which it has promulgated an NSPS. In this case, EPA issues guidelines for these sources that are implemented by states. Accordingly, EPA and states could require both new and existing facilities, including power plants, refineries, and other industrial facilities, to achieve compliance with specific emissions limitations – for example, a benchmark quantity of GHG emissions per unit of physical output of the facility (US EPA 2008b). Figure 5 displays the steps in the process of how the issuance of an NSPS for GHGs for an industrial source could translate into regulations on existing facilities.

**Figure 5. Regulating GHGs from Industrial Facilities Under Section 111(d) of the Clean Air Act**  
Adapted from Richards, Fraas, and Burtraw (2010)



Section 111 of the Clean Air Act gives EPA significant flexibility in defining NSPS, including who is subject to the standards, when the regulations are phased in, the units and stringency of the standard, and, potentially, what emission-control systems are required. Accordingly, the process for developing greenhouse gas NSPS for industrial facilities is not immediately clear. EPA has stated that they “would need to consider how to develop a metric for measuring and benchmarking” GHG emissions “in terms of the facility’s output production (e.g., amount of GHG per unit of production for a given facility)” (US EPA 2008b).<sup>35</sup> Whether EPA takes such an approach for greenhouse gases remains to be seen. EPA has shown a tendency to move towards more output-based standards under NSPS. For example, EPA has proposed, in its updates to the Portland cement NSPS, to switch the NSPS from being based on tons of input to tons of output (clinker): “Adopting an output-based standard avoids rewarding a source for becoming less efficient, i.e., requiring more feed to produce a unit of product, therefore promoting the most efficient production processes” (US EPA 2008c, p. 34076).

EPA is statutorily required to review NSPS every eight years. Development and inclusion of emissions performance standards for greenhouse gases would likely occur during these reviews (US EPA 2008d). In 2010, EPA is revising its NSPS for cement, expected to be finalized and published in the *Federal Register* in August 2010.<sup>36</sup> Some observers have speculated that EPA will include greenhouse gas emissions in the revisions (Bravender 2009). EPA has requested budget from Congress for funds to develop GHG NSPS for stationary sources, suggesting they do intend to develop NSPS for GHGs in the near future.<sup>37</sup> If EPA does not include GHGs in the revised cement NSPS, some observers expect a legal challenge, as was the case in 2008 when EPA did not include GHGs in its updated NSPS for petroleum refineries (Richardson, Fraas, and Burtraw 2010).

Federal New Source Performance Standards set a performance floor for permitting in the New Source Review program under Section 111 of the Clean Air Act. Implementation of the New Source Review permitting program

<sup>35</sup> EPA also discussed potential approaches in individual sectors. For example, regarding the petroleum refining sector, EPA states, “We are aware of proprietary metrics that exist that are used by refiners to benchmark their operations with respect to GHG emissions; however the use of a proprietary metric is problematic from a rulemaking perspective. We believe that a more transparent metric is desirable that could be used to describe the amount of GHG per unit of production for a given refinery” (US EPA 2008b, 21). For a list of existing NSPS for other pollutants, see: <http://www.epa.gov/ttn/atw/nsps/nspsbtl.html>.

<sup>36</sup> Per <http://yosemite.epa.gov/oepi/rulegate.nsf/byRIN/2060-AO42?opendocument>.

<sup>37</sup> See <http://www.whitehouse.gov/omb/budget/fy2011/assets/environmental.pdf>.

(involving case by case determination of best available control technology, or BACT) is carried out by state and local air pollution control agencies, such as the Washington State Department of Ecology and the Puget Sound Clean Air Agency. The Department of Ecology and most local air agencies in Washington have adopted most of the federal New Source Performance Standards covering other pollutants by reference. Washington State and local air agencies in the state have adopted several output-based performance standards for other pollutants, as summarized in Table 4, indicating a precedent for such an approach in Washington.<sup>38</sup>

**Table 4. Sample of Existing Output-based Emissions Performance Standards for Industrial Facilities in Washington**  
(Including examples from both State regulations and local permits)

Sector	Pollutant	Sub-sector or Process	Benchmark	Jurisdiction	Source of Regulation or Permit
Aluminum	Particulate matter (PM)	Primary aluminum	7.5 grams PM per kilogram of aluminum produced	Washington Department of Ecology	WAC 173-415-030
Electricity	Greenhouse gases (CO <sub>2</sub> e)	Baseload thermal-electric generation facilities	1,100 lb CO <sub>2</sub> e per MWh	Washington Department of Ecology	WAC 173-407-130
Glass	Particulate matter (PM)	Container glass (St. Gobain Containers)	0.5 lb PM <sub>10</sub> /ton of glass produced	Puget Sound Clean Air Agency	Puget Sound Clean Air Agency Order of Approval No. 5193 and 5289
Iron & steel	Nitrous oxides	Electric arc furnace (Nucor Steel)	0.48 lb NO <sub>x</sub> per ton of steel produced	Puget Sound Clean Air Agency	Puget Sound Clean Air Agency Order of Approval 9669
Pulp & paper	Sulfur dioxide (SO <sub>2</sub> )	Sulfite pulping mills that incinerate spent sulfite liquor	10 g SO <sub>2</sub> / kg pulp produced <sup>39</sup>	Washington Department of Ecology	WAC 173-410-040

As discussed above, federal NSPS apply only to new and modified sources. Section 111(d) of the Clean Air Act also allows EPA to regulate *existing* sources under the NSPS program.<sup>40</sup> Under Section 111(d), the Clean Air Act would require EPA to set performance guidelines (similar to, but likely less stringent, than NSPS) for existing sources and then require states (or EPA if a state were to fail to act) to create actual performance standards and submit plans to implement the standards (Richardson, Fraas, and Burtraw 2010).

In Washington State, the Department of Ecology might have the authority to regulate GHG emissions from existing facilities through mechanisms other than the federal Clean Air Act, such as the Washington State Clean Air Act. The State Clean Air Act (RCW 70.94) authorizes the Department of Ecology to develop emission standards applicable to all sources in a particular source category. State law also allows Ecology or a local air pollution control authority to determine reasonably available control technology (RACT) for a source category. In either case, the emission standard has to be developed and issued as a rule.<sup>41</sup> Current emission standards for pollutants other than GHGs have been developed for kraft and sulfite pulp mills, aluminum smelters, and gasoline dispensing facilities.

<sup>38</sup> Performance standards are not always based on output (i.e., benchmarks). Instead they can be in terms of concentration of pollutant from a stack. For example, WAC 173-415-030 specifies that SO<sub>2</sub> emissions from primary aluminum facilities must not exceed one thousand parts per million in any gas, in addition to specifying a benchmark-based standard of 30 g SO<sub>2</sub> per kg aluminum produced.

<sup>39</sup> Air dried, unbleached pulp.

<sup>40</sup> The authority to regulate existing sources using performance standards only applies if the pollutant is not regulated under the National Ambient Air Quality Standards (NAAQS) or as toxic pollutants under Section 112 of the Clean Air Act. Each of these has been discussed as an alternative or complementary pathway to regulating GHGs but are generally considered less feasible than NSPS. Nevertheless, this restriction on applying NSPS to existing sources may limit options for integrated approaches that combine regulation under different provisions of the Clean Air Act (Richardson, Fraas, and Burtraw 2010).

<sup>41</sup> With the exception that, for RACT in the case where there are less than 3 facilities in that category, then RACT would be set through an administrative order called an order of approval.

The state standards would be developed by evaluating the emission controls already in place, the ability of the existing sources to implement new or improved controls, the cost of compliance for individual facilities, and time required to install controls, among other factors. The determination of RACT or emission standards can be expressed in a common sense manner such as pounds of pollutant per unit of production or concentration (parts per million by volume).

### Box 1. New Source Performance Standards and Best Available Control Technology (BACT)

New Source Review is the process for obtaining construction permits for new and modified stationary sources under the Clean Air Act (CAA) and is sometimes also called Prevention of Significant Deterioration (PSD). Under the New Source Review (NSR) program:

1. **EPA establishes New Source Performance Standards (NSPS) for new and modified sources.**
2. **A new or modified facility emitting more than the pollutant threshold applies for a permit to a state or local air agency and must undergo preconstruction review and permitting.** EPA's final "tailoring rule" (US EPA 2010d) sets thresholds for GHG emissions that define when PSD permits are required. The rule "tailors" the requirements of the CAA to require permits from existing facilities that increase their emissions by at least 75,000 tons CO<sub>2</sub>e annually or from new facilities that emit at least 100,000 tons CO<sub>2</sub>e annually. The rule shields stationary sources that emit less than 50,000 tons CO<sub>2</sub>e from permitting before April 30, 2016.
3. **The state or local air agency determines Best Available Control Technology (BACT) on a case-by-case basis,** taking into account energy, environmental, and economic impacts. Determinations of BACT must be at least as stringent as the NSPS.

Determination of BACT for GHGs will soon be required under the NSR program. In April 2010, EPA issued final rules that set GHG emissions and mileage standards for cars and light trucks (US EPA and US DOT 2010). These rules trigger regulation of GHGs for stationary sources under NSR and will require that major new or modified sources install BACT (Pew Center on Global Climate Change 2010). EPA has stated that limits (or related "work practice standards") for GHGs will be required in PSD permits for those stationary sources that meet the criteria of the tailoring rule (as described above) on January 2, 2011 (US EPA 2010b).

The definition of BACT for greenhouse gases at stationary sources is a major unknown, and defining what technologies qualify as BACT could be an enormous challenge. The normal process for determining BACT is to:

1. Identify all control options
2. Eliminate technically infeasible options
3. Rank remaining control options
4. Eliminate control options based on evaluation of collateral impacts
5. Select BACT

The difficulties of this task for GHGs were pointed out in a report from an EPA advisory committee. The interim report, by thirty-five representatives from industry, state and local governments, and environmental and public health non-profit organizations, identified several areas of contention on defining BACT for GHGs, including how tightly to draw the boundary around what emissions are regulated, criteria to use to determine whether a technology is feasible, and criteria for eliminating particular control technologies from consideration (Clean Air Act Advisory Committee 2010). The EPA's tailoring rule discusses the need to streamline BACT determinations, including developing a "presumptive BACT", based on emission limits that could be based on sector benchmarks (US EPA 2010d, p. 397).

Some initial lessons may be drawn from the first facility in the U.S. to undergo a BACT determination for GHGs: the Russell City Energy Center, a combined cycle natural gas-fired power plant in Hayward, CA, which underwent the 5-step process above (Calpine 2010). In particular, that facility defined BACT as a net energy efficiency value expressed as a benchmark value of emissions (1100 lb CO<sub>2</sub>/MWh, the California GHG emission performance standard for power plants). This value was not the maximum possible efficiency but was instead a level that could be consistently maintained under all operating conditions.

## Summary: Benchmarks in the Three Policy Approaches

Emissions benchmarks are used in each of the three policy approaches discussed above. For example,

- Member companies of the International Aluminum Institute (IAI) have committed to operate by 2020 with perfluorocarbons (PFC) emissions per ton of aluminum no higher than the 2006 global median level for their technology type. Alcoa, for example, is a member of the IAI, and its Washington facilities already exceed these targets. The IAI goals are an example of a voluntary, unilateral initiative undertaken by industry to reduce emissions of one highly potent GHG below a benchmark level.
- The Waxman-Markey bill, which passed out of the U.S. House of Representatives in June 2009, would allocate allowances to energy-intensive, trade-exposed industries at the level of a sector-average benchmark. For example, cement kilns would receive a number of allowances for each ton of cement produced to cover their direct emissions. This is an example of the use of benchmarks in a cap-and-trade program.
- Washington State has set a limit on the release of sulfur dioxide emissions from sulfite pulp mills of 10 grams of SO<sub>2</sub> per ton of pulp produced. This is an example of a mandatory performance standard on emissions.

The process for developing benchmarks such as these in the three different policy contexts share many common traits, issues, and options. In the following section, we describe several issues and options for constructing greenhouse gas benchmarks for industry and assess how these factors – and the process for constructing benchmarks – might differ according to the policy approach selected.

### 3. Benchmark Construction: Issues and Options

In this section, we discuss and assess several key issues and options for constructing GHG benchmarks for industry. These include:

- **Definition of product or sector being benchmarked**, including factors to consider in determining whether benchmarks are assigned at a sector-wide level (e.g. pulp and paper) or instead for particular products, processes (e.g., sulfite pulp), or other facility-specific factors;
- **Measurement protocol and boundaries**, such as whether to focus benchmarks on direct emissions only or all emissions (including the indirect emissions associated with purchased energy, such as electricity);
- **Units for normalizing the benchmark**, meaning alternative choices for benchmark denominator, such as tons of output, dollars of output, or tons of input;
- **Benchmark ambition**, or whether to make the benchmark based on an average across facilities or instead some better-than average value; and
- **Data sources** that may support development of benchmarks.

At the end of the section, we reflect on how the different policy approaches described in Section 2 – voluntary goals, output-based allocation in a cap-and-trade program, and emission performance standards – might affect how benchmarks are constructed. We also describe a potential alternative to benchmarking particular products or sectors: benchmarking heat production, an activity that extends across sectors.

#### Definition of Product or Activity Being Benchmarked

Benchmarks can be developed for entire industries (e.g., the global steel industry) or for individual plants with particular fuel choices and feedstocks (e.g., a steel plant with an electric arc furnace that uses 100% scrap steel). The choice of scale at which to define the benchmark – that is, the level of aggregation across subsectors, product types, technologies and other plant circumstances – is a critical design choice for ensuring that the benchmark provides an appropriate and effective incentive for reducing emissions.

Benchmarks based on an entire class of products (e.g., steel or cement) will tend to give the industry maximum long-term flexibility in reducing emissions. Under an industry-wide benchmark, industry actors could adapt by increasing the efficiency of existing plants, switching fuels from coal or oil to natural gas or low-carbon electricity, phasing out more GHG-intensive technologies in favor of less GHG-intensive technologies, or using a higher fraction of secondary (recovered) feedstock.

Consider the U.S. steel industry. The American Iron and Steel Institute reports that the U.S. steel industry emits an average of 1.24 tCO<sub>2</sub>e per ton of steel produced (US EPA 2008a). Of the two primary types of steel mills, integrated (e.g., basic oxygen furnace or BOF) mills tend to produce much higher emissions than this average, in part because they must first convert iron to steel rather than rely on scrap steel. Electric arc furnaces (that rely on scrap steel as feedstock) produce much lower emissions (IEA 2008). Accordingly, implementing a policy approach based on a single industry-wide benchmark of 1.24 tCO<sub>2</sub>e per ton of steel could provide a significant incentive to increase production at electric arc furnaces at the expense of production at integrated mills, provided that increased quantities of scrap steel were available to supply the electric arc furnaces.<sup>42</sup> Such an incentive – even as it allows maximum flexibility to the industry to make investments that cost-effectively reduce emissions – would not allow for site- or market-specific considerations and could lead to the closure of smaller, older manufacturers that cannot as readily upgrade, replace capital stock, or access supplies of alternative (e.g., recovered) feedstocks.

By contrast, a benchmark based on the specifics of individual plants may help recognize particular, site-specific conditions, but provides less incentive for larger-scale restructuring of the industry. For example, if individual benchmark-based regulatory performance standards were developed for each type of facility, each fuel choice, each type or quality of feedstock, and other site-specific parameters (such as the availability of recovered feedstocks), then the benchmark would provide relatively little (if any) incentive to alter these factors to reduce GHG emissions, leaving process efficiency improvements or minor retrofits as the only option. If site-specific benchmarks were developed in a cap-and-trade setting, then each facility would receive an allocation roughly equivalent to historic emissions, at least for the first allowance distribution period.<sup>43</sup> Allocating based on historic emissions (“grandfathering”) has been criticized for not rewarding those facilities that have undertaken “early action” to reduce emissions before the start of the cap-and-trade program (EAAC 2010; Raymond 2003).

To address the tension between benchmark aggregation and specificity, one approach could be to develop individual benchmarks for each type of unique product produced by an industry. This approach has been employed in the European Union’s cap-and-trade program, where it is has been called “one product, one benchmark.” Under such an approach, only one benchmark would be developed for each product. Separate benchmarks would not be developed for different production technologies, fuel choices, type or quality of feedstock, local climate circumstances, product color, or other facility-specific factors.

For example, a benchmark on the production of writing paper would recognize the unique processes used to produce writing paper instead of another paper grade (e.g., newsprint). Separate benchmarks for different paper products would avoid incentivizing the production of one type of paper at the expense of another that could result if only one benchmark for all paper grades were applied. Even under a “one product, one benchmark” approach, however, many challenges would still remain in defining what constitutes a unique product. Although writing paper is clearly different from newspaper, cases could be made for distinguishing more specific grades of some types of paper (e.g., coated versus uncoated papers, or different types of containerboard). Similar decisions exist in most other sectors, including steel, aluminum, and chemical sectors.

An additional challenge with the “one product, one benchmark” approach is how to develop benchmarks for facilities that produce many different products from the same process units. To address this problem, some stakeholders have argued for technology or process-specific benchmarks that may apply across product categories.

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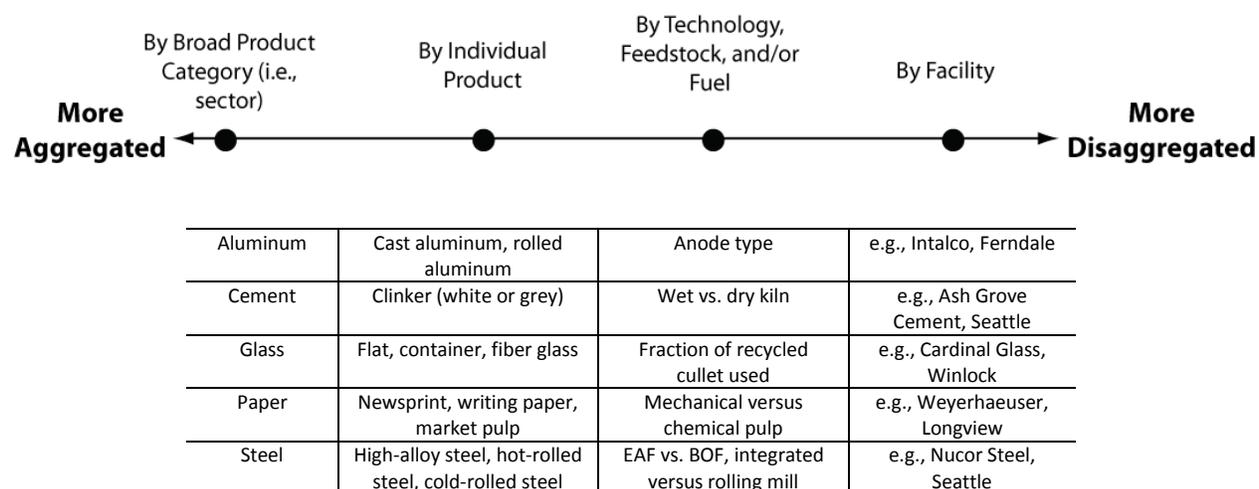
<sup>42</sup> The emissions benefits of an electric arc furnace (EAF) rely strongly on the use of scrap steel, of which supplies are limited. The alternative (virgin) feedstock for an EAF is direct reduced iron (DRI). According to the International Energy Agency, production of steel from DRI can be more or less emissions intensive than producing steel in a basic oxygen furnace depending on whether coal or natural gas, respectively, are used to produce the DRI (IEA 2008).

<sup>43</sup> Since still based on output, allocations in future years would depend on the facility continuing production.

For example, the Northwest Pulp and Paper Association has suggested that benchmarks be developed for the paper-making processes used to produce a variety of products. Such an approach could indeed help simplify benchmark development and application for facilities that produce multiple products from a single process or set of processes, but doing so would remove the incentive to switch to a more energy-efficient process.

Figure 6, below, displays the continuum of levels of benchmark disaggregation along with samples of the choices at each level.

**Figure 6. Choices of Benchmark Disaggregation Lie along a Continuum**  
(With Sample Choices by Sector)



In a cap-and-trade program, a “one product, one benchmark” approach could help preserve a clear price signal to firms to make investments in reducing emissions. Under cap-and-trade programs like the EU-ETS and the program proposed in H.R. 2454, the program administrator would freely allocate or rebate emissions allowances to each firm according to the benchmark value. Facilities that emit more than the benchmark level would have the flexibility of purchasing allowances from the market to cover their additional emissions, while facilities that emit less than the benchmark value would have allowances to sell. Analysis conducted to support the EU’s benchmark development process has found that benchmark-based allocation based on the “one product, one benchmark” concept (but not including consideration of technology or process type, fuels, or feedstock variations) best preserves the price signal to individual firms (Neelis et al. 2009).

Unlike in a cap-and-trade program, a “one product, one benchmark” approach may not be as applicable in a regulatory system using performance standards, however, unless some degree of trading or crediting was provided to the facilities to provide flexibility in meeting the benchmark.

### Benchmark Disaggregation in the Three Policy Approaches

The type and extent of disaggregation for setting benchmarks can have important implications for how well the underlying policy can achieve its objectives. For example, in seeking to reduce GHG emissions, policymakers may also strive to maximize the economic efficiency of emission reductions attained, to avoid emissions leakage, and/or to manage cost burdens in an equitable manner. From an economic perspective, the rationale for disaggregating benchmarks by technology, feedstock, or fuel can differ by policy approach, as follows.

- Cap-and-trade programs use benchmark-based allowance allocation to avoid carbon leakage while retaining an overall CO<sub>2</sub> price signal to incentivize lower-emissions production.** An aggregated benchmark (e.g., uniform across the industry sector) sends the same CO<sub>2</sub> price signal to all installations, irrespective of size, fuel, technology or age. If the benchmarks were instead highly differentiated by

facility-specific factors, total economic costs of attaining a particular reduction in GHG emissions would **increase** total economic costs, since overall GHG abatement is determined by the emissions cap and awarding free allowances to facilities based on their individual circumstances diminishes the price signal to shift production from more GHG-intensive technologies, feedstocks, or fuels to less GHG-intensive technologies, feedstocks, or fuels. In other words, and in most cases, the benchmark value does not control the level of abatement. Rather, it helps avoid carbon leakage while attempting to preserve appropriate price signals to individual facilities.

- **In contrast to allowance allocation, regulatory performance standards directly determine the level of abatement. Since a performance standard also acts as a go/no-go threshold, the level of the benchmark will more directly determine whether new facilities are constructed or existing facilities continue to operate.** If the costs of abatement are different for different technologies, feedstocks, or fuels, it may be appropriate to consider more ambitious benchmarks for those with low abatement costs, and a less ambitious benchmark where abatement costs are higher. Where abatement costs are higher, allowing for disaggregation by technology, feedstock, or fuel could **reduce** the total economic costs to achieve a given level of abatement. This outcome is more likely for existing facilities with long-lived capital investments and high switching costs. With new facilities the case for disaggregation may be less compelling.
- **In voluntary approach, the differentiating among technologies, feedstocks or fuels might encourage greater participation, especially by those companies with long-lived investments in technologies for which abatement options are more limited or costly.** Similar to regulatory performance standards, it may make sense to differentiate benchmarks if the costs of abatement are different between technologies. In this way, allowing for disaggregation can **reduce** total economic costs.

In summary, from an economic perspective, it may make more sense to disaggregate benchmarks by technology, feedstock, or fuel under voluntary and regulatory approaches, than for allowance distribution under a cap-and-trade system.

### Considerations for Intermediate Products

Benchmarks are typically set on a measure of final product output, such as tons of steel or paper produced. . In some contexts, however, developing separate benchmarks for intermediate products (such as iron used to make steel, or pulp used to make paper) that are energy-intensive and commonly traded between firms and installations may help advance program goals.

In particular, in a cap-and-trade system, the primary motivation for free benchmark allocation is to avoid carbon leakage, while preserving the price signal and rewarding top performers that have undertaken “early action.” If the benchmark were based only on the final product, then companies could instead import the emission intensive intermediate product from non-regulated regions, therefore potentially increasing the risk of carbon leakage. To address this risk, benchmarks can be developed for emissions-intensive intermediate products that are traded between firms and internationally.

Such an approach could (but need not necessarily) be employed under regulatory or voluntary approaches as well. Defining the benchmark on the final product only would help incentivize GHG emission reductions along the whole supply chain (including the intermediate products), allowing for greater flexibility (and, in turn, lower abatement costs) and potentially also for more ambitious benchmarks. On the other hand, calculating benchmarks for the full life-cycle emissions of an industry or facility’s products could introduce new extra methodological complexity for sectors where a significant fraction of an energy-intensive feedstock is traded between firms. For example, if paper mills were responsible for the emissions of the pulp they purchase from other facilities, new market data systems would be needed to allow pulp sellers to measure and communicate the emissions intensity of their pulp to paper makers purchasing this pulp on the market.

Table 5, below, summarizes the benefits and challenges of different levels of benchmark disaggregation discussed above.

**Table 5. Benefits and Challenges of Benchmark Disaggregation**

Level of Disaggregation	Benefits	Challenges
<b>Broad product category (i.e., sector-wide)</b> Benchmarks developed for an entire sector's output (e.g. pulp and paper)	Can be simpler than more disaggregated benchmarks. Provides maximum flexibility to industry in reducing emissions.	Smaller, older manufacturers performing far from the sector-wide average may be less able to upgrade, replace capital stock, or access alternative feedstocks. Does not recognize trade of intermediate products.
<b>Product-specific</b> Benchmarks developed for particular products (e.g., cardboard) but not for individual facilities	Provides greater flexibility and incentive to industry to reduce emissions than do facility-specific benchmarks, particularly in cap-and-trade context.	Determining what constitutes a unique product (including intermediate products) can be very challenging. Requires confidential data on product output. May not be as applicable in performance standard or voluntary context since does not recognize facility-specific conditions.
<b>With consideration for technology, feedstock, and/or fuel</b>	Can recognize long-lived investments or particular market conditions, possibly increasing flexibility in a voluntary program	Potentially large administrative burden. Erodes incentive for larger-scale restructuring of the industry (distorts price signal.)
<b>Facility-specific</b> Individual benchmarks developed for each facility (e.g., a particular paper mill)	Can tailor benchmarks to individual sites and set more ambitious benchmarks for facilities with greater GHG-reduction opportunities, thereby potentially increasing economic efficiency, at least in a regulatory or voluntary context	Potentially huge administrative burden to develop benchmarks for each individual facility. Erodes incentive for larger-scale restructuring of the industry (distorts price signal).

## Measurement Protocol and Boundaries

To ensure that all relevant emission sources are included and produce effective benchmarks, policymakers and administrators need common guidelines, tools, and methods to measure or estimate greenhouse gas emissions and production at the facility level.<sup>44</sup> Fortunately, several GHG measurement protocols have already been established. For example, the World Business Council on Sustainable Development and World Resources Institute, working in partnership with industry groups, developed the GHG Protocol, which has been used widely for the past decade. Recently, US EPA established protocols to guide mandatory reporting of greenhouse gas emissions for all facilities in certain sectors (e.g., aluminum, cement) and for facilities that emit more than 25,000 tons CO<sub>2</sub>e annually in most other sectors. The rule will also require reporting of production volumes for those industrial sectors required to report. Washington State will be harmonizing the reporting methodologies for its Greenhouse Gas Reporting Rule, which will cover facilities that emit at least 10,000 tons CO<sub>2</sub>e, with those of EPA.<sup>45</sup>

Ideally, the same measurement protocol should be used both for constructing benchmarks and for monitoring the emissions to which the benchmark will apply. Using the same measurement protocol for both will help to ensure that monitored facility performance can be readily and meaningfully compared against an established benchmark: emission sources, benchmarked products, and facility boundaries (units used to make the benchmarked products) would be defined and measured in a similar fashion.

### Include Indirect Emissions?

A critical question in developing GHG benchmarks will be whether and how to account for indirect emissions, in particular the emissions associated with electricity or heat purchased by industrial facilities.

The decision depends in part on the policy context of the benchmark development. In case of voluntary performance goals, including both direct and indirect emissions puts facilities on a more equal footing, and avoids meeting emission reduction goals simply by substituting purchased heat or electricity for on-site fuel combustion.

<sup>44</sup> Secure and robust data systems must be put in place to maintain confidence and, where needed, confidentiality.

<sup>45</sup> [http://www.ecy.wa.gov/programs/air/globalwarm\\_RegHaze/6-11\\_GHG\\_Advisory\\_Presentation.pdf](http://www.ecy.wa.gov/programs/air/globalwarm_RegHaze/6-11_GHG_Advisory_Presentation.pdf)

While such a shift might reduce direct on-site emissions, it would increase emissions outside the facility boundary if fossil fuels were used to produce the purchased heat or electricity.

For cap-and-trade systems, however, the choice is less obvious. Under a cap-and-trade system that covers both electricity generators and industrial facilities, generators would need to secure allowances for the emissions associated with electricity sold to industrial facilities. Therefore, there is no need to separately account for indirect emissions from electricity purchased by industrial facilities.

However, industrial facilities could experience cost impacts due to any increase in the cost of electricity resulting from the price of allowances. Accordingly, some cap-and-trade program design (including of H.R. 2454 and Australia’s proposed cap-and-trade system) provide further cost support to industry through benchmark-based allowance allocation for indirect emissions similar to the allocation for direct emissions. (In H.R. 2454, the allocation for purchased electricity is based on the emissions rate of the local electricity provider, and is adjusted downward to the extent allowances provided to the local electricity provider reduces the carbon price felt by the purchaser.)

For regulatory performance standards, the choice of whether to include direct and indirect emissions may be even yet more complex. The concern about a facility switching from onsite fossil fuel combustion to electricity with little or no reduction in overall (direct + indirect) emissions still exists, but is difficult to address given that typical air pollution provisions, such as NSPS and BACT in the Federal Clean Air Act, are designed to address direct emissions, not indirect emissions or total energy use. Nevertheless, EPA has been exploring means of encouraging energy efficiency through provisions in BACT, a co-benefit that could also encourage reductions in indirect emissions. Further research is necessary on means of addressing indirect emissions in a performance-standard approach.

**Table 6. Benefits and Challenges of Including Direct or All Emissions in Benchmark Construction**

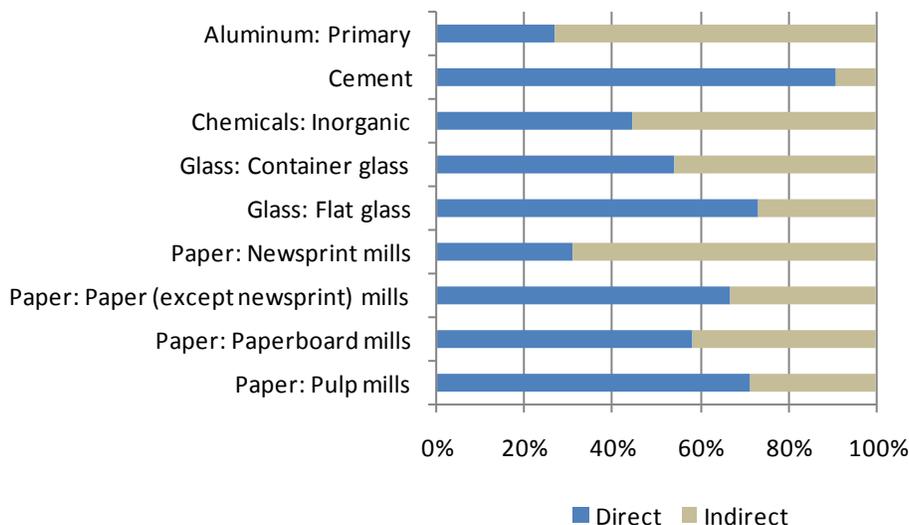
	<b>Voluntary</b>	<b>Allowance Rebate in Cap-and-trade</b>	<b>Performance Standards</b>
<b>Direct only</b>	<ul style="list-style-type: none"> <li>▪ <b>Benefits:</b> simpler</li> <li>▪ <b>Challenges:</b> might encourage emissions “leakage” to electricity sector</li> </ul>	<ul style="list-style-type: none"> <li>▪ <b>Benefits:</b> aligns well with basic structure of cap-and-trade</li> <li>▪ <b>Challenges:</b> could disincen combined heat and power</li> </ul>	<ul style="list-style-type: none"> <li>▪ <b>Benefits:</b> simpler</li> <li>▪ <b>Challenges:</b> could encourage emissions “leakage” to electricity sector</li> </ul>
<b>All (Direct + Indirect)</b>	<ul style="list-style-type: none"> <li>▪ <b>Benefits:</b> includes more sources of emissions over which facility has control</li> <li>▪ <b>Challenges:</b> greater data needs and methodological complexity</li> </ul>	<ul style="list-style-type: none"> <li>▪ <b>Benefits:</b> can help offset any added costs to industry from higher electricity prices</li> <li>▪ <b>Challenges:</b> greater data needs and methodological complexity</li> </ul>	<ul style="list-style-type: none"> <li>▪ <b>Benefits:</b> includes all sources of emissions over which facility has control</li> <li>▪ <b>Challenges:</b> BACT not designed to address indirect emissions; greater data needs and methodological complexity; might need to regulate electricity or heat purchases as a proxy for indirect emissions.</li> </ul>

The relative importance of direct versus all (direct +indirect) emissions also varies by sector. Some sectors (particularly cement) release far more emissions directly than indirectly. For many others (e.g., aluminum), a significant fraction of the sector’s emissions are released indirectly through electricity production. Figure 7 displays the overall fraction of direct versus indirect emissions for select industry sectors in the U.S. If a similar graph were produced for the northwestern U.S., the relative amount of direct and indirect emissions would change for many of the sectors, due to the region’s relatively higher reliance on low-carbon hydroelectricity.

Even more critical than the balance of direct and indirect emissions is the relative substitutability of electricity and fossil fuels within a sector and the emissions-intensity of that electricity. For example, it could be argued that the electricity-dependent electric arc furnaces and the fossil-fuel-dependent (and more emissions-intensive) basic oxygen furnaces produce equivalent products and should be compared using the same benchmark. If that were

the case, such a benchmark would be likely to incentivize the use of electric arc furnaces due to their lower emissions intensity, even considering the emissions used to produce the electricity.

**Figure 7. Relative Overall U.S. Fraction of Direct and Indirect GHG Emissions in Select Energy-Intensive, Trade-exposed Sectors (US EPA, US EIA, and US Treasury 2009).**



### Treatment of Combined Heat and Power

Another, related and complex issue is the treatment of combined heat and power (CHP), or cogeneration. With CHP, boilers or turbines at industrial facilities simultaneously generate both power and usable heat. The power or heat may be used internally, or sold to the grid or to other facilities. Producing heat and power using CHP systems requires approximately 25% less energy than would producing heat and power using separate equipment (IEA 2008). However, a facility that invests in a CHP system may see its direct emissions increase. For example, suppose an industrial facility operating a natural gas boiler to produce heat (as steam) invests in a natural gas CHP system. That facility will now produce both heat and power, allowing it to meet most or all of its power needs through electricity generated on-site in the CHP installation instead of purchased from a local utility. The facility's own, direct emissions will increase as a result of the added fuel needed to produce both heat and power. However, overall emissions may decrease as the facility avoids the need for purchased electricity and the emissions associated with its generation.

If not appropriately designed, benchmarks could inadvertently discourage CHP. Since CHP will increase facility's on-site, direct emissions without affecting the amount product manufactured, it will be more difficult (or costly) to meet a benchmark value based only on direct emissions per unit output. In particular, following are some considerations for applying benchmarks to CHP in the three policy approaches considered here.

- In a voluntary and regulatory context, benchmarks** based on direct emissions per unit output alone will discourage CHP unless other provisions are put in place. For example, CHP units meeting specific criteria could be exempted from regulation, or direct financial incentives could be provided to CHP facilities. Alternatively, a benchmark could include indirect emissions and thereby aim to reflect the full emission reduction benefit of CHP. Ideally, indirect emissions would be calculated in a manner that reflects the emissions rate of the marginal electricity generation unit(s) avoided by the CHP unit.
- In a cap-and-trade context,** output-based rebates based solely on direct emissions might or might not provide a proper incentive to invest in, or operate, a CHP unit, depending in large part on how electricity is priced in the local context. As noted above, an industrial facility will need to hold additional allowances to cover the added direct emissions from the CHP plant, which places an additional cost on the facility. At

the same time, to the extent that electricity prices for purchased electricity increase as the result of the cap-and-trade program, the facility will accrue a cost saving as the result of avoiding the carbon price reflected in the electricity it would have otherwise purchased. (A similar situation holds in the case where a CHP unit sells electricity to the grid; to the extent that the carbon price faced by the facility is reflected in the price paid for electricity sales, then the facility will accrue added revenue.) If the following conditions were to hold, then an output-based allowance rebate based on a direct emissions only benchmark would indeed provide a proper price signal to the operation of CHP units: a) the carbon price were fully reflected in the electricity price (for buying and/or selling electricity); and b) electricity was priced on a marginal, rather than average basis (thus reflecting the emissions of the grid electricity facilities avoided by the CHP unit). However, in Washington State, where electricity is generally priced on an average rather than marginal cost basis<sup>46</sup>, these conditions may be difficult to meet; furthermore, cap-and-trade programs may contain provisions that limit the extent to which carbon prices are reflected in electricity prices.

As a result, program designers may wish to consider other options for addressing CHP. One option would be to develop separate benchmarks for CHP installations, where the benchmarks would reflect the emissions associated with heat and power produced separately on-site. Alternatively, if benchmarks were to include indirect emissions based on the marginal emissions rate of the local electricity provider (as is the intent of H.R. 2454), then an incentive for CHP would be provided (as long the emissions associated with the added CHP electricity production are less than the marginal emissions rate of the local electricity provider).<sup>47</sup> However, in this case, if in addition, the industrial facility with on-site CHP also receives a financial benefit from avoiding the purchase (or selling) of electricity at higher price (due to the carbon price impact of the cap-and-trade program), it could receive an incentive that is beyond the level justified by its GHG emission savings. Given the wide regional variation in electricity pricing across regulated and deregulated regions in the US, as well as uncertainty on the extent to which carbon prices will be reflected in electricity prices, it will be difficult to design a benchmark that provides the incentive for CHP that appropriately reflects its emission reduction benefits in all circumstances.

CHP can be a complicated topic. Policymakers will need to decide whether to provide added support to CHP by measures such as including indirect emissions in the benchmark, or whether to remain technology neutral (e.g. by ignoring indirect emissions), and thereby risk potential disincentives to CHP installations.

In Washington State, the refining and pulp and paper sectors are those with the greatest installed CHP generation capacity.<sup>48</sup> The refining sector operates CHP systems fired by oil and natural gas, whereas the pulp and paper sector's CHP installations are fired by natural gas, wood waste, or waste liquors from the pulping process.

### Benchmark "Base Period" and Updating

The discussion of emissions measurement protocol and boundaries above focuses largely on the operational boundaries and scope of emissions included in the benchmark value, but the question of *when* emissions are measured and benchmarks developed and updated is also important. Two issues present themselves regarding timing of benchmark development and application:

- **Lag time between benchmark development and application.** Most industry sectors have made significant improvements in energy and emissions intensity in recent decades and are projected to continue to make gains in the future (IEA 2009a). A benchmark developed in one year – especially a benchmark based on average performance – could be expected to lose incentive properties over time.

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<sup>46</sup> This situation is generally the case for both for publicly-owned as well as rate-regulated investor-owned utilities.

<sup>47</sup> Since the marginal electricity facility in Washington is most likely a natural-gas fired plant and the average portfolio includes a considerable fraction of low-carbon electricity, a CHP facility's carbon intensity would likely be lower than the marginal facility but higher than the average facility. Calculating the benchmark based on the marginal value would best reflect the actual emissions being avoided by introduction of the CHP system.

<sup>48</sup> Per the *Combined Heat and Power Installation Database* maintained by the U.S. Department of Energy and Oak Ridge National Laboratory, <http://www.eea-inc.com/chpdata/>.

Accordingly, benchmarks can be updated on a regular schedule. For example, benchmarks used for allocating allowances under H.R. 2454 are to be updated every four years but cannot be greater than they were in the previous year (Waxman and Markey 2009, 1110). One criticism of updating for allowance allocation is that since firms can directly influence their emissions intensity, they may be able to affect the benchmark value and in turn their allocation in future years (Stavins 2007).

- **Cyclical fluctuations in business cycles.** Given cyclical fluctuations at individual facilities and in the economy, developing a benchmark based on more than one year of data may be appropriate. Program designers must strike a balance between including data from enough years to smooth out important fluctuations but not so long that the benchmark is based on data too old to be representative. For example, under H.R. 2454 benchmarks are to be based on the most recent four years of emissions and output data, whereas in the upcoming third phase of the European Union's ETS, benchmarks are based on two years of data.

As with other issues, the choice of data years to reflect in a benchmark will need to take into account the policy context as well as data constraints.

### Treatment of New Versus Existing Facilities

As stated above, industrial emissions intensity has improved in recent decades, in part as newer, more-efficient technologies replace older facilities. How benchmarks provide incentive to both new and existing facilities depends on the policy approach. In a regulatory context, strong precedent exists for separate benchmarks for new and existing facilities; for example, in the federal Clean Air Act, separate provisions and procedures apply to new and modified (New Source Review) as compared with existing facilities (e.g. Section 111 and 111(d) noted above). In most cases, existing facilities could not be expected to meet the same benchmarks as new facilities. In a cap-and-trade program, new and existing facilities can be assigned either the same or a different benchmark. Assigning the same benchmark has the benefit of encouraging production at the lowest emitting facilities, and investment in low-GHG technology, consistent with a clear, undistorted carbon price signal. However, since benchmarks values are typically drawn exclusively from the performance of existing facilities, a common benchmark may provide more allowances to new facilities than needed to prevent leakage (especially if based on the average performance of existing facilities). For further discussion of benchmark ambition and possible drawbacks of benchmarks set too high in a cap-and-trade program, see the section on Benchmark Ambition, beginning on page 28.

### Units for Normalizing

As described in the introduction to this paper, GHG benchmarks are typically expressed as a quantity of emissions per unit of output, as in the following simple equation:

$$GHG \text{ Benchmark} = \frac{\text{Emissions (tons CO}_2\text{e)}}{\text{Unit of Output (tons, \$, or other metric)}}$$

The denominator of this equation – the *unit of output* – is often a physical unit of product output (e.g., a ton of cement, steel, or aluminum). However, the denominator could instead be a unit of input (e.g., a ton or barrel of crude oil refined), or some other metric, such as production capacity or a monetary output (e.g., net value added or revenue of product shipped). Benchmarking can also utilize a combination of factors, expressed in terms of an equation, as in the method of the US EPA ENERGY STAR program. This section discusses the rationale and tradeoffs with alternate choices of benchmark denominator, or the units for normalizing the benchmark.

Most, but not all, existing benchmarking efforts use physical product output as the benchmark denominator. For example, the formulas for constructing sector-average benchmarks in the U.S. Waxman-Markey bill (H.R. 2454), existing emissions performance standards in Washington State (e.g., NO<sub>x</sub> from steel mills, SO<sub>2</sub> from sulfite pulp mills), and most of the voluntary efforts summarized in Section 2 of this White Paper all rely on a weight-based,

physical unit of output. Physical units are not affected by cyclical variations in prices or other economic fluctuations and link more directly to technology performance and efficiency than do monetary denominators.

Furthermore, a physical unit of *output* (rather than input) will tend to better enable assessment of technology performance and efficiency. If a unit of *input* was used, the benchmark performance (emissions per ton or per unit of heat input) could provide a perverse incentive to use input feedstocks less efficiently, since using more input to produce the same unit of output would drive up the benchmark denominator and therefore improve the apparent GHG performance of the facility. By contrast, basing the benchmark on output provides an incentive to increase production – a goal that, while it may also have unintended consequences, does support manufacturing within the benchmark region and may help address industry competitiveness concerns, particularly in a cap-and-trade context. Still, for some industry sectors basing the benchmark on a unit of input may be desirable if defining and quantifying output-based benchmarks is too onerous. The petroleum refining industry is one sector where benchmarking based on inputs (e.g., barrels of crude oil) is commonly discussed and implemented.

Table 7, summarizes benefits and challenges associated with alternative choices of physical versus monetary and input versus output in selecting benchmark denominators.

**Table 7. Benefits and Challenges of Alternative Choices of Benchmark Denominator**

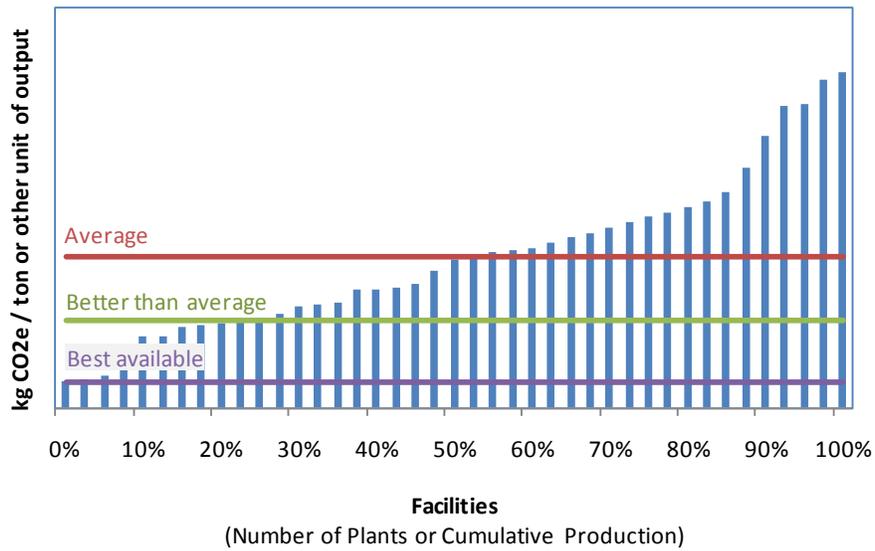
	<b>Benefits</b>	<b>Challenges</b>
<b>Physical Input</b>	Can be well-suited to industry sectors where the products are far more complicated than the inputs (e.g., petroleum refining)	Fails to reward efficient use of raw material feedstock in producing a product and can lead to perverse incentives
<b>Physical Output</b>	Links directly to technology performance and efficiency and therefore can more directly be used to help identify improvements possible through new technologies. Can enable comparisons between world regions regardless of the structure of each region’s industry and economic data.	Requires data on product output, which is generally confidential, though will be supplied under mandatory GHG reporting in most instances
<b>Monetary Input</b>	None identified	Would require confidential information on each facility’s expenditures on raw materials yet would not provide any physical unit (e.g., barrels of crude oil) on which to assess plant efficiency
<b>Monetary Output</b>	Some such data already exist, at least at the sector-wide level, through existing sources (e.g., U.S. Census Bureau). Can create a common denominator across sectors.	Using a monetary unit can introduce other types of variation (price or currency fluctuations) that would obscure the underlying technical performance of the plant

## Benchmark Ambition

The choice of an emissions benchmark – whether average, better-than-average, or best available – depends on the intended use. If the goal is to assess performance relative to average emissions practices, a simple average can be sufficient, particularly when coupled with a curve such as was presented in Figure 1.

A benchmarking curve (and its underlying data) can also be used to assess potential benchmarks with ambitions other than a simple average performance. For example, a benchmarking curve can be used to understand the best achieved level of emissions performance, to set a goal for a specified improvement over the current average (e.g., a 20% improvement in emissions intensity by a certain year), or to select a definition of top-performing plants (e.g., the plants in the top 25<sup>th</sup> percentile of performers). In Figure 8, below, the green horizontal line depicts the emissions intensity of the top 25<sup>th</sup> percentile of plants and the purple horizontal line depicts the best-performing plant for a fictional industry sector.

Figure 8. Hypothetical Benchmark Curve: Choice of Benchmark Ambition



How ambitious to make the benchmark depends on the policy context and goals of the program. Under regulatory performance standards and voluntary programs, the level of benchmark ambition directly determines the level of greenhouse gas abatement and each sector’s share of the costs of meeting a particular regional emissions target, as was discussed under “Benchmark Disaggregation in the Three Policy Approaches”, beginning on page 21. When used for allowance allocation, on the other hand, the ambition of the benchmark does not itself determine the level of abatement but instead helps avoid carbon leakage while preserving price signals to individual facilities. Economic modeling, as in the U.S. Interagency Report (US EPA, US EIA, and US Treasury 2009), can be used to estimate the benchmark level (average or otherwise) that would be likely to limit overall emissions leakage in individual industries, as well as to avoid subsidizing domestic production if set too high

Governor Gregoire’s Executive Order 09-05 specifically calls for benchmarks developed by the Department of Ecology to “be based on industry best practices, reflecting emission levels from highly efficient, lower emitting facilities in each industry sector.” This language suggests that benchmarks should be set at emission rates that lie below the average level. In developing benchmarks based on best available or other top-performing facilities, an understanding of factors and conditions that have enabled that high level of performance is important to ensure these factors or conditions are available to other facilities. For example, if the best performing facility in a given sector had access to a power, fuel, or feedstock source unavailable to the other facilities, then using that best performing facility as the benchmark may not be appropriate.

Some stakeholders have raised concerns regarding potential adverse impacts of GHG benchmarking on older, more greenhouse gas intensive facilities, where there may be significant technical or economic barriers to major efficiency improvements. For example, in discussions concerning national cap-and-trade legislation,<sup>49</sup> some stakeholders argued for a “rebate collar” to limit the spread between the sector benchmark (the level at which allowances are awarded) and the emissions intensity of any given facility. Such a rebate collar would effectively relax the benchmark level for more GHG-intensive facilities, awarding them more allowances than they otherwise would have received, and lessening the cost impact on these facilities.

An alternative to the rebate collar could be to offer financing and/or technical assistance to help these less-efficient installations make upgrades at their facilities. For example, in a cap-and-trade setting, allowances could be allocated for the specific purpose of helping to finance (on a competitive basis) facility upgrades through a

<sup>49</sup> In particular, the “rebate collar” concept surfaced prior to the release of the discussion draft of the Kerry-Lieberman *American Power Act* in May, 2010

revolving loan or similar financing mechanism, with supporting technical assistance offered. The EU is considering a similar “innovation / technology accelerator” (European Commission 2010b, p. 75). Similar concepts could be explored for regulatory or voluntary benchmark programs.<sup>50</sup>

## Data Sources

Despite the potential for use of benchmarks to help address greenhouse gas emissions from industry, relatively few comprehensive data sources exist to develop and set benchmarks. In general, four types of data providers exist:

- **Industry groups and associations**, such as the Cement Sustainability Initiative, International Aluminum Institute, Northwest Food Processors Association, or National Council for Air and Stream Improvement. These organizations tend to have (or are developing) the most detailed and comprehensive data on production, energy use, and emissions at the level of individual facilities. However, none of these efforts are known to make their facility-level data publicly available.<sup>51</sup> Furthermore, comparable efforts do not exist in all sectors. Still, benchmarking curves with facility-level resolution have been published by the Cement Sustainability Initiative (CSI 2009) and the International Aluminum Institute (International Aluminum Institute 2009) and could serve as the basis for a benchmarking effort for these sectors.
- **Government surveys**, such as the Energy Information Administration’s Manufacturing Energy Consumption Survey (MECS) or the US Census Bureau’s Annual Survey of Manufactures and Economic Census.<sup>52</sup> These sources cover some but not all applicable sectors or emissions sources. They also do not provide emissions estimates, but rather fuel use and production data that can be used, with standard emission factors, to estimate emission levels. Physical production data may be limited<sup>53</sup>, and use of such data is typically restricted, even for government analysts (Schneck et al, 2009). Following strict procedures to maintain confidentiality, EPA uses Census Bureau data in developing energy benchmarks for industry in the agency’s ENERGY STAR program. H.R. 2454 also lists these data as sources for determining industry eligibility for EITE provisions.<sup>54</sup>
- **Air permits held by state and local air agencies**. Air permits and other agency sources (e.g., information on fuel type) sometimes contain production levels and other data sufficient to perform reasonably accurate estimate of GHG emissions. For example, the Puget Sound Clean Air Agency has estimated process CO<sub>2</sub> emissions from both the Ash Grove and Lafarge cement kilns in Seattle based on clinker production data (Puget Sound Clean Air Agency 2008). Compiling data from air agencies around the country or region in order to develop benchmarking curves could be prohibitively difficult, given the sheer number of such agencies and potentially disparate and inconsistent data they may hold.<sup>55</sup>
- **Mandatory GHG reporting rules**. Data from state and federal mandatory reporting rules on GHGs are likely to provide the best source of data for benchmarking. However, these data are not yet available. US EPA’s Mandatory Reporting of Greenhouse Gases rule will require all facilities that emit at least 25,000 tons CO<sub>2</sub>e and all facilities in some sectors (e.g., aluminum, cement, several chemical industry sectors) to report greenhouse gas emissions and production volumes for year 2010 by March 31, 2011 (US EPA 2009a). Washington State’s Mandatory Greenhouse Gas Reporting Rule will require facilities that emit at

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<sup>50</sup> Thanks to James Bradbury of the World Resources Institute for suggesting this idea.

<sup>51</sup> In some cases, compiled information with facility identifiers removed can be acquired for a fee.

<sup>52</sup> An additional possible source of data is EPA’s triennial national emission inventory (NEI), which includes company and state emission estimates for criteria and hazardous pollutants and production and fuel usage information that may be applicable for benchmark development.

<sup>53</sup> One potential source of production data is the US Geological Survey’s (USGS) annual Minerals Yearbook, which reports some national and regional production volumes but facility-specific data are very limited (e.g., the USGS reports production capacity at Alcoa’s Ferndale and Wenatchee facilities but not actual annual production) (USGS 2009).

<sup>54</sup> For the ENERGY STAR program, EPA relies on a sworn Census agent at the Triangle Research Data Center at Duke University to conduct these analyses.

<sup>55</sup> One potential source to facilitate such data collection is EPA’s RACT/BACT/LAER Clearinghouse, which compiles facility-specific information on “best available” air pollution technologies. Since this system (<http://cfpub.epa.gov/rblc/>) is designed to collect permitting decision information rather than emissions and production information, it does not include the level of detail for the Ash Grove and Lafarge cement plants that is on the Puget Sound Clean Air Agency’s own website, suggesting that the Clearinghouse may not be an appropriate tool for consolidating relevant GHG benchmarking data. EPA does intend to modify the system to include permit limit data for greenhouse gases.

least 10,000 tons of GHGs to report in 2013 for year 2012 emissions.<sup>56</sup> The reporting methodologies for the Washington State rule will be harmonized with the federal rule.

The need for more comprehensive production, energy, and emissions data for developing greenhouse gas benchmarks –at least for benchmarks to be used in a cap-and-trade or performance standard setting – is clear. This need is recognized by national and regional policymakers. Notably, an interagency analysis of the competitiveness and leakage provisions of H.R. 2454 concluded that implementation of any mechanism to use output-based allocations would require “data from facilities on output levels, electricity use, and emissions associated with electricity use (in addition to data already planned via the Mandatory Reporting Rule)” and also require that “such data can be generated at a sufficiently disaggregated level for EPA to develop meaningful benchmarks for output-based allocations” (US EPA, US EIA, and US Treasury 2009). Facility-level data on physical production or sales is generally considered confidential information and not available to most analysts, regardless of whether the data are collected and held by industry groups (e.g., the Cement Sustainability Initiative) or government sources (e.g., the U.S. Census Bureau). Still, some industry groups (e.g., the international aluminum and cement industries) have voluntarily released GHG benchmarking curves or worked with government partners (e.g., the European Union) to develop and publicize GHG benchmarking curves which display, but do not identify, individual facility-level GHG intensity values. Lastly, monetary sales data are generally available in the U.S. at an aggregate industry level (e.g., six-digit NAICS code).

Table 8, below, displays an assessment of existing possible data sources for GHG benchmarking.

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<sup>56</sup> [http://www.ecy.wa.gov/programs/air/globalwarm\\_RegHaze/6-11\\_GHG\\_Advisory\\_Presentation.pdf](http://www.ecy.wa.gov/programs/air/globalwarm_RegHaze/6-11_GHG_Advisory_Presentation.pdf)

**Table 8. Assessment of Possible Data Sources for GHG Benchmarking**

Data Source	Level of Disaggregation (e.g., facility, product)	Types of Data	If Includes GHGs, Uses Accepted Protocol?	Geographic Coverage (& Country Resolution)	Threshold for Coverage	Scope (Direct / Indirect)	Publicly Available at Disaggregated Level	Years of Data Available	Other Considerations
<b>Industry Groups and Associations</b>									
<b>Cement Sustainability Initiative</b>	Facility	<ul style="list-style-type: none"> <li>▪ CO<sub>2</sub></li> <li>▪ Energy</li> <li>▪ Clinker and cement</li> </ul>	Yes, WBCSD/CSI	Global down to North America; low coverage in developing countries (e.g., China)	CSI member companies only	Direct + Indirect	In benchmarking curve	1990-2007	
<b>International Aluminum Institute</b>	Facility	<ul style="list-style-type: none"> <li>▪ PFCs</li> <li>▪ Primary aluminum</li> </ul>	Yes, IPCC	Global (60% of production); low coverage in China	All facilities	Direct	In benchmarking curve	1990-2008	
<b>Government Surveys</b>									
<b>MECS</b>	Facility	<ul style="list-style-type: none"> <li>▪ Energy</li> </ul>	N/A	U.S.	All but the smallest producers in each covered sector	Direct (fuels) + Indirect (electricity)	No	1991, 1994-2006 in 4-year increments	Does not cover all sectors; only sworn Census agents can access
<b>Census Bureau Economic Census and ASM</b>	Facility	<ul style="list-style-type: none"> <li>▪ Value of shipments</li> </ul>	N/A	U.S.	All facilities	N/A	No	Annual	Only sworn Census agents can access
<b>USGS</b>	Facility (for U.S. data)	<ul style="list-style-type: none"> <li>▪ Production of metals and minerals</li> </ul>	N/A	Global (175 countries) and U.S.	All facilities	N/A	No (country or region only)	1932-2008	
<b>Air Permits From Local Air Agencies</b>									
<b>Puget Sound Clean Air Agency (as example)</b>	Facility	Varies. May include GHGs and production	Varies	Limited to facilities in each individual air agency	Only those facilities required to be permitted for other (non-GHG) pollutants	Direct	Yes but data limited	Varies	Local air agencies may not use consistent methods for estimating GHGs
<b>Mandatory GHG Reporting Rules</b>									
<b>WA GHG Reporting Rule</b>	Facility	<ul style="list-style-type: none"> <li>▪ 6 GHGs</li> <li>▪ Production</li> </ul>	Yes, US EPA	Washington State	Facilities that emit more than 10,000 tons CO <sub>2</sub> e	Direct	Yes (emissions only)	2012 on	Data first reported in 2013
<b>US GHG Reporting Rule</b>	Facility	<ul style="list-style-type: none"> <li>▪ 6 GHGs</li> <li>▪ Production</li> </ul>	Yes, US EPA	U.S.	All facilities in certain sectors (e.g., aluminum, cement); others if over 25,000 tCO <sub>2</sub> e	Direct	Yes (emissions only)	2010 on	Data first reported in March, 2011

Regardless of the data sources used, there are not likely to be enough facilities in Washington State in any given industry sector to enable the development of meaningful benchmarks based only on in-state data. Washington has only a handful of facilities in key industrial sectors, and so a broader geographic cohort of facilities would be needed – across the Western Climate Initiative (WCI), the US, or North America – to establish robust and useful benchmarks. Broadening the geographic cohort could also help reflect the relative performance of Washington industries and potentially bring opportunities for Washington industry to be a leader in advancing approaches to address greenhouse gas emissions.

## How Different Policy Approaches Might Affect Benchmark Construction

In the discussion above, we describe and assess several issues and options with benchmark construction and application. A few of these issues and options (e.g., what units to use for normalizing the benchmark) remain relatively consistent and apply equally regardless of policy approach. Several others, however, imply very different incentives or outcomes in different policy approaches. In Table 9 below, we summarize how different policy approaches – voluntary goals, output-based allocation in a cap-and-trade program, or emission performance standards – might affect how benchmarks are constructed and used. A key lesson is that disaggregating benchmarks by feedstock type, fuel, or technology distorts the price signal in a cap-and-trade program but may be necessary (or even desirable) in a regulatory performance standard or voluntary framework.

**Table 9. How Benchmark Application May Affect Benchmark Construction**

	<b>Allowance rebates in Cap-and-trade</b>	<b>Regulatory Performance Standard</b>	<b>Voluntary</b>
Disaggregation by Feedstock type / fuel/ technology / other factors	Disaggregation should be minimized in order to provide the incentive to adopt to more efficient technologies and practices.	Some disaggregation might be necessary to consider cost-effectiveness and achievability, particularly for existing facilities	Some disaggregation might be necessary to distribute abatement costs between companies.
Disaggregation by specific product type	Disaggregation is desirable to extent that products are non-substitutable, and there is sufficient number of distinct facilities producing them to develop a meaningful benchmark.	Similar to above.	Similar to above.
Consideration of indirect electricity emission factors	Indirect emissions do not have to be taken into account as the carbon price signal is part of the electricity price and automatically incentivizes an optimal use of fuel and electricity.	Indirect emissions should be taken into account in order to avoid perverse incentives to use more (carbon free) electricity instead of fuel.	Indirect emissions should be taken into account in order to avoid perverse incentives to use more (carbon free) electricity instead of fuel.
Point of regulation	In order to avoid carbon leakage the benchmark should be based on the point of regulation. This means that the benchmark should be set for the (intermediate) product leaving the installation.	In order to incentivize all abatement options the benchmark should be derived for the final product.	In order to incentivize all abatement options the benchmark should be derived for the final product.

**Box 2. An Alternative to Product-specific Benchmarks: Benchmarking Heat Production**

In several industries, the main source of emissions is the production of heat (as steam or hot water) in a boiler. That is, while many industrial sectors (e.g., aluminum, cement, glass, and steel) emit large quantities of greenhouse gas emissions directly from the a production process or from burning of fossil fuels to directly heat materials (e.g., in furnaces), others (e.g., food processors and some chemical industry companies) generate most of their emissions from the burning of fossil fuels to produce steam or hot water or to heat other heat-transfer liquids. Heat could therefore be considered as the product of the boiler and benchmarked accordingly, at least for facilities where other product-specific benchmarks are not applied. The EU has taken this approach in the development of its cap-and-trade program by developing a “fall-back” benchmark approach for sectors and facilities that generate and use heat but are not assigned product-specific benchmarks. The main advantage of applying a benchmark on heat is the relative simplicity and the potential application across sectors.

Three factors influence GHG emissions from combustion processes that generate heat as steam or hot water: the choice of fuels, the efficiency of the heat production, and the efficiency of heat end use (Ecofys, Fraunhofer Institute, and Öko Institut 2009a). A benchmark on heat production would account for the first two factors but not the third. As a result, one issue in benchmarking heat (at least relative to alternative approaches, such as benchmarking end products) is that a heat benchmark would not encourage increased efficiency of the use of that heat in producing a final product such as paper, a food product, or chemicals.

An important question is whether a heat production benchmark should be differentiated by sector. Different industrial sectors may use different boiler technologies (with varying efficiencies) or rely historically on different fuels, factors that may suggest the use of differentiated benchmarks by sector, at least in a voluntary or regulatory approach. Under a cap-and-trade program, disaggregation by sector may be less appropriate as the goal is to encourage long-term technology and fuel transitions and facilities can purchase or sell allowances depending on whether they are emitting above or below the respective benchmarks.

Table 10 summarizes some benefits and challenges of benchmarking heat as opposed to developing individual product benchmarks.

**Table 10. Benefits and Challenges of a GHG Benchmark on Heat Production**

<b>Benefits</b>	<b>Challenges</b>
<ul style="list-style-type: none"> <li>▪ Can be simpler than product-specific benchmarks for some sectors (e.g., food processing)</li> <li>▪ Incentivizes low-GHG heat production through fuel choice and boiler efficiency</li> <li>▪ Potentially applicable across a variety of industrial and commercial users, since many use boilers</li> <li>▪ Does not require confidential production data (e.g., tons of frozen french fries, pulp, chemical product) other than steam/hot water production and fuel input data, which may be less sensitive</li> </ul>	<ul style="list-style-type: none"> <li>▪ Does not directly encourage efficient use of heat in producing a final product</li> <li>▪ Differentiating heat production benchmarks by sector, may be desirable, which would limit the benefit of applying a single benchmark across multiple sectors</li> <li>▪ Does not apply to process emissions, which are large in some sectors.</li> <li>▪ Harder to apply to direct-heating applications (e.g., furnaces) than boilers</li> </ul>

US EPA has conducted some initial research on possible GHG performance standards for heat production from industrial and commercial boilers. Federal New Source Performance Standards (NSPS) for other pollutants already exist for industrial boilers, and thus EPA may be required to develop GHG performance standards for boilers.<sup>57</sup>

<sup>57</sup> EPA reports that a first step in developing an NSPS for GHGs for industrial boilers would be to “consider how to develop a metric for measuring and benchmarking boiler GHG emissions in terms of the facility’s output production” (US EPA 2008b). US EPA also has a GHG offset protocol for quantifying emission reductions from projects in industrial boilers: [http://epa.gov/stateply/documents/resources/industrial\\_boiler\\_protocol.pdf](http://epa.gov/stateply/documents/resources/industrial_boiler_protocol.pdf)

## 4. Focus on Particular Industry Sectors

This section provides a deeper dive into the particular issues and options for benchmarking in key industrial sectors: aluminum, cement, chemicals, food processing, glass, paper and pulp, and steel. We selected these sectors for further examination because they (or closely related sectors) are present in Washington State and are relatively energy-intensive and trade exposed. In addition, we discuss heat production as its own sector. Several other sectors generate most of their greenhouse gas emissions through the production of heat as an intermediate product in their operations, suggesting that a focus on heat could provide benefits to several industry sectors.

Research on each of the sectors has helped inform the issues and options discussed in Section 3, which generally apply across sectors. For example, the level of benchmark disaggregation and availability of comprehensive, facility-specific, publicly available data sources are key considerations in each sector. In this section, we instead focus primarily on key issues and options that are unique to each sector, such as the treatment of waste-derived fuels in the cement sector, availability and quality of recycled cullet in the glass sector, and whether separate benchmarks are needed for integrated versus non-integrated mills in the pulp and paper sector. In addition, this section also provides a review of the emission sources, production processes, and corresponding benchmarks already developed in each sector. For a review of upcoming mandatory GHG reporting data under federal and state rules, please see Appendix A.

As the Washington State Department of Ecology (Ecology) proceeds in the second phase of its work on industry GHG benchmarks under Executive Order 09-05, the agency may choose to focus to develop emission benchmarks for some subset of industries in the state. Accordingly, Ecology may choose to develop criteria to guide selection of sectors. Such criteria may include, for example, minimum thresholds of the following:

- **Energy-intensiveness and trade-exposure.** Industries that are particularly energy-intensive and exposed to global trade may have a greater risk of competitiveness impacts from domestic cap-and-trade legislation. Accordingly, such industry sectors may have a greater need for free allocation of allowances, potentially suggesting a benchmarking approach. For example, as discussed in Section 1, H.R. 2454 includes allowance rebates based on a sector being classified as an energy-intensive, trade-exposed (EITE) industry according to criteria of energy or greenhouse gas intensity and trade intensity. Since GHG benchmarks are often considered well suited to such energy-intensive and trade exposed industries in a cap-and-trade program, a criterion could be whether the industry sector in Washington is included as an EITE sector in federal legislation.
- **Contribution to Washington's annual GHG emissions.** The higher the industry's contribution to the state's total GHG releases, the greater the opportunity to develop approaches such as benchmarking for reducing those emissions. Accordingly, one criterion could be the fraction of the state's total annual GHG emissions (94.8 million metric tons CO<sub>2</sub>e in 2005) contributed as direct emissions by the sector.
- **Experience with GHG benchmarking.** The process of developing benchmarks for use in a cap-and-trade system can be complex and time-consuming and may not be appropriate for all industry sectors. The process of assessing issues and options for benchmarks in Washington State may be facilitated by focusing on sectors where relevant data, or benchmarks themselves, have already been developed, and corresponding challenges addressed. For example, the international aluminum and cement industries have made significant strides in data collection and GHG benchmarking methodologies, and the Northwest Food Processors Association is embarking on an energy benchmarking effort. An additional source of research is the European Union, which is currently developing an approach to benchmark-based free allocation of emissions allowances, in coordination with industry associations, and where benchmarks are in their final stages of development, scheduled for release in mid- 2010.

Table 11, below, presents a preliminary assessment of industry sectors against these three criteria.

**Table 11. Potential Criteria for Selecting Industry Sectors to Benchmark**

Sector	NAICS Codes	Energy-intensive, trade-exposed (as covered by EITE Provisions in Federal Legislation) <sup>58</sup>	Estimated Contribution to Washington's Annual GHG Emissions <sup>59</sup>	Sector Experience with Benchmarking
Aerospace	336411	No	Low	
Aluminum (Primary)	331312	Yes	Medium	IAI*, EU
Aluminum (Secondary)	331314	No	Low	EU
Cement	327310	Yes	High	CSI*, EU
Chemical <sup>60</sup>	325188 325199	Yes	Low	EU
Electricity	221112	No	High	
Fertilizer	[Many]	Yes <sup>61</sup>	Low	EU
Food Processing	[Many]	Partial <sup>62</sup>	Medium	NWFPA*
Glass	327211 327212 327213	Yes	Low	EU
Gypsum	327420	No	Low	EU
Lime	327410	Yes	Low	EU
Natural Gas Transmission	486210	No	Medium	
Natural Gas Distribution	221210	No	High	
Oil refineries	324110	No <sup>63</sup>	High	EU
Pulp and Paper	322110 322121 322122 322130	Yes	High	EU
Semiconductors / solar	334413	No	Medium	
Steel	331111	Yes	Low	EU

\* IAI = International Aluminum Institute  
 CSI = Cement Sustainability Initiative  
 NWFPA = Northwest Food Processors Association  
 EU = European Union Emissions Trading System

<sup>58</sup> For a comprehensive, national list of industrial sectors likely to be considered EITE under H.R. 2454, see EPA, EIA et al (2009).

<sup>59</sup> These categorizations are based on the Department of Ecology's estimates (Washington Dept. of Ecology 2009). A rating of *Low* indicates the sector is estimated to contribute 0.2% or less of the State's total GHG emissions, a rating of *Medium* indicates the sector is estimated to contribute between 0.2% and 1%, and a rating of *High* indicates an estimated contribution of more than 1%.

<sup>60</sup> The chemical industry is very diverse. Sectors listed here qualify for EITE rebates per EPA, EIA and Treasury (2009), but other sectors may not.

<sup>61</sup> Per EPA, EIA and Treasury (2009), "Nitrogenous fertilizer manufacturing" (NAICS 325311) is included.

<sup>62</sup> The only food processing subsectors that appear to be included are "malt manufacturing (NAICS 311213), "wet corn milling" (311221), and "rendering and meat byproduct processing" (311613) per EPA, EIA and Treasury (2009)

<sup>63</sup> Petroleum refining receives its own free allocation of allowances under Sections 782 (j) and 787 of H.R. 2454 and so is explicitly excluded from the EITE provisions of H.R. 2454. Under the definition of EITE industries, petroleum refining may not have qualified as energy- or emissions-intensive. Because H.R. 2454's intensity criterion uses value of shipments in the denominator (instead of value added, as in the EU), and since the value of crude oil purchased is high, the denominator is great enough that the energy- or emissions-intensiveness of the petroleum refining may not meet the 5% (Bradbury 2009).

## Aluminum

Aluminum is produced in one of two ways. In primary aluminum production, alumina is produced from bauxite and then processed to aluminum via electrolysis. In secondary aluminum production, aluminum is refined or remelted from scrap.

In the North America, over half of the aluminum supply is from primary production, about a third is from secondary production, and the remainder is imported as ingot or partially assembled components (Aluminum Association 2009). Historically, most aluminum production in Washington State has been primary and has benefited from relatively inexpensive, abundant hydroelectricity. In recent years, increases in energy prices and a drop in world aluminum markets have led to a decline in the state's aluminum industry, including the closing of primary aluminum smelters.

In Washington, aluminum-producing facilities include two primary aluminum smelters: Alcoa facilities in Ferndale and Wenatchee; and the Kaiser Aluminum secondary aluminum facility in Spokane.<sup>64</sup>

### Overview of Production Process and Emissions Sources

Primary aluminum is produced in the following process:

- **Bauxite mining.** Most of the bauxite used in North American aluminum refineries is mined in other countries, with Jamaica, Guinea, Brazil, Guyana, and Sierra Leone being significant suppliers (USGS 2009).
- **Alumina refining.** Alumina (aluminum oxide) is produced from bauxite using the Bayer process in which bauxite is digested and then alumina is clarified, precipitated, and then dried and calcined. The bauxite digestion process uses significant quantities of (usually fossil fuel) energy to heat the caustic soda, as does the calcining of alumina (IEA 2009b). The end product of alumina refining is a fine white powder.
- **Anode manufacturing,** in which coal tar pitch and petroleum coke is ground pressed into green anodes, and then baked<sup>65</sup> at high temperatures in gas-heated furnaces (Worrell et al. 2008). Anodes can either be made onsite at the smelter or in separate, specialized plants. The Alcoa facilities in Ferndale and Wenatchee both use pre-baked anodes made on-site. The Ferndale facility uses "side worked pre-bake" anodes and the Wenatchee facility uses "center work pre bake" anodes.
- **Aluminum smelting.** In aluminum smelting, known as the Hall-Héroult process, alumina is dissolved in an electrolyte bath under a strong electric current. The electric current separates the aluminum oxide molecules by pulling the oxygen ions towards the carbon anode, where they react with carbon, leaving molten aluminum behind. Smelting uses significant quantities of electricity.
- **Aluminum casting and forming.** Molten aluminum is shaped into forms and semi-finished products via casting of ingots, hot and cold rolling, extrusion, drawing, finishing, and cutting.

Producing secondary aluminum from scrap requires much less energy than primary production. Steps in the production of secondary aluminum include:

- **Scrap collection and processing.** Scrap aluminum needs to be collected, sorted, cleaned, and shredded. Sources of scrap aluminum include both post-consumer products (e.g., used beverage cans, old automobile parts, windows and doors) as well as post-industrial production scrap.
- **Remelting and refining,** which can occur via one of several processes, including reverberatory furnaces, rotary furnaces, or induction technology.
- **Aluminum casting and forming,** similar to that described above for primary aluminum.

The table below summarizes the major processes in aluminum production and sources of emissions.

<sup>64</sup>Per the Department of Ecology (2009) and <http://www.ecy.wa.gov/programs/swfa/industrial/facilities.html>.

<sup>65</sup>In a Soderburg aluminum smelter, the anodes are not pre-baked. Instead the heat from the aluminum reduction cell provides the heat to 'bake' the anodes at the same time it is being consumed in the smelting process.

**Table 12. Summary of Aluminum Production Processes, Emission Sources, and Existing Benchmark Sources**

Step	Dominant Emissions Sources	Proposed or Existing GHG Benchmarks under Cap-and-trade	Other Benchmarks or Best-Practice Values	Key Issues / Options
<b>Primary</b>				
Bauxite mining	<ul style="list-style-type: none"> <li>Fossil fuel burning for equipment</li> </ul>	<ul style="list-style-type: none"> <li>None known</li> </ul>	<ul style="list-style-type: none"> <li>None known</li> </ul>	
Alumina refining	<ul style="list-style-type: none"> <li>Fossil fuel for heat generation</li> </ul>	<ul style="list-style-type: none"> <li>Proposed EU benchmark on alumina</li> <li>H.R. 2454 (Waxman-Markey), passed in the US House of Representatives in 2009, included a formula for constructing an average benchmark for alumina refining</li> </ul>	<ul style="list-style-type: none"> <li>Worrell et al (2008) list world best-practice energy benchmarks for alumina production</li> </ul>	<ul style="list-style-type: none"> <li>Few installations produce alumina and with a wide spread of emissions, complicating benchmark development</li> </ul>
Anode manufacture	<ul style="list-style-type: none"> <li>Fossil fuel for furnace</li> <li>Process CO<sub>2</sub> from anode baking</li> </ul>	<ul style="list-style-type: none"> <li>Proposed EU benchmark on pre-baked anodes</li> </ul>	<ul style="list-style-type: none"> <li>Worrell et al (2008) list world best-practice energy benchmarks for anode manufacture</li> </ul>	
Aluminum smelting	<ul style="list-style-type: none"> <li>Fossil fuel for heat generation</li> <li>Process CO<sub>2</sub> from consumption of carbon anodes</li> <li>Perfluorocarbons (PFCs) from the anodes</li> <li>Electricity production for electrolysis</li> </ul>	<ul style="list-style-type: none"> <li>Proposed EU benchmark on primary aluminum smelting</li> <li>H.R. 2454 (Waxman-Markey), passed in the US House of Representatives in 2009, included a formula for constructing an average benchmark for primary aluminum smelting</li> </ul>	<ul style="list-style-type: none"> <li>Worrell et al (2008) list world best-practice energy benchmarks for aluminum smelting</li> <li>International Aluminum Institute has published benchmark curves for PFC emissions (International Aluminum Institute 2009)</li> </ul>	<ul style="list-style-type: none"> <li>Choice of carbon anode type (e.g., pre-baked anodes versus Söderberg) can affect energy and process CO<sub>2</sub> emissions greatly</li> <li>In the EU, the aluminum industry has argued for a separate benchmark for primary cast houses with adjustment factors for degree of secondary remelting and homogenization</li> </ul>
Aluminum casting and forming	<ul style="list-style-type: none"> <li>Fossil fuel for production machinery</li> <li>Electricity production to run machinery</li> </ul>	<ul style="list-style-type: none"> <li>Proposed EU benchmark on primary cast aluminum</li> <li>EU has proposed using the separate “fall-back” approach for products from rolling plants, extrusion plants, and foil plants</li> </ul>	<ul style="list-style-type: none"> <li>Worrell et al (2008) list world best-practice energy benchmarks for aluminum casting</li> </ul>	
<b>Secondary</b>				
Scrap collection	<ul style="list-style-type: none"> <li>Fossil fuel and electricity to operate equipment</li> </ul>	<ul style="list-style-type: none"> <li>None known</li> </ul>	<ul style="list-style-type: none"> <li>None known</li> </ul>	
Scrap processing	<ul style="list-style-type: none"> <li>Fossil fuel and electricity to operate equipment</li> </ul>	<ul style="list-style-type: none"> <li>Proposed EU benchmark on secondary aluminum</li> </ul>	<ul style="list-style-type: none"> <li>Worrell et al (2008) list world best-practice energy benchmarks for secondary aluminum</li> </ul>	<ul style="list-style-type: none"> <li>See above if secondary aluminum remelting occurs in a primary cast house</li> <li>In EU, stakeholders have argued that production from low-quality scrap may be more energy-intensive than production of high-quality scrap and may deserve its own benchmark</li> </ul>
Remelting and refining	<ul style="list-style-type: none"> <li>Fossil fuel for furnace</li> <li>Electricity production (if electric furnace used)</li> </ul>			
Aluminum casting and forming	<ul style="list-style-type: none"> <li>Fossil fuel for production machinery</li> <li>Electricity production to run machinery</li> </ul>			

### Key Issues in Benchmarking Aluminum

As with all sectors, the data availability and level of benchmark disaggregation are key issues. This is discussed in detail in Section 3 of this *White Paper*. In addition, some stakeholders have suggested that quality of recovered scrap may be an issue for the secondary aluminum industry (Ecofys, Fraunhofer Institute, and Öko Institut 2009b). The quality of recovered scrap can affect energy required for production of secondary aluminum. However, under

a cap-and-trade system on greenhouse gases, differentiating the benchmark based on aluminum scrap quality may be less appropriate, since the entity could use the savings realized from purchasing less expensive, lower-quality scrap to secure additional emissions allowances.

## Cement

Cement is the binding agent in concrete and most mortars, and is generally produced from a feedstock of limestone, clay, and sand. In the United States, 118 cement plants produce about 85 million metric tons of cement annually.<sup>66</sup> In Washington State, the largest cement plants are Ash Grove Cement and Lafarge Cement, both located in Seattle. Together, these facilities emit about 900,000 tons CO<sub>2</sub>e of GHGs annually in the course of producing about one million tons of cement (Washington Dept. of Ecology 2009).

### Overview of Production Processes and Emission Sources

The production of cement involves four sequential production processes (Matthes et al. 2008):

- **Raw material extraction**, in which limestone and clay, sand, or other materials are quarried. Neither cement kiln in Washington State operates its own quarry; both import limestone from Texada Island in British Columbia, from which the limestone is transported by barge to the plants.
- **Raw material preparation**, in which a raw mixture of limestone (approximately 90%) and other materials (e.g., clay, sand) are crushed and ground into a mixture with a specific chemical composition. This step can occur either as a dry process, in which the product is a fine dry powder, or in a wet process, where the crushed material is mixed into a slurry prior to grinding. Over 75% of cement produced in the U.S. uses the dry process (Worrell and Christina Galitsky 2008).
- **Clinker production**, in which the fine powder or slurry is heated to over 2,500°F in a kiln. The heating first transforms the ground limestone (CaCO<sub>3</sub>) into lime (CaO), releasing CO<sub>2</sub>, in a process called calcination, and then into solid pellets called clinker, the material which gives cement its binding properties. Two major kiln types exist globally: vertical shaft kilns, and the more-efficient rotary kilns. No vertical shaft kilns remain in the U.S. or Canada. Of rotary kilns, the wet kilns are less efficient because they require more energy to produce clinker due to the need to evaporate the slurry water prior to calcination. No new wet kilns have been built in the U.S. since the 1970s (US EPA 2008a). The Lafarge plant in Seattle (a wet kiln) has recently announced intentions to stop manufacturing clinker at the end of 2010.<sup>67</sup> There are opportunities to reduce energy use and GHG emissions in dry kilns, for example, by introducing a heater to pre-heat the raw materials prior to being fed into the kiln, as well as by the introducing a second combustion chamber between the pre-heater and the kiln (IEA 2009a).<sup>68</sup>
- **Cement grinding and blending**, in which clinker is mixed with other ingredients to produce cement. To make Portland cement, only about 5% gypsum is added. Other, “blended cements” can be made by mixing in other materials with cementitious properties, especially byproducts from other industries, such as fly ash from coal power plants or blast-furnace slags.

The table below summarizes the major processes and sources of emissions in cement production.

<sup>66</sup> Per USGS (2009) and the Portland Cement Association ([www.cement.org](http://www.cement.org)).

<sup>67</sup> <http://www.westseattleherald.com/2010/04/30/news/update-lafarge-cement-forced-make-changes-its-seattle-plant>

<sup>68</sup> Use of pre-heater and pre-caliner technology in cement kilns has risen rapidly in North America in recent years, from about 15% of kilns in 1990 to about half of kilns in 2006 (IEA 2009a).

**Table 13. Summary of Cement Production Processes, Emission Sources, and Existing Benchmarks**

Step	Dominant Emissions Sources	Proposed or Existing GHG Benchmarks under Cap-and-trade	Other Benchmarks or Best-Practice Values	Key Issues / Options
Raw material extraction	<ul style="list-style-type: none"> <li>Fossil fuel for extraction equipment and transport from mine to plant</li> <li>Electricity for conveyors</li> </ul>	<ul style="list-style-type: none"> <li>None known</li> </ul>	<ul style="list-style-type: none"> <li>None known</li> </ul>	
Raw material Preparation	<ul style="list-style-type: none"> <li>Fossil fuel and/or electricity production for machinery to crush, grind, and dry (if necessary) the raw meal</li> </ul>	<ul style="list-style-type: none"> <li>None known (emissions from this phase are included in clinker production phase in the EU benchmark)</li> </ul>	<ul style="list-style-type: none"> <li>Worrell et al (2008) list world best-practice energy benchmark for raw materials preparation</li> </ul>	<ul style="list-style-type: none"> <li>Higher moisture content and hardness of the limestone increase energy use.</li> </ul>
Clinker production	<ul style="list-style-type: none"> <li>Process CO<sub>2</sub> released in the calcination reaction</li> <li>Fossil fuel burning for kiln heating</li> <li>Electricity production for machinery, including fans, kiln drive, cooler, and material transport</li> </ul>	<ul style="list-style-type: none"> <li>EU has proposed benchmark on clinker production<sup>69</sup></li> </ul>	<ul style="list-style-type: none"> <li>Cement Sustainability Initiative (2009) lists global and regional average GHG intensities</li> <li>Worrell et al (2008) and IEA (2008) list world best-practice energy benchmark for clinker production</li> <li>US EPA ENERGY STAR has an energy benchmarking tool that compares energy per ton of clinker</li> </ul>	<ul style="list-style-type: none"> <li>The choice of whether to benchmark based on clinker or cement is the most significant issue. Basing the benchmark on cement incentivizes blending with clinker substitutes (thereby reducing the emissions associated with clinker). On the other hand, in theory a cement benchmark could create a perverse incentive to import clinker or else to restructure the industry to create companies that only grind clinker and do not make cement</li> <li>Treatment of biomass and wastes as heating fuels for the kiln can affect benchmark development</li> <li>Some have argued that different benchmarks should be created for grey versus white cement, but the possible applications (if not the aesthetics) are the same<sup>70</sup>. Both cement kilns in Washington produce grey cement.</li> </ul>
Cement grinding and blending	<ul style="list-style-type: none"> <li>Fossil fuel needed for heat for drying of additives, if necessary</li> <li>Electricity for equipment for blending and grinding of additives and final product</li> </ul>	<ul style="list-style-type: none"> <li>H.R. 2454 (Waxman-Markey), passed in the US House of Representatives in 2009, included a formula for constructing an average benchmark for cement (not clinker) production</li> </ul>	<ul style="list-style-type: none"> <li>Cement Sustainability Initiative (2009) lists global and regional average GHG intensities</li> <li>Worrell et al (2008) list world best-practice energy benchmark for grinding and blending</li> </ul>	

### Key Issues in Benchmarking Cement

Based on review of benchmarking and related efforts in the cement sector, key questions to address in developing benchmarks for the cement sector would include:

- Whether to benchmark based on cement or clinker.** A benchmark based on clinker helps drive kiln and process efficiency upgrades but fails to incentivize the use of clinker substitutes (such as fly ash and slag) in blending to reduce emissions. A benchmark based on cement provides incentive for blending of clinker substitutes but could lead to restructuring in the cement industry. In particular, if the benchmark were only applied to cement, cement facilities may choose to no longer make emissions-intensive clinker themselves, instead importing it or else purchasing it from facilities that only grind clinker and do not make cement (therefore potentially exempting themselves from the cement-based benchmark). Such a

<sup>69</sup> Information pertaining to benchmarking of cement from the EU is taken largely from Ecofys, Fraunhofer Institute, & Öko Institut (2009c). Final benchmarks are being developed in the EU in the first half of 2010.

<sup>70</sup> The EU has recommended that no separate benchmarks be developed for white versus grey cement (European Commission 2010a). In Washington State, both cement kilns produce grey cement.

restructuring, if it occurred, would provide little or no overall decrease in cement industry emissions. However, the perverse incentives for restructuring could be overcome in benchmark construction by taking into account the quantities of clinker imported or transferred from other sites (Ecofys, Fraunhofer Institute, and Öko Institut 2009c; Holcim 2010). The question of whether to benchmark based on cement or clinker depends further on the policy approach. For example, under a cap-and-trade program, the decision on whether to base a benchmark on cement or clinker may be made primarily based on which is expected to best prevent leakage, while retaining the incentive to adopt practices and technologies that reduce emissions from cement manufacture and use. Answering such a question requires additional research, and needs to address a number of factors such as a) the availability of clinker substitutes (e.g., fly ash from coal-fired power plants or blast-furnace slags), for which availability can vary by region or company; b) the point at which allowances should be distributed (cement manufacturers, ready-mix facilities, and/or cement substitute producers); and c) the net impact on clinker production, the process step most susceptible to emissions leakage.

- **Treatment of wastes and biomass as fuels**, in particular, how emissions from these fuels are calculated and included in the benchmark, including treatment of fuels such as used tires. To avoid distorting the price signal, GHG emissions from these fuels should be treated the same way as in the overall GHG management program, regardless of whether that is a cap-and-trade or a regulatory or voluntary approach.

In addition, the cement system would also face issues similar to all sectors – such as what data are available and how many products to distinguish. Note that EPA is currently revising its NSPS for cement, expected in June 2010. Some observers have speculated that EPA will include greenhouse gas emissions in the revisions (Bravender 2009).

## Chemicals

The chemical industry is a diverse, energy-intensive sector that generates products such as plastics, fertilizers, cleaners, pharmaceuticals, and numerous other products from feedstocks of natural gas, crude oil, and sometimes coal or other materials. The U.S. chemical industry is the largest in the world (Worrell et al. 2000). From an energy and emissions perspective, the three most significant subsectors of the chemical industry include (IEA 2008; Worrell et al. 2000):

- **Petrochemicals**, in which firms convert oil and natural gas feedstocks into chemical building blocks used to produce polymers, plastics, synthetic rubbers, solvents, and other organic chemicals. Petrochemical producers use large quantities of heat to power distillation columns and other processes, such as steam-cracking, the process used to produce ethylene (the most widely used petrochemical intermediate compound nationally and globally) and other chemicals.
- **Fertilizers** and related products, where the production of ammonia is the most energy-intensive production step. Ammonia is produced by a reaction of hydrogen and nitrogen. Most ammonia is converted to other compounds to be utilized as fertilizer.
- **Inorganic chemicals**, which include the energy-intensive chemicals chlorine, caustic soda (sodium hydroxide), carbon black, and soda ash, among others.

Major sources of greenhouse gas emissions from chemical manufacturers include direct combustion of fossil fuels to produce heat and non-combustion process emissions that occur from the use of fossil fuels as feedstocks and the use of other raw materials (US EPA 2008a).

In Washington State, the chemical industry includes numerous small companies that manufacture a variety of chemicals. Larger facilities include Solvay Chemicals and Emerald Kalama Chemicals. Solvay makes hydrogen peroxide (an inorganic chemical) from hydrogen it produces in a steam-methane reformer. The process of reforming methane (CH<sub>4</sub>) to hydrogen (H<sub>2</sub>) releases CO<sub>2</sub> as both a combustion emission and a process emission. Emerald Kalama Chemicals makes petrochemical additives for the food industry; the firm's primary source of emissions would likely be fuels used to heat multiple boilers and heaters.

The huge diversity of the chemical industry, and many thousands of products made, complicate efforts to discuss production processes and greenhouse gas emission sources. A number of benchmarking efforts are underway globally, however, and may help inform possible benchmark development in other regions. These include efforts by the EU to develop benchmarks for the upcoming third phase of the EU Emissions Trading System (Ecofys, Fraunhofer Institute, and Öko Institut 2009d); development of a benchmarking approach for steam crackers (used to make ethylene and other petrochemicals) developed by the consulting firm Solomon Associates; documentation of world “best practice” energy intensity values for ammonia and ethylene production (Worrell et al. 2008); efforts to document best available techniques in the chemicals sector (European Commission 2003); and global average or typical energy and GHG emission intensities for production of several particular chemicals (IEA 2008). These efforts focus on the chemicals that comprise a large fraction of the worldwide chemical sector’s energy consumption and emissions releases, and in most cases focus little attention on the chemicals produced at scale in Washington State: hydrogen (and then hydrogen peroxide) and food additives. The EU study (Ecofys, Fraunhofer Institute, and Öko Institut 2009d) does specifically address hydrogen and therefore may be relevant to Solvay Chemicals. That study includes a proposed benchmark value on hydrogen production that was developed in part through data provided by the European Industrial Gases Association (EIGA) as well as elements of the Solomon Associates approach. In addition, an approach similar to the EU’s fall-back benchmarking method for heat (as discussed further in the Heat section of this White Paper, beginning on page **Error! Bookmark not defined.**) may be applicable to Emerald Kalama Chemicals.

In addition, H.R. 2454 (“Waxman-Markey”), passed out of the U.S. House of Representatives in June 2009, included a formula for constructing average, sector-wide benchmarks for several energy-intensive and trade-exposed subsectors of the chemical industry. The benchmarks were to be used to issue allowance rebates to these industry sectors.<sup>71</sup> Inorganic chemicals (NAICS 325188), a sector that includes Solvay Chemicals, and organic chemicals (NAICS 325199), a sector that includes Emerald Kalama chemicals, are both included in the proposed benchmarking approach to output-based rebates.

### Key Issues in Benchmarking Chemicals

In general, key issues in developing GHG benchmarks in the chemicals industry include the large number of chemicals produced (which could, in theory, require hundreds of benchmarks), the rapidity by which some facilities can change the chemicals they produce in response to market demand, data availability (even for those chemicals that are dominant from an energy or emissions perspective, such as ammonia or ethylene), and the treatment of heat (generally in the form of steam) given that different types of facilities produce or import varying degrees of heat depending on individual plant needs and the product made.

## Food Processing

Food processing facilities in Washington manufacture diverse products such as frozen french fries, juice, and dairy products. Together, large food processing facilities in Washington emit approximately 300,000 metric tons of greenhouse gases per year (Washington Dept. of Ecology 2009).

### Overview of Production Processes and Emission Sources

Major sources of greenhouse gas emissions from food processing facilities include fossil fuel combustion for heating, cooking, drying, and other processes; non-combustion processes, such as methane emissions from onsite wastewater treatment plants and hydrofluorocarbon emissions from refrigeration; and purchased electricity (US EPA 2008a). Although difficult to generalize given the wide variety of food processing facilities, steps involved in food processing often include (Masanet et al. 2008):

- **Inspection, grading, and washing**, involving a variety of electrical equipment including motors, conveyors, and pumps;

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<sup>71</sup> For more information, see the discussion of benchmarking in the context of cap-and-trade legislation that begins on page 6.

- **Processing**, including any of a wide variety of activities that can include peeling, blanching, juice extraction, filtering, pasteurization, and others, depending on the particular product being made;
- **Freezing or canning**, in which the products are frozen (using large quantities of electricity) or canned (often using large quantities of heat); and
- **Packaging**, in which the products are placed in their final packaging for shipment.

Few efforts are known to benchmark greenhouse gas emissions in the food processing industry, although regional and national efforts are underway to benchmark energy performance. These include the US EPA's ENERGY STAR program for frozen french fry manufacturers and juice processing plants and a regional effort by the Northwest Food Processors Association. More specifically:

- **ENERGY STAR** released tools in 2009 to evaluate energy performance at frozen potato and juice processing plants. Two frozen fried potato facilities in Washington have since been awarded the ENERGY STAR: the JR Simplot plant in Quincy and the ConAgra plant in Othello. EPA estimates that these two plants are in the top 25<sup>th</sup> percentile in terms of energy efficiency performance and use about 20% less energy than similar plants throughout the nation (US EPA 2010a).
- **Northwest Food Processors Association (NWFPA)** members adopted a goal to reduce industry-wide energy intensity by 25% in 10 years and 50% in 20 years. In February 2009, NWFPA signed a Memorandum of Understanding (MOU) with the US Department of Energy supporting that goal. To date, 49 NWFPA-member facilities have documented energy intensities for 2006 through 2009. NWFPA is establishing an industry-wide baseline for 2009 against which industry progress toward achieving the energy intensity reduction goal can be tracked.<sup>72</sup> Other activities include expanding data collection to include the 180 or so member facilities, benchmarking energy intensities by subsectors (at the six digit NAICS level), and developing a "roadmap" to guide efforts to achieve the 2020 energy intensity goal.

The diversity of the food processing industry, and many products made, complicate efforts to provide a more detailed overview of production processes and greenhouse gas emission sources as provided in this report for other industries.

## Glass

Broadly speaking, four types of glass are manufactured in the U.S.: flat glass (e.g., windows), container (hollow) glass, fiberglass, and specialty glass. Glass is made primarily from silica sand with lime, soda, cullet (recycled glass), and other ingredients added. In the United States, glass manufacturers produce approximately 20 million tons of glass annually (Worrell et al. 2008). In Washington State, the largest glass plants are Cardinal Glass, a flat glass manufacturer in Winlock (near Chehalis), and St. Gobain Containers, a glass bottle manufacturer in Seattle. Together these facilities emit approximately 150,000 metric tons of greenhouse gases annually (Washington Dept. of Ecology 2009). Accordingly, the container glass and flat glass segments of the industry will be the focus of this section. Several producers of fiberglass-reinforced plastics, as well as a variety of smaller specialty glass products, also exist in Washington State and are not addressed here.

### Overview of Production Processes and Emission Sources

The production of glass involves four sequential steps (Worrell et al. 2008):

- **Batch preparation and mixing**, in which silica (sand), soda, potash, and (in some cases) cullet are combined with stabilizers lime, magnesium oxide, and aluminum oxide. Refining agents may be added to help remove air bubbles in the subsequent melting step. Other additives are included here to give the glass the desired color and other properties.
- **Melting and refining**, in which the raw materials are fired in a furnace (usually a "tank" furnace) heated either by combustion or electricity or a combination of both, and sometimes using oxygen instead of regular combustion air to increase efficiency and reduce nitrous oxide emissions. Refining, which involves

<sup>72</sup> Personal communication between Eli Levitt, Washington Department of Ecology and NWFPA staff, March 24, 2010.

removal of bubbles, and homogenization, also occur in the furnace. In the U.S., most glass furnaces are fired by natural gas and some (especially container-glass furnaces) use electric boosters, as glass is a conductor at high temperatures. In such cases, electricity can represent up to 20% of the energy input to the furnace. Use of electric boost is less common in furnaces that produce flat glass.

- **Conditioning and forming**, in which glass is transferred out of the furnace into a forehearth, where it is conditioned to have the desired temperature distribution, and then delivered to the forming equipment, where it is either shaped continuously (e.g., the float or rolled glass processes used to make flat glass) or separated into individual portions (“gobs”) for blowing or pressing into containers.
- **Finishing**, in which various processes and treatments may be applied to affect glass characteristics. These steps may include annealing (reheating and cooling of the glass to remove stresses), toughening (also accomplished by a reheating, followed by rapid cooling with air jets), and coatings (e.g., mirrors).

The table below summarizes the major processes and sources of emissions in glass production.

**Table 14. Summary of Flat and Container Glass Production Processes, Emission Sources, and Existing Benchmarks**

Step	Dominant Emissions Sources	Proposed or Existing GHG Benchmarks under Cap-and-trade	Other Benchmarks or Best-Practice Values	Key Issues / Options
Batch preparation and mixing	<ul style="list-style-type: none"> <li>▪ Electricity production or natural gas combustion for equipment operation</li> </ul>	E.U. has proposed benchmarks on: <ul style="list-style-type: none"> <li>▪ Flat glass</li> <li>▪ Hollow glass<sup>73</sup></li> </ul>	<ul style="list-style-type: none"> <li>▪ IEA (2008) reports some average and best-practice energy-intensity values</li> <li>▪ European Commission (2009) reports energy and CO<sub>2</sub> levels of typical and “best available techniques” for different types of glass production</li> <li>▪ US EPA ENERGY STAR has an energy benchmarking tool that compares energy per ton of glass sand input (for flat glass) or glass sand plus cullet (for container glass)<sup>74</sup></li> </ul>	<ul style="list-style-type: none"> <li>▪ Use of cullet can reduce energy use and process emissions in the manufacture of container glass, but availability and quality of cullet can vary substantially by region depending on local recycling programs, which can complicate assumptions about default rate of cullet use in development of benchmark</li> <li>▪ The potential substitutability of natural gas and electricity can complicate a benchmark based on direct emissions only</li> <li>▪ Whether to base a benchmark based on product packed or product “pulled” from the furnace</li> <li>▪ High degree of consolidation in the glass industry complicates data availability for benchmark development</li> </ul>
Melting and refining	<ul style="list-style-type: none"> <li>▪ Natural gas for firing the furnace</li> <li>▪ Production of electricity used for boosting furnace, if applicable</li> <li>▪ Process CO<sub>2</sub> emissions resulting from the decarbonization of soda ash and lime</li> </ul>	H.R. 2454 (Waxman-Markey), passed in the US House of Representatives in 2009, included a formula for constructing a average benchmarks for: <ul style="list-style-type: none"> <li>▪ Flat glass</li> <li>▪ Pressed / blown glass</li> <li>▪ Glass containers</li> </ul>		
Conditioning and forming	<ul style="list-style-type: none"> <li>▪ Natural gas burning or electricity production for heating of the forehearth</li> <li>▪ Electricity production or natural gas combustion for equipment operation</li> </ul>			
Finishing	<ul style="list-style-type: none"> <li>▪ Electricity production or natural gas combustion for equipment operation</li> </ul>	None known	<ul style="list-style-type: none"> <li>▪ IEA (2008) reports some average and best-practice energy-intensity values</li> </ul>	

### Key Issues in Benchmarking Glass

As with all sectors, the data availability and number of products to distinguish (e.g., whether to develop separate benchmarks by container shape or color) may be key issues. In addition, three issues particular to the glass industry are:

- **How to treat use of cullet (recycled glass)**, particularly in container glass production. Use of cullet can reduce energy use and process emissions, but its availability and quality can vary substantially by region depending on local recycling programs, such that areas with more-developed recycled glass collection and processing infrastructures may have significant advantages in meeting a benchmark level. However, under a cap-and-trade system on greenhouse gases, differentiating the benchmark based on cullet usage

<sup>73</sup> The EU has also proposed a benchmark in continuous filament fibers that is not discussed here because the focus is on flat and container glass (Ecofys, Fraunhofer Institute, and Öko Institut 2009e)

<sup>74</sup> Cardinal Glass has been a participant in an EPA Work Group as part of the ENERGY STAR program: [http://www.energystar.gov/index.cfm?c=in\\_focus.bus\\_glass\\_manuf\\_focus](http://www.energystar.gov/index.cfm?c=in_focus.bus_glass_manuf_focus).

or quality may be less appropriate, since the goal is to encourage the use of lowest-GHG processes and feedstocks and facilities have the flexibility to purchase allowances or offsets. Under a regulatory or voluntary framework, some level of accounting for cullet quality and availability may be desirable, assuming facilities are asked to meet a particular benchmark and do not have flexibility to purchase allowances or offsets to meet the benchmark.

- **Relative ease of substitution between electricity and natural gas** in some glass furnaces (especially container-glass furnaces) could complicate benchmark development and application. If the benchmark was based only on direct emissions, then the facilities that are more reliant on electricity would appear to fare much better, regardless of overall GHG intensity (including the emissions released in electricity production).

**Whether to base the benchmark on melted (or “pulled”) or packed glass.** Glass furnaces are usually constructed to operate without interruption for 10 years or more (Neelis et al. 2009), as the damage caused by shutting down a facility (e.g., from the molten glass solidifying in the furnace) can be very expensive. In periods of low demand (such as in the current economic recession), glass furnaces can slow production, but many facilities must continue to produce more than they can sell, crush the surplus, and feed it back into the furnace to maintain minimum throughput volume and avoid damage to the furnace. Benchmarks based on the output coming directly from the furnace (i.e., the melted or “pulled” glass) may help recognize these cyclical fluctuations and may also align better with the type of data already rigorously collected by manufacturers. On the other hand, basing benchmarks on the final quantity of product packed would provide a better incentive for energy and emissions efficiency as it would encourage optimization of the production process to maximize saleable product (Ecofys, Fraunhofer Institute, and Öko Institut 2009e).

## Pulp & Paper

With extensive forests, the Pacific Northwest (and Washington State in particular) has historically been a leader in the pulp and paper industry. In recent decades, the state’s industry has contracted due to increased competition and decreased prices due to rising global production capacity (particularly in Asia), increased energy prices, and decreased supply of raw materials (e.g., wood chips). However, many pulp and paper mills remain in the state, with most being integrated mills, meaning they produce both pulp and paper. Together these large pulp and paper emitted approximately 850,000 metric tons of greenhouse gases in 2007 (Washington Dept. of Ecology 2009).

Table 15 summarizes the active pulp and/or paper mills in Washington State.

Table 15. Active Pulp & Paper Mills in Washington State<sup>75</sup>

Facility	City	Mill Type	Pulp Type	Products
Boise*	Wallula	Integrated	▪ Kraft	▪ Bleached paper ▪ Coated paper ▪ Corrugating medium
Georgia Pacific*	Camas	Integrated	▪ Kraft	▪ Bleached kraft paper ▪ Tissue ▪ Paper towels
Grays Harbor Paper	Hoquiam	Non-integrated	▪ Recycled paper and Kraft (purchased)	▪ Writing paper
Inland Empire*	Spokane	Integrated	▪ Mechanical ▪ Deinked recycled	▪ Newsprint
Kimberly Clark*	Everett	Integrated	▪ Sulfite (ammonia-based)	▪ Tissue
Longview Fibre*	Longview	Integrated	▪ Kraft	▪ Container board
Nippon Paper	Port Angeles	Integrated	▪ Mechanical pulp and recycled paper	▪ Telephone directory paper
Ponderay Newsprint	Usk	Integrated	▪ Thermomechanical	▪ Newsprint
Port Townsend Paper*	Port Townsend	Integrated	▪ Kraft and recycled OCC	▪ Unbleached kraft pulp ▪ Lightweight linerboard ▪ Corrugating medium ▪ Unbleached converting grades
Simpson Tacoma Kraft*	Tacoma	Integrated	▪ Kraft	▪ Unbleached kraft pulp ▪ Bleached and unbleached packaging paper ▪ Linerboard
Sonoco	Sumner	Integrated	▪ Recycled cardboard and magazine-type papers	▪ Recycled paperboard
Weyerhaeuser Co.*	Longview	Integrated	▪ Kraft ▪ De-ink (recycled) ▪ Thermomechanical	▪ Bleached kraft pulp ▪ Paperboard ▪ Newsprint ▪ Publishing papers

\*These facilities are estimated to emit at least 25,000 tons CO<sub>2</sub>e annually (Washington Dept. of Ecology 2009)

One of the most significant distinctions between mills is the production process used to create pulp. The main pulp processes are chemical pulping (including the kraft and sulfite processes), mechanical pulping, or paper recycling, with mechanical pulping being the most greenhouse-gas intensive. The type of process used in each of Washington's mills is noted in Table 15 and described in more detail below.

### Overview of Production Processes and Emission Sources

The production of pulp and paper involves four main processes:

- **Raw material harvest or collection**, in which either virgin wood is harvested and chipped or post-consumer or post-industrial paper feedstocks are collected and sorted.
- **Virgin pulp production**, in which the wood chips are broken down into their raw cellulose fibers by one of three dominant types of processes:
  - Kraft (sulfate) pulping, in which fibers are released by dissolving the wood chips in a high-temperature sulfate chemical solution (the cooking process) and which produces black liquor, a waste product that contains a significant quantity of lignin;

<sup>75</sup> Summarized from the Department of Ecology's industrial section web page (<http://www.ecy.wa.gov/programs/swfa/industrial/facilities.html>) and individual company web pages.

- Sulfite pulping, in which the cooking process uses a bisulfate liquor in a pressurized vessel. Sulfite pulping is rare and is used mainly for specialty papers, and produces a byproduct called “red liquor.”
- Mechanical pulping, in which wood fibers are mechanically separated. One type of mechanical pulping is the groundwood process, in which wood is ground to produce relatively short fibres (e.g., for newsprint) in an electricity-intensive process. Mechanical pulping can also involve pre-softening with steam (thermo-mechanical pulping) or with chemicals (chemi-mechanical pulping), either of which can involve more use of fossil fuel than other mechanical-based pulps.

Methods of recovering energy are possible in all three types of pulping. In the kraft process, black liquor can be combusted to recover substantial quantities of energy from the lignin, even producing more heat than is needed in the pulping process.<sup>76</sup> Similar energy recovery is possible from red liquor produced in sulfite pulping. In mechanical pulping, heat generated from the application of mechanical energy (only a fraction of which is used to separate the cellulose fibers) can also be recovered as hot water or steam.

In all of the pulping processes, bleach may or may not be applied depending on the desired brightness of the finished product.

- **Recovered paper processing**, which involves collecting and sorting post-consumer and pre consumer waste as feedstocks, cleaning and de-inking. Use of recovered paper requires energy but tends to lower the overall energy and emissions intensity of paper production.
- **Paper production**, in which the pulp is fed into the paper making machine, screened, vacuumed of water, pressed by rollers, and dried. If necessary, sizing (to affect absorption and wear) and coatings are then applied.

Table 16 summarizes the major processes and sources of emissions in pulp and paper production.

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<sup>76</sup> Lime can also be recovered from the kraft pulping process.

**Table 16. Summary of Paper Production Processes, Emission Sources, and Existing Benchmarks**

Step	Dominant Emissions Sources	Proposed or Existing GHG Benchmarks under Cap-and-trade	Other Benchmarks or Best-Practice Values	Key Issues / Options
Raw material harvest or collection	<ul style="list-style-type: none"> <li>Fossil fuel for extraction equipment</li> </ul>	None known	None known	
Virgin pulp production	<ul style="list-style-type: none"> <li>Fossil fuel for heat or steam (particularly for start-up if recovering energy from waste liquors) and to power the lime kilns in the kraft process</li> <li>Process emissions from production of lime in the kraft process</li> <li>Electricity production (particularly for mechanical pulping)</li> </ul>	<ul style="list-style-type: none"> <li>EU has proposed benchmark for kraft pulp (for lime kiln operation only)<sup>77</sup></li> <li>H.R. 2454 (Waxman-Markey), passed in the US House of Representatives in 2009, included a formula for constructing an average benchmark for pulp production (NAICS 322110)</li> </ul>	<ul style="list-style-type: none"> <li>Worrell et al (2008) and IEA (2008) list world best-practice energy and “best available technology” benchmarks, respectively, for virgin pulp production</li> </ul>	<p>Heat at the mill can be produced using feedstocks that are either:</p> <ul style="list-style-type: none"> <li>Inherent to the pulping process (e.g., liquor recovery or from heat recovery from mechanical pulping), in which case heat recovery can exceed that needed for the pulping process and the facility can be a net exporter of heat; no benchmark may be needed (as in the EU)</li> <li>Unrelated to the pulping process (e.g., bark or wood residues, wastewater treatment, and short fiber sludges), which in the EU is left outside the pulp benchmark system boundary since it is not directly related to the performance of pulp making; this heat production may still receive a benchmark under the allocation for cross-facility heat flows</li> </ul>
Recycled paper processing	<ul style="list-style-type: none"> <li>Fossil fuel and electricity for processing equipment, particularly for pulping and deinking</li> </ul>	<ul style="list-style-type: none"> <li>EU has proposed a benchmark on processed recovered paper</li> </ul>	<ul style="list-style-type: none"> <li>Worrell et al (2008) and IEA (2008) list world best-practice energy and “best available technology” benchmarks, respectively, for recovered pulp production</li> </ul>	<ul style="list-style-type: none"> <li>Use of a separate benchmark for processed recovered paper avoids the need to derive an assumed ratio of recycled fibers to virgin pulp in paper benchmarks</li> </ul>
Paper production	<ul style="list-style-type: none"> <li>Fossil fuel for dryers, heaters (for production of coated papers), and other equipment</li> <li>Electricity production for equipment, including rollers, presses, motors, and pumps</li> </ul>	<p>EU has proposed benchmarks on:</p> <ul style="list-style-type: none"> <li>Recycled paper</li> <li>Newsprint</li> <li>Uncoated fine paper</li> <li>Coated fine paper</li> <li>Tissue</li> <li>Container board</li> <li>Carton board</li> <li>Other papers</li> </ul> <p>H.R. 2454 (Waxman-Markey) included formulas for calculating benchmarks for:</p> <ul style="list-style-type: none"> <li>Newsprint, NAICS 322122</li> <li>Paperboard, NAICS 322130</li> <li>Other Paper, NAICS 322121</li> </ul>	<ul style="list-style-type: none"> <li>Worrell et al (2008) and IEA (2008) list world best-practice energy and “best available technology” benchmarks, respectively, for numerous paper grades</li> </ul>	<ul style="list-style-type: none"> <li>Benchmarks developed based on integrated mills may be too low for non-integrated mills that buy market pulp (and therefore don’t have pulp residuals available as fuels), but splitting emissions in integrated mills between pulp and paper making is very difficult.</li> <li>The EU reports that containerboard, carton board, and other papers may need further disaggregation but that data are insufficient.<sup>78</sup></li> </ul>

<sup>77</sup> The EU has not proposed benchmarks for heat consumption for kraft, sulfite, or mechanical pulp because the recovery of waste products from these processes can produce more than enough heat to supply to the pulping process (Ecofys, Fraunhofer Institute, and Öko Institut 2009f). The allocation for lime production is for the fossil fuel use only, not for the process CO<sub>2</sub>, because the process CO<sub>2</sub> here is from a biomass source (considered zero carbon in the EU system), unlike in normal lime production (Neelis et al. 2009).

<sup>78</sup> A subsequent finding by the European Commission (European Commission 2010a) suggests separate benchmarks for two types of containerboard: kraftliner and testliner/fluting.

## Key Issues in Benchmarking Pulp & Paper

Three issues particular to the pulp and paper industry are:

- **How to treat use of recycled pulp or recovered paper.** Since use of recovered paper affects the GHG intensity of paper production, benchmark construction may need to either assume a default rate of recovered paper (or recycled pulp) use or else develop a separate benchmark for use of processed recovered paper, as is currently being explored in the EU.
- **Whether paper benchmarks based on integrated mills can be applied to non-integrated mills.** Integrated mills make paper from their own pulp and have pulping residuals (e.g., black liquor) left over to use as fuel in the boiler. Accordingly, non-integrated mills that buy market pulp or produce pulp by recycling papers may not be able to meet benchmarks based largely on emissions from integrated mills. Differentiating the benchmark for integrated and non-integrated mills may be particularly relevant for benchmarks in a regulatory or voluntary context. However, under a cap-and-trade system on greenhouse gases, such differentiating may be less appropriate, since the goal is to encourage the lowest-GHG processes and facilities have the flexibility to purchase allowances or offsets.
- **How to treat heat production and possibility for cross-facility heat flows,** especially since recovery of black liquor from the kraft pulping process can result in production of excess heat that could be sold to another facility or used to make electricity. In such case, some researchers (Ecofys, Fraunhofer Institute, and Öko Institut 2009f) have considered (but generally discarded due to methodological complexity) whether a *negative* benchmark might be considered to account for the heat that could be sold and exported as a separate product. Regardless, the question of how to account for cross-facility heat or power flows will need to be carefully considered.

The Washington Department of Ecology has been working with five pulp and paper mills in the state to select indicators of sustainability, including greenhouse gas emissions, for the pulp and paper industry. That project – termed the Industrial Footprint Project – may help to identify other issues for benchmarking GHGs in the pulp and paper sector or help address those issues listed above.<sup>79</sup>

## Steel

Crude steel is produced from both virgin materials (primary iron, which is made from iron ore) and secondary materials (scrap). The steel industry employs two distinct production technologies to make steel: the basic oxygen furnace (BOF), which is integrated with the production of pig iron, and the electric arc furnace (EAF), in which steel is produced by the melting of scrap or direct reduced iron with the help of electric arcs. Globally, about two-thirds of steel is produced via the first process, which uses mostly iron ore as its feedstock (with small amounts of scrap). In the U.S., more steel is produced in the electric arc furnaces, which is generally less greenhouse-gas intensive than production via basic oxygen furnace (IEA 2008).<sup>80</sup> Other technologies, including the outdated open-hearth furnaces, account for a very small fraction of steel making. The industry, in collaboration with researchers at the Massachusetts Institute of Technology, is also investigating new steelmaking technologies, such as molten oxide electrolysis, that would generate zero direct carbon emissions, but that would require large quantities of electricity (IEA 2009b).

In Washington State, the only producer of crude steel is Nucor Steel in Seattle, an electric arc furnace that uses scrap (recycled) steel to make steel rebar, flat bar, channel, and other similar products. We cover both BOF and EAF technologies here, however, as basic oxygen furnaces have existed in Washington previously, and they continue to be major producers of steel in other parts of the country.

<sup>79</sup> For more information on this project, see <http://www.ecy.wa.gov/programs/swfa/industrial/IndFootprintBackground.html>.

<sup>80</sup> The exception would be if the electric arc furnace is fueled by direct reduced iron produced using coal, in which case total emissions per ton of steel can be higher than from a basic oxygen furnace (IEA 2008).

After crude steel is cast, additional processes convert the steel to finished products at forges. One forge, Jorgenson Forge, is based in Tukwila, WA. Together, Nucor Steel and Jorgensen Forge release an estimated 135,000 tons CO<sub>2</sub>e of greenhouse gases each year (Washington Dept. of Ecology 2009).

### Overview of Production Processes and Emission Sources

Production of steel occurs in five distinct steps (Ecofys, Fraunhofer Institute, and Öko Institut 2009g; Neelis and Patel 2006):

- **Mining and treatment of raw materials.** Two significant raw materials are used to make steel: iron ore and coal. Coal is converted to coke by heating in the absence of oxygen to remove the volatile components and tars. Iron ore is sintered, a process in which iron ores of different grain sizes (particularly finer-grained ore) are agglomerated together with additives (e.g., limestone) to make a consistent feedstock for the blast furnace.
- **Iron making,** in which iron ore is smelted with coke in a blast furnace and iron oxides are reduced to liquid pig iron. Alternatively, iron ore can instead be reduced, below its melting point and retaining its original shape, into direct reduced iron (DRI) (also called “sponge iron”) for use in an electric arc furnace.<sup>81</sup>
- **Steel making.** In the basic oxygen furnace, oxygen is blown through the molten pig iron, oxidizing the carbon, silicon, and phosphorus in the pig iron and producing steel. Some amount of scrap may be added at this stage to help control the reaction and aid in cooling. In an electric arc furnace, as in the Nucor facility in Seattle, melting of scrap (recycled steel) and direct reduced iron occurs in a bath at high temperatures attained with the help of an electric arc.
- **Casting,** in which liquid steel is cast into large ingots, billets, or, semi-finished products such as slabs. In the Nucor facility in Seattle, steel is cast into a billet.
- **Rolling and finishing,** in which the steel is converted to finished steel products via various foundry, rolling, pickling, annealing, welding, or other steps.

Table 17 summarizes the major processes and sources of emissions in iron and steel production. Note that the first two processes: raw material treatment and iron-making, do not occur in Washington State.

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<sup>81</sup> Washington’s only steel mill, Nucor Steel, an electric arc furnace, does not use direct reduced iron.

Table 17. Summary of Iron and Steel Production Processes, Emission Sources, and Existing Benchmark Sources

Step	Dominant Emissions Sources	Proposed or Existing GHG Benchmarks under Cap-and-trade	Other Benchmarks or Best-Practice Values	Key Issues / Options
Mining and treatment of raw materials	<ul style="list-style-type: none"> <li>▪ Fossil fuel burning for coking and sintering</li> <li>▪ Direct CO<sub>2</sub> emissions from residue materials and from limestone calcinations</li> <li>▪ Direct CO<sub>2</sub> and CH<sub>4</sub> emissions from coke-making (usually transferred as a waste gas to the blast furnace) or sinter making</li> </ul>	<p>EU has proposed benchmarks for:</p> <ul style="list-style-type: none"> <li>▪ Coke</li> <li>▪ Sinter</li> </ul>	<ul style="list-style-type: none"> <li>▪ Worrell et al (2008) list world best-practice energy benchmarks for pellets</li> </ul>	<ul style="list-style-type: none"> <li>▪ Treatment of waste gases from the coke oven, blast furnace, and basic oxygen furnace can be used in internal processes or transferred to other installations. Benchmarks for these waste gases could be established and allowances allocated (if in a cap-and-trade setting) to either producer or consumer of them (or split between them).<sup>82</sup></li> <li>▪ EU states that a separate benchmark for iron ore pellets (an alternative to sinter) may be warranted if data are sufficient</li> </ul>
Iron making	<ul style="list-style-type: none"> <li>▪ Fossil fuel burning to fire blast furnaces</li> <li>▪ Direct CO<sub>2</sub> emissions from use of coke as a reducing agent in a blast furnace</li> </ul>	<p>None known (In the EU, emissions for producing pig iron are included in the hot steel benchmark)</p>	<ul style="list-style-type: none"> <li>▪ Worrell et al (2008) list world best-practice energy benchmark for ironmaking, including direct reduced iron</li> </ul>	<p>Arguments exist both for and against having a separate benchmark for pig iron:</p> <ul style="list-style-type: none"> <li>▪ For: it can be traded as its own intermediate product</li> <li>▪ Against: Rarely is cooled and sold as its own product; could create perverse incentives for altering ratio or quality of pig iron use; separate pig iron and hot metal benchmarks would likely be impossible for an integrated facility to simultaneously attain.<sup>83</sup></li> </ul>
Steel making	<ul style="list-style-type: none"> <li>▪ In a BOF, fossil fuel burning and direct CO<sub>2</sub> emissions from oxidizing the carbon in the pig iron</li> <li>▪ In an EAF, direct, process CO<sub>2</sub> emissions from carbon from electrodes and scrap oxidizing, as well as emissions from production of electricity</li> </ul>	<p>EU has proposed benchmarks for:</p> <ul style="list-style-type: none"> <li>▪ Hot steel</li> <li>▪ EAF steel</li> </ul> <p>H.R. 2454 (Waxman-Markey), passed in the US House of Representatives in 2009, included a formula for constructing average benchmarks for:</p> <ul style="list-style-type: none"> <li>▪ Steel from integrated mills</li> <li>▪ EAF steel</li> </ul>	<p>IEA (2008) lists global averages for</p> <ul style="list-style-type: none"> <li>▪ EAF steel from scrap</li> <li>▪ EAF steel from direct reduced iron</li> <li>▪ BOF steel</li> </ul> <p>Worrell et al (2008) list world best-practice energy benchmarks for steelmaking and casting</p> <p>US EPA (2008a) reports U.S. average 1.24 tons of CO<sub>2</sub> per ton of steel, including both direct and indirect emissions, based on AISI data</p>	<ul style="list-style-type: none"> <li>▪ Treatment of waste gases can be critical (see above under treatment of raw materials)</li> <li>▪ EAF high-alloy steel may warrant its own benchmark as it may be considered a distinctly different product, but in the EU data were insufficient</li> <li>▪ The substitutability of electricity and fossil fuel in EAFs may be debated</li> <li>▪ A key decision may be in what casting steps to include in a steel benchmark versus to treat downstream with a separate benchmark (perhaps using a fall-back approach given limited data)</li> </ul>
Casting	<ul style="list-style-type: none"> <li>▪ Fossil fuel burning or electricity production</li> </ul>	<p>EU treats with a fall-back approach</p>	<ul style="list-style-type: none"> <li>▪ Worrell et al (2008) list world best-practice energy benchmarks for rolling and finishing</li> </ul>	<ul style="list-style-type: none"> <li>▪ EU considering separate benchmarks for foundry products and warm rolling if products are similar enough</li> </ul>
Rolling and finishing	<ul style="list-style-type: none"> <li>▪ Fossil fuel burning or electricity production for equipment</li> </ul>	<p>EU treats with a fall-back approach</p>	<ul style="list-style-type: none"> <li>▪ Worrell et al (2008) list world best-practice energy benchmarks for rolling and finishing</li> </ul>	<ul style="list-style-type: none"> <li>▪ EU considering separate benchmarks for foundry products and warm rolling if products are similar enough</li> </ul>

<sup>82</sup> For a lengthy discussion of waste gases in the iron and steel sector, including stakeholder comments, see Ecofys, Fraunhofer Institute, and Öko Institut (2009g)

<sup>83</sup> For a full discussion, see Ecofys, Fraunhofer Institute, and Öko Institut (2009g).

## Key Issues in Benchmarking Steel

As with all sectors, the data availability and number of products to distinguish may be key issues. In addition, three issues particular to the steel industry are:

- **Treatment of waste gases**, which can either be used internally as furnace fuel or to generate electricity. To what extent these waste gases are counted when the benchmark is constructed, and whether they are counted under the producer or consumer (if applicable) of these gases, can be important questions (Ecofys, Fraunhofer Institute, and Öko Institut 2009g).
- **Treatment of intermediate products.** Coke, sinter and hot metal are important intermediate products that can be traded between installations. How to account for these possible trades can be an important question. The EU proposed to develop benchmarks for these intermediate products (Ecofys, Fraunhofer Institute, and Öko Institut 2009g). **Substitutability of electricity and fossil fuel in an electric arc furnace.** In an electric arc furnace, oxy-fuel burners can also be used to provide heat to the furnace. Within certain limits, and depending on the product being made, the fraction of heat supplied by the oxy-fuel burner can be altered. Accordingly, a benchmark based only on direct emissions could tend to favor electric arc furnaces that use a lower fraction of heat from the oxy-fuel burner, regardless of overall (direct + indirect) GHG intensity. However, this issue would be less of a concern under a cap-and-trade program that also included electricity, since the cost of emissions from electricity production would be reflected in the price of the electricity.

## Alternative to Product Benchmarking: Heat Benchmarking

So far, this section has discussed considerations in defining benchmarks on products in particular industry sectors. An alternative to product-based benchmarking could be to develop benchmarks for common processes (or intermediate products) common to several industries. One such possibility is to develop benchmarks for heat production.

Many industrial processes use heat (usually as hot water or steam) produced in boilers, many of which are fired using fossil fuels. Nationally, EPA estimates that the approximately 45,000 industrial boilers in use emit 1,250 MtCO<sub>2e</sub> annually, or approximately 20% of the U.S. greenhouse gas inventory (US EPA 2008b). Boilers are also used in commercial and institutional settings such as hospitals, schools, and shopping malls. Boiler sizes exist along a continuum from small residential-scale units to factory-built intermediate-sized units to large site-built units. While the differing boiler sizes can be subject to similar emission reduction options and benchmarking considerations, here we address only boilers used at industrial sources.

The use of boilers and generation of heat applies across many of the industry sectors discussed in this *White Paper* (including pulp and paper, chemical, and food processing sectors), as well as many other sectors not discussed in detail (e.g., petroleum refining). More specifically, use of boilers is particularly common in the following sectors (Energy and Environmental Analysis, Inc. 2005; IEA 2008):

- **Pulp and paper**, with about 3,400 boilers nationally, and where the dominant fuel is black liquor, a byproduct of the chemical pulping process, and where bark, wood chips, and production wastes are other common feedstocks.
- **Chemicals**, with about 12,000 boilers nationally, many of them smaller than the 10 MMBtu/hour threshold for Clean Air Act standards, and where dominant fuels are natural gas, by-products, and coal or coke.
- **Petroleum refining**, with 1,200 (generally large) boilers nationally, and where the dominant fuels are crude oil, natural gas, refiner gas, and residual fuel oil.
- **Food processing**, where boilers are generally fueled by natural gas or residual fuel oil.
- **Wood products**, where the boilers are generally fueled by wood wastes.
- **Miscellaneous industrial products**, where the boilers are generally fueled by what fuel is available, is lowest cost at time of initial installation of the boiler, or is allowed in an air permit.

Accordingly, heat is not an industry *per se*,<sup>84</sup> but instead is an intermediate product produced and used by several industry sectors – a product that is usually generated and consumed in the same facility but is sometimes sold or transferred between facilities. Because many different types of facilities produce and use heat, some existing or proposed benchmarking efforts have considered developing separate benchmarks based on heat (e.g., steam) production in addition to or instead of other (product) benchmarks. These include the EU’s effort to develop industry benchmarks for the third phase of its Emissions Trading System, where a heat production benchmark has been recommended as a “fall-back” approach for sectors or products where product-specific benchmarks are not developed and applied (Ecofys, Fraunhofer Institute, and Öko Institut 2009a). Additionally, US EPA has considered developing benchmark-based performance standards for industrial boilers as it has evaluated alternative possibilities for regulating greenhouse gases under the Clean Air Act (US EPA 2008b) and has also developed a protocol for measuring reductions in greenhouse gas emissions from industrial boilers (US EPA 2008e).

## Overview of Production Processes and Emission Sources

The production and use of steam (the most common heat transfer medium) in industrial processes involves four sequential steps (LBNL and Resource Dynamics 2004):

- **Generation.** Steam is produced either in a boiler or in a system to recover heat from another industrial process. In either case, steam is produced by transferring heat to water, which when heated to the boiling point, produces steam. The temperature and pressure of the steam produced in a boiler is influenced by the boiler design and by the ultimate uses of the steam produced.
- **Distribution.** Under pressure, steam flows from the generator into distribution lines, which carry the steam to the points of end use and which involve various types of valves to regulate pressure.
- **End Use.** Steam can be used for process heating, mechanical drives via turbines, moderation of chemical reactions, drying of paper products, fractionation of hydrocarbons in petroleum refining, or used directly as a hydrogen feedstock in a steam-methane reformer (e.g., at Solvay Chemicals.)
- **Recovery.** Wet steam or condensed steam used in process heating is returned to the boiler area where it is cooled in a heat exchanger and collected in a boiler feedwater tank. From the collection tank, the water is pumped to a deaerator, where it is stripped of oxygen and non-condensable gases and fed back into the boiler along with any makeup water needed to repeat the cycle.

Release of greenhouse gases occurs in the generation stage as a result of burning of fuels used to heat the boiler. Fuels used include the fossil fuels coal, oil, refinery gas (petroleum refining), and natural gas; waste products such as bark or wood chips, pulping liquors (pulp and paper sector), or landfill gas; plus other fuels. Boiler efficiency can vary tremendously by boiler age, size, and design. Coal and natural gas fired boilers are typically about 80 to 85% efficient, whereas a boiler fired by spent pulping liquors is approximately 70% efficient (Energy and Environmental Analysis, Inc. 2005). Significant losses of efficiency can also arise in the distribution system. According to the International Energy Agency, the best opportunity to increase efficiency of a heat system is through a combined heat and power (CHP) system (IEA 2008). In Washington State, combined heat and power systems are prevalent in the refinery, pulp and paper, and wood products industries.

## Key Issues in Benchmarking Heat

Three factors influence GHG emissions from combustion processes that generate steam or other forms of heat: the choice of fuels, the efficiency of the heat production, and the efficiency of heat end use (Ecofys, Fraunhofer Institute, and Öko Institut 2009a). A benchmark on heat production would easily account for the first two factors, but the third would be harder to include. As a result, one issue in benchmarking heat (at least relative to alternative approaches, such as benchmarking end products) is that a heat benchmark would not account for the efficiency of the *use* of that heat in producing a final product such as paper, a food product, or chemicals, or heating buildings. To address this limitation for processes not otherwise covered by product-specific benchmarks, the EU has considered whether an adjustment factor may be applied to the heat benchmark to account for

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<sup>84</sup> Unless the steam is the product of a specialized area heating/cooling facility that provides steam to heat office buildings in the area around the plant. The Seattle Steam plant in downtown Seattle is an example of such a facility.

potential end-use efficiency improvements (Ecofys, Fraunhofer Institute, and Öko Institut 2009a). In other words, for sectors with large end-use efficiency opportunities, the benchmark value could be adjusted to help encourage pursuit of the end-use efficiency opportunities.

The biggest issue with benchmarking heat, however, may be whether to differentiate a benchmark by sector. Different industrial sectors may use different boiler technologies (with varying efficiencies) or (as described above) rely historically on different fuels, factors which may suggest the use of differentiated benchmarks by sector or by fuel and boiler design, at least in a voluntary or regulatory approach. The U.S. Department of State, for example, has written “the efficiencies of industrial boiler applications in the U.S. are dictated by operational and emission requirements making no single emissions performance value applicable for the variety of industrial boilers in use in the U.S.” (US Department of State 2010). Under a cap-and-trade program, developing different heat benchmarks for each sector may be less appropriate as the goal is to encourage long-term technology and fuel transitions and facilities can purchase or sell allowances depending on whether they are emitting above or below the respective benchmarks.

In some sectors (especially the pulp and paper sector), biomass (e.g., wood) and waste (e.g., pulping liquor) fuels are common in boilers. To avoid distorting the price signal to reduce GHG emissions, emissions from these fuels should use the same accounting framework or rules in benchmark development and application as will be used to govern the overall GHG management program. For example, if biomass is considered to have zero net emissions in the overall GHG management program, then to avoid distorting the price signal, biomass would also need to be considered a zero emission resource in benchmark development and application.

### Treatment of Cross-boundary Heat Flows

A particular challenge arises when a facility subject to a heat benchmark exports heat to a heat-consuming facility that is subject to a product benchmark. For example, consider a paper mill that has outsourced its heat supply to a boiler at a nearby chemical plant. Assume for the sake of discussion, that the chemical plant is benchmarked on the basis of heat production (per above), and the paper mill on the basis of tons of paper product produced.

If the benchmark on the heat-consuming facility (paper mill) were to include the indirect emissions associated with heat production (by the chemical plant), then both facilities would have an incentive to reduce overall emissions and the emissions intensity of purchased heat production. Under a regulatory or voluntary approach, benchmarking emissions both for the heat producer and heat consumer would generally not present a problem – both would face an incentive to reduce the emissions associated with heat production and use.

However, under a cap-and-trade program with output-based rebates, considerations are more complex. The paper mill could claim an allocation for the paper produced and the chemical plant could claim an allocation for the heat produced. This could result in a double allocation for the same emitting activity (heat produced to manufacture), providing an inappropriate incentive to outsource heat production to facilities with heat benchmarks. To avoid this perverse outcome, heat benchmarks should be applied only to the heat used within the facility.

## 5. Findings and Potential Next Steps

Executive Order 09-05 directs the Department of Ecology both to “develop emission benchmarks” and to deliver “recommendations on industry benchmarks, and the appropriate use of these benchmarks in achieving the state emission reduction targets” to the Governor by July 1, 2011.

Ecology has divided benchmarking work under the Executive Order into two phases. This report presents findings of the first, exploratory Phase I on key issues and options in benchmark development. Phase II could involve the development of benchmarks and will involve developing specific recommendations on their appropriate use. This section begins by reviewing our preliminary findings for Phase I, and then presents some possible paths forward under a Phase II.

Industries in Washington State and throughout the world use benchmarking to compare their performance to others. Such comparisons have helped to identify the range of current practices across a given region, including industry averages and best practices. Use of benchmarks to improve energy efficiency is well established, while benchmarking to reduce GHG emissions is increasingly explored and in some instances, practiced. Internationally, the cement and aluminum industries, for example, have made significant in-roads in developing GHG benchmarks and using these to set GHG performance targets.

As discussed in this paper, benchmarking is incorporated in most of the key efforts to address industrial GHGs: cap-and-trade programs, voluntary initiatives and agreements, and regulatory performance standards. From a climate policy perspective, industrial benchmarking is most advanced in the EU, where benchmarks have been used for voluntary agreements between national governments and industrial sectors or individual companies, and where detailed benchmark development is well underway for allowance distribution under the third phase of the EU's Emission Trading System. However, as described in Section 2, GHG benchmarking is gaining ground in the U.S. as well. Benchmarking provides a tool for developing GHG performance standards under the Clean Air Act, and the possible basis for distributing allowances under a cap-and-trade system.

It is important to note that developing meaningful benchmarks will require collecting and comparing performance data across a significant proportion of product markets. The development of GHG benchmarks is thus most relevant at a regional, national, or international level, even as such benchmarks may be applied at more local (e.g., state) levels. This has implications for Ecology's work in Phase II.

The construction of benchmarking presents a number of challenges, such as:

- The appropriate level of disaggregation by technology, feedstock, fuel or other facility-specific factors; The ability to differentiate by specific product type;
- Whether and how to include indirect emissions from purchased electricity and heat;
- How to address cogeneration (combined production of heat and power);
- Whether to develop and use a more generic heat production benchmark;
- What data sources to use, including how many facilities are needed to yield a meaningful data set for benchmarking; and
- The level of ambition to which the benchmark should be constructed to inform/motivate industry actors.

As described in Section 3, the policy context – cap-and-trade allowance distribution, regulatory performance standards, or voluntary targets – will influence how each of the challenges is resolved. Executive Order 09-05 calls for Ecology specifically to “develop emission benchmarks, by industry sector, for facilities the Department of Ecology believes will be covered by a federal or regional cap-and-trade program” and to “support the use of these emission benchmarks... as an appropriate basis for the distribution of emission allowances.” At the same time, the Executive Order is also clear that benchmarks “shall be developed to allow their application as state-based emissions standards, should they be needed to complement the federal program, or in the absence of a federal program.” Regardless of the ultimate policy approach – cap-and-trade or regulatory performance standards – there is some common work to collect and analyze sectoral benchmarking data.

Indeed, benchmarking is a highly data-intensive exercise, and comprehensive and consistent facility-level greenhouse gas emissions data are only just now beginning to emerge, especially here in the U.S., through mandatory reporting rules and industry-led efforts. Benchmarking data can also be sensitive or difficult to procure, since the production data used to index performance are often considered confidential business or production information. As we note in Section 3, however, a number of sources can be utilized to analyze and gauge emissions, production, and other data needed to develop benchmarks. The timing of policies that will depend on benchmarks will determine the data sources that can be relied upon for benchmark construction, which in turn will influence how the benchmarks can be designed. If benchmarks are needed by July 1, 2011, for example, then they will be able to rely upon, at most, one year of U.S.-wide mandatory reporting data.

In keeping with the Executive Order, and as reflected in this paper, Ecology is currently proceeding with an approach to benchmarking that leaves open how benchmarks might ultimately be used: for allowance distribution in a cap-and-trade system or for emissions performance standards. Such an approach enables Washington State agencies and industries to be prepared for, and be involved in shaping, a climate policy landscape that is currently highly uncertain. This approach allows Ecology to proceed with certain elements of benchmark development, such as data collection and analysis, that do not depend on policy context. However, as we illustrate in this paper, other elements of benchmark development, such as levels of ambition and disaggregation, are likely to depend upon whether benchmarks are used for allowance rebates, performance standards, or other applications.

As a path forward, Ecology could continue to cover all the bases with a comprehensive effort that would involve developing benchmarking data and methodologies, and constructing proposed benchmarks, that are appropriate for each policy context. This path forward would require significant resources and would depend on finding ways to overcome possible data limitations, especially if all potentially relevant sectors are covered. Pursuing such an approach would maintain maximum flexibility and could include the greatest possible share of industrial GHG emitters in the state, but could forego the opportunity to use limited resources to develop a path forward tailored to policy approaches or industry sectors for which benefits are likely to be the greatest.

Alternatively, Ecology could choose more focused paths, for instance, by doing one or more of the following:

- Concentrate on one benchmark context alone, such as output-based allowance distribution. Doing so would allow Ecology to contribute to more detailed methodology development (with potential broader influence) yet would require the implementation of a national or regional cap-and-trade program to actually implement the use of benchmarks in this manner.
- Select one or more sectors for initial benchmark development. As a first step, Ecology could establish and use criteria upon which such a selection could be made. Section 4 of this report discussed particular industry sectors and how they might be evaluated under some potential criteria, such as energy-intensiveness or trade exposure, level of emissions in Washington State, data availability, and experience with benchmarking.
- Dive more deeply into a) resolving specific benchmarking questions, such as the feasible and desirable levels of product differentiation (e.g., writing paper, newspaper, or all paper within the pulp and paper sector) or technology or other differentiation in benchmarks for selected sectors, or b) collecting and analyzing performance data, rather than developing actual benchmark values.

More specifically, Ecology could identify particular combinations of policy context, sectors, and unresolved benchmarking issues where the agency believes it could yield significant emissions and/or economic benefit for Washington industry. For example, to support a national cap-and-trade program, Ecology could choose to emphasize benchmark development in sectors where Washington industry is significantly less GHG-intensive than the national average. Helping to develop benchmarks in such sectors would help to demonstrate feasibility of the benchmarking approach, and thereby enhance the prospects of a mechanism (output-based rebates) that stands to reward Washington industries for taking early action. Alternatively, if regulatory performance standards (whether federal or state-based) are perceived as a more feasible or likely near-term policy approach, then Ecology may instead choose to develop methodologies for benchmark development in those sectors that represent the greatest opportunity for cost-effective emission reductions in Washington state, since the level of the benchmark will directly drive emission reductions in a given sector (by determining the allowable level of plant emissions). In contrast, in a cap-and-trade context where benchmarks are used to address leakage and competitiveness concerns, they drive allowance allocation rather than emissions reductions (which is accomplished by the overall emissions cap).

The table below explores possible combinations of policy context, sectors, and unresolved benchmarking issues: one for each of the three policy contexts discussed in this paper, plus some additional possible paths forward that could apply across policy contexts. These approaches are not intended to be exhaustive nor mutually exclusive and are displayed here only as examples of possible paths Ecology could take.

**Table 18. Possible Paths Forward for Benchmark Development in Washington State**

Policy Context	Key Criteria for Selecting Sectors	Key Unresolved Benchmark Issues	Possible Path Forward
Cap-and-trade	<ul style="list-style-type: none"> <li>▪ <i>Energy-intensive and trade-exposed (EITE)</i>, since the primary purpose of output-based rebates is to protect against leakage</li> <li>▪ <i>GHG performance of Washington facilities exceeds national average</i>, since the Washington facilities would therefore be rewarded relative to other facilities</li> </ul>	<ul style="list-style-type: none"> <li>▪ <i>Benchmark disaggregation</i>, since general agreement that six-digit NAICS codes can in some cases be too broad</li> <li>▪ <i>Benchmark ambition needed to address leakage in a cap-and-trade context</i>, since debates continue on average vs. better-than-average benchmarks</li> </ul>	<ul style="list-style-type: none"> <li>▪ Pursue means of disaggregating federal benchmarks beyond six-digit NAICS codes based on pilots for particular EITE sectors thought to be significantly more efficient in Washington State than the national average (e.g., flat glass, hydrogen production)</li> </ul>
Regulatory Performance Standards	<ul style="list-style-type: none"> <li>▪ <i>Sectors with significant reductions possible at relatively low marginal cost</i>, since the benchmark level will determine the level of abatement in Washington</li> <li>▪ <i>Sectors where existing regulatory authority exists</i>, to facilitate benchmark application</li> </ul>	<ul style="list-style-type: none"> <li>▪ <i>Data sources and process for benchmark development under regulatory performance standards</i>, given that no GHG performance standards for industrial facilities yet exist</li> </ul>	<ul style="list-style-type: none"> <li>▪ Develop performance standards for a sector or intermediate product (e.g., heat) responsible for a large fraction of Washington’s industrial greenhouse gas emissions and where significant modernization is possible (e.g., pulp and paper)</li> </ul>
Voluntary Program	<ul style="list-style-type: none"> <li>▪ <i>Sectors with significant reductions possible at relatively low marginal cost</i>, since the benchmark level will determine the level of abatement in Washington</li> <li>▪ <i>Sectors with are readily available data and a demonstrated history of responsiveness to voluntary initiatives</i></li> </ul>	<ul style="list-style-type: none"> <li>▪ <i>How to develop ambitious voluntary goals that go beyond “business-as-usual” improvement in a sector</i>, perhaps coupled with some form of financial assistance</li> </ul>	<ul style="list-style-type: none"> <li>▪ Work with aluminum, cement, or food processing sectors to develop a state-specific, voluntary approach that builds on (and goes further than) existing broader voluntary initiatives already underway, e.g., the Cement Sustainability Initiative, International Aluminum Institute anode effects goals, and/or Northwest Food Processors Association partnership with U.S. Department of Energy</li> </ul>
All Policy Contexts		<ul style="list-style-type: none"> <li>▪ <i>How to finance large capital investments</i> that may be needed to meet a regulatory or voluntary benchmark (or exceed an output-based allocation under cap-and-trade)</li> <li>▪ <i>Methodologies to appropriately address key outstanding issues</i>, such as maintaining appropriate incentives for CHP, resolving the choice between cement and clinker benchmarking, and addressing cases where product benchmarking is particularly challenging</li> </ul>	<ul style="list-style-type: none"> <li>▪ Investigate potential financing mechanisms for major process improvements that can yield significant reductions in emissions intensity</li> <li>▪ Further examine alternatives to product-based benchmark, such as process-based (or heat production, e.g., boiler standards) benchmarks, for sectors where several products are made from a common process</li> </ul>

The direction and extent of Phase II work will depend on a number of factors, from available resources at Ecology to policy developments occurring beyond the state's borders. With federal climate policy in considerable flux, and regional efforts (i.e., WCI) still under development, Ecology could take an incremental approach, undertaking one or more of the paths forward noted above during the second half of 2010, and then re-evaluating whether and how to proceed with benchmark development and/or other paths in the first half of 2011.

Other steps that Ecology may consider, regardless of the path taken as outlined above, would be to:

- Partner with other interested jurisdictions in the WCI, Midwest Greenhouse Gas Reduction Accord (MGGRA), or Regional Greenhouse Gas Initiative (RGGI) on benchmark data collection;
- Establish a collaborative agreement with EPA and/or industry associations and facilities to gain better access to data and to pilot specific benchmarking methods; and/or
- Convene expert groups to review and evaluate benchmark methodologies for their relevancy to the Washington state context and the Governor's Executive Order.

Ecology's work under Governor Gregoire's Executive Order 09-05 brings the opportunity to significantly advance a transition to a low-carbon economy in Washington's industrial sector. Several choices on policy context, benchmarking methodology, and sectors remain before benchmarks can be delivered to the Governor by July 1, 2011. Our hope is that this paper helps lay groundwork for the Department of Ecology and other interested stakeholders to develop partnerships, policy approaches, and initiatives to address industrial greenhouse gas emissions in Washington State and beyond.

## 6. References Cited

- Aldy, Joseph E, and William A Pizer. 2009. *The Competitiveness Impacts of Climate Change Mitigation Policies*. Resources for the Future, May.
- Alsalam, Jason. 2009. *A Pragmatic Approach to Regulating Greenhouse Gases Under the Clean Air Act*. Washington, D.C.: Center for Clean Air Policy.  
[http://www.ccap.org/docs/resources/614/Clean%20Air%20Act%20and%20GHGs\\_CCAP\\_March%202009.pdf](http://www.ccap.org/docs/resources/614/Clean%20Air%20Act%20and%20GHGs_CCAP_March%202009.pdf).
- Aluminum Association. 2009. Facts at a Glance - 2008. September.  
<http://www.aluminum.org/Content/NavigationMenu/NewsStatistics/StatisticsReports/FactsAtAGlance/factsataglance.pdf>.
- Bradbury, James. 2009. Carbon Leakage Provisions in U.S. Climate Policy. Western Climate Initiative Webinar: Addressing Leakage and Competitiveness Issues.
- Bravender, Robin. 2009. EPA notice sets stage for regulation writing, lawsuit. *Greenwire*, December 15.  
<http://www.eenews.net/public/Greenwire/2009/12/15/3>.
- Calpine. 2010. GHG BACT Analysis Case Study: Russell City Energy Center. February 3.
- Center for Climate Strategies. 2007. *Washington State Greenhouse Gas Inventory and Reference Case Projections, 1990-2020*. Washington State Department of Ecology and State of Washington Department of Community, Trade, and Economic Development, December.
- Clean Air Act Advisory Committee. 2010. Interim Phase I Report of the Climate Change Work Group of the Permits, New Source Review and Toxics Subcommittee, Clean Air Act Advisory Committee. February 3.
- CSI. 2009. Cement Industry Energy and CO2 Performance “Getting the Numbers Right”. Cement Sustainability Initiative.
- Davis, Molly. 2010. Industry Pushes for Key Confidentiality Provisions in EPA GHG Registry. *Carbon Control News*, March 22.
- Dröge, Susanne, Harro van Asselt, Thomas Brewer, Michael Grubb, Roland Ismer, Yasuko Kameyama, Michael Mehling, et al. 2009. Tackling Leakage in a World of Unequal Carbon Prices. Climate Strategies.
- Dutch Benchmarking Committee. 1999. Energy efficiency benchmarking covenant. <http://www.benchmarking-energie.nl/index.php3>.
- Dutrow, Elizabeth, Gale Boyd, Ernst Worrell, and Leo Dodendorf. 2010. Shifting Energy Performance in U.S. Cement Production. In .
- EAAC. 2010. *Allocating Emissions Allowances Under California’s Cap-and-Trade Program: Recommendations to the California Air Resources Board From the Economic and Allocation Advisory Committee*. Economic and Allocation Advisory Committee, March.
- Ecofys, Fraunhofer Institute, and Öko Institut. 2009a. *Report on the project approach and general issues. Methodology for the free allocation of emission allowances in the EU ETS post 2012*. By Order of the European Commission, Contract: 07.0307/2008/515770/ETU/C2.

- . 2009b. *Sector report for the aluminum industry*. Methodology for the free allocation of emission allowances in the EU ETS post 2012. By Order of the European Commission, Contract: 07.0307/2008/515770/ETU/C2.
- . 2009c. *Sector report for the cement industry*. Methodology for the free allocation of emission allowances in the EU ETS post 2012. By Order of the European Commission, Contract: 07.0307/2008/515770/ETU/C2.
- . 2009d. *Sector report for the chemicals industry*. Methodology for the free allocation of emission allowances in the EU ETS post 2012. By Order of the European Commission, Contract: 07.0307/2008/515770/ETU/C2.
- . 2009e. *Sector report for the glass industry*. Methodology for the free allocation of emission allowances in the EU ETS post 2012. By Order of the European Commission, Contract: 07.0307/2008/515770/ETU/C2.
- . 2009f. *Sector report for the pulp and paper industry*. Methodology for the free allocation of emission allowances in the EU ETS post 2012. By Order of the European Commission, Contract: 07.0307/2008/515770/ETU/C2.
- . 2009g. *Sector report for the iron and steel industry*. Methodology for the free allocation of emission allowances in the EU ETS post 2012. By Order of the European Commission, Contract: 07.0307/2008/515770/ETU/C2.
- Energy and Environmental Analysis, Inc. 2005. *Characterization of the U.S. Industrial Commercial Boiler Population*. Oak Ridge National Laboratory, May.
- EPA, EIA, and Treasury. 2009. *The Effects of H.R. 2454 on International Competitiveness and Emission Leakage in Energy-Intensive Trade-Exposed Industries: An Interagency Report Responding to a Request from Senators Bayh, Specter, Stabenow, McCaskill, and Brown*. Washington, D.C.
- European Commission. 2003. *Reference Document on Best Available Techniques in the Large Volume Organic Chemical Industry*. Institute for Prospective Technological Studies, Joint Research Centre of the European Commission, February.
- . 2009. *Draft Reference Document on Best Available Techniques in the Glass Manufacturing Industry*. Institute for Prospective Technological Studies, Joint Research Centre of the European Commission, July.
- . 2010a. Non Paper: Evaluation of Requests for Product Benchmarks – Emissions Trading System – Post 2012. February.
- . 2010b. Commission Staff Working Document Accompanying the Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions - Analysis of options to move beyond 20% greenhouse gas emission reductions and assessing the risk of carbon leakage {SEC(2010) 650}. *Official Journal of the European Union*. Background Information and Analysis (May 26).
- European Union. 2008. *Directive 2003/87/EC (Revised 17 December 2008)*.
- Fischer, Carolyn. 2003. Output-based allocation of environmental policy revenues and imperfect competition. *Resources for the Future Discussion Paper 2*: 60.
- Fischer, Carolyn, and Alan K. Fox. 2007. Output-Based Allocation of Emissions Permits for Mitigating Tax and Trade Interactions. *Land Economics* 83, no. 4 (January 1): 575-599. doi:10.3368/le.83.4.575.
- . 2009. *Comparing policies to combat emissions leakage: border tax adjustments versus rebates*. Washington, D.C.: Resources for the Future.

- Flemish Benchmarking Commission. 2010. Energy Benchmarking Covenant. <http://www.benchmarking.be/en/default.asp>.
- German Federal Ministry of the Environment. 2006. Germany tightens up its national climate protection programme. [http://www.bmu.de/english/press\\_releases/archive/16th\\_legislative\\_period/pm/38299.php](http://www.bmu.de/english/press_releases/archive/16th_legislative_period/pm/38299.php).
- Holcim. 2010. Combined Cement and Clinker Benchmarking: Clinker Benchmark Taking Account of Clinker Substitution: Holcim Compromise Proposal. March.
- IEA. 2008. *Tracking Industrial Energy Efficiency and CO2 Emissions*. Paris: International Energy Agency.
- . 2009a. *Energy technology transitions for industry: Strategies for the Next Industrial Revolution*. Paris: International Energy Agency.
- . 2009b. *Energy technology transitions for industry: Strategies for the Next Industrial Revolution*. Paris: International Energy Agency.
- International Aluminum Institute. 2009. *Results of the 2008 Anode Effect Survey*. August 24.
- LBL, and Resource Dynamics. 2004. *Improving Steam System Performance: A Sourcebook for Industry*. Industrial Technologies Program. Lawrence Berkeley National Laboratory and Resource Dynamics Corporation for the U.S. Department of Energy.
- Lyon, TP. 2003. *Voluntary versus mandatory approaches to climate change mitigation*. Resources for the Future.
- Masanet, Eric, Ernst Worrell, W Graus, and C Galitsky. 2008. *Energy Efficiency Improvement and Cost Saving Opportunities for the Fruit and Vegetable Processing Industry. An ENERGY STAR Guide for Energy and Plant Managers*. Lawrence Berkeley National Laboratory.
- Matthes, Felix Chr., Julia Repenning, Ernst Worrell, Dian Phylipsen, and Nicolas Müller. 2008. *Pilot on Benchmarking in the EU ETS*. Öko-Institut and Ecofys.
- Metz, B, OR Davidson, PR Bosch, R Dave, and LA Meyer. 2007. Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. *Cambridge University Press, Cambridge, UK and New York, NY. Retrieved June 26: 2007*.
- Morgenstern, Richard, and William A Pizer. 2007. *Reality check: the nature and performance of voluntary environmental programs in the United States, Europe, and Japan*. Resources for the Future.
- Neelis, Maarten, and Martin Patel. 2006. Long-term production, energy use and CO2 emission scenarios for the worldwide iron and steel industry.
- Neelis, Maarten, Ernst Worrell, Nicolas Mueller, and Tana Angelini. 2009. *Developing Benchmarking Criteria for CO2 Emissions*. EcoFys Netherlands and the Fraunhofer Institute for Systems and Innovation Research.
- Nordhaus, RR. 2007. New Wine Into Old Bottles: The Feasibility of Greenhouse Gas Regulation Under the Clean Air Act. *NYU Env'tl. LJ* 15: 53.
- Parker, Larry, and Jeanne J. Grimmett. 2010. Climate Change: EU and Proposed U.S. Approaches to Carbon Leakage and WTO Implications. Congressional Research Service, April 10.
- Parker, Larry, and James E. McCarthy. 2009. Climate Change: Potential Regulation of Stationary Greenhouse Gas Sources Under the Clean Air Act. Congressional Research Service, May 14.
- Pew Center on Global Climate Change. 2010. Sequence of Events Leading to Regulation of Greenhouse Gases through EPA. <http://www.pewclimate.org/docUploads/epa-action-narrative.pdf>.

- Portland Cement Association. 2009. presented at the WCI Cement Collaborative, May 28.
- Puget Sound Clean Air Agency. 2008. 2005 Air Emission Inventory for King, Kitsap, Pierce, and Snohomish Counties. March. [http://www.pscleanair.org/news/library/reports/Air\\_Emission\\_Inventory\\_2005.pdf](http://www.pscleanair.org/news/library/reports/Air_Emission_Inventory_2005.pdf).
- Raymond, LS. 2003. *Private rights in public resources: equity and property allocation in market-based environmental policy*. Resources for the Future.
- Richardson, Nathan, Art Fraas, and Dallas Burtraw. 2010. *Greenhouse Gas Regulation under the Clean Air Act: Structure, Effects, and Implications of a Knowable Pathway*. Discussion Paper. Resources for the Future, April.
- Schneck, Joshua, Brian C. Murray, Jan Mazurek, and Gale Boyd. 2009. *Protecting Energy-Intensive Trade-Exposed Industry: Nicholas Institute Discussion Memo on H.R. 2454 American Clean Energy and Security Act of 2009*. Nicholas Institute for Environmental Policy Solutions at Duke University.
- Stavins, Robert N. 2007. *A US Cap-and-Trade System to Address Global Climate Change*. Hamilton Project Discussion Paper. The Brookings Institution, October.
- Tonkonogy, Bella. 2009. Preliminary Analysis of Carbon Leakage Provisions in H.R. 2454. CCAP Dialogue.
- US Department of State. 2010. Submission by the United States of America to UNFCCC Concerning Standardized Baselines in the CDM. March 22.
- US EPA. 2008a. *2008 Sector Performance Report*. Sector Strategies Program.
- . 2008b. Technical Support Document for the Advanced Notice of Proposed Rulemaking for Greenhouse Gases; Stationary Sources, Section VII. June 5.
- . 2008c. Standards of Performance for Portland Cement Plants; Proposed Rule. *Federal Register* 73, no. 116 (June 16). <http://www.epa.gov/ttn/atw/nsps/pcemnsps/fr16jn08.pdf>.
- . 2008d. Regulating Greenhouse Gas Emissions Under the Clean Air Act: Advanced Notice of Proposed Rulemaking. *Federal Register* 73, no. 147 (July 30). <http://www.epa.gov/fedrgstr/EPA-AIR/2008/July/Day-30/>.
- . 2008e. Climate Leaders Greenhouse Gas Inventory Protocol Offset Project Methodology for Project Type: Industrial Boiler Efficiency: Version 1.3. August.
- . 2009a. Mandatory Reporting of Greenhouse Gases. *Federal Register* 74, no. 209 (October 30).
- . 2009b. Endangerment and Cause or Contribute Findings for Greenhouse Gases Under Section 202(a) of the Clean Air Act. *Federal Register* 74, no. 239 (December 15).
- . 2010a. Food Processing Plants Increase Energy Efficiency, Earn EPA's Energy Star. January 19. <http://www.epa.gov/newsroom/newsreleases.htm>.
- . 2010b. Reconsideration of Interpretation of Regulations That Dermine Pollutants Covered by Clean Air Act Permitting Programs; Final Rule. *Federal Register* 75, no. 63 (April 2). <http://edocket.access.gpo.gov/2010/2010-7536.htm>.
- . 2010c. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008*. U.S. Environmental Protection Agency, April 15.
- . 2010d. Prevention of Significant Deterioration and Title V Greenhouse Gas Tailoring Rule. May 13. <http://www.epa.gov/nsr/documents/20100413final.pdf>.

- US EPA, and US DOT. 2010. Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards; Final Rule. <http://www.epa.gov/otaq/climate/regulations/ldv-ghg-final-rule.pdf>.
- US EPA, US EIA, and US Treasury. 2009. *The Effects of H.R. 2454 on International Competitiveness and Emission Leakage in Energy-Intensive Trade-Exposed Industries: An Interagency Report Responding to a Request from Senators Bayh, Specter, Stabenow, McCaskill, and Brown*. Washington, D.C., December 3.
- USGS. 2009. *2008 Minerals Yearbook*. <http://minerals.usgs.gov/minerals/pubs/myb.html>.
- Washington Dept. of Ecology. 2009. *Significant Sources of Greenhouse Gas Emissions in WA*. Olympia, WA. [http://www.ecy.wa.gov/climatechange/docs/20090520\\_GHGsources.pdf](http://www.ecy.wa.gov/climatechange/docs/20090520_GHGsources.pdf).
- Waxman, Henry, and Edward Markey. 2009. *American Clean Energy and Security Act of 2009*. June 26.
- WBCSD, and WRI. 2004. *The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard*. World Business Council for Sustainable Development and the World Resources Institute.
- Worrell, Ernst, and Christina Galitsky. 2008. *Energy Efficiency Improvement and Cost Saving Opportunities for Cement Making: An ENERGY STAR Guide for Energy and Plant Managers*. Ernest Orlando Lawrence Berkeley National Laboratory, March.
- Worrell, Ernst, Christina Galitsky, Eric Masanet, and W Graus. 2008. *Energy Efficiency Improvement and Cost Saving Opportunities for Glass Making: An ENERGY STAR Guide for Energy and Plant Managers*. Ernest Orlando Lawrence Berkeley National Laboratory, March.
- Worrell, Ernst, Dian Phylipsen, Dan Einstein, and Nathan Martin. 2000. *Energy Use and Energy Intensity of the U.S. Chemical Industry*. Ernest Orlando Lawrence Berkeley National Laboratory, April.
- Worrell, Ernst, Lynn Price, Maarten Neelis, Christina Galitsky, and Zhou Nan. 2008. *World Best Practice Energy Intensity Values for Selected Industrial Sectors*. Ernest Orlando Lawrence Berkeley National Laboratory, February.
- Zabin, Carol, Andrea Buffa, and Lynn School. 2009. *The Impact of Climate Change Policies on Carbon-Intensive Manufacturing Industries in Oregon*. UC Berkeley Labor Center, November.

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## Appendix A. Expected GHG Reporting Data

In Section 3 of this White Paper, we assess possible sources for emissions and production data that could enable construction of benchmark curves. One of the most promising – but as yet unavailable – sources of data will be mandatory greenhouse gas reporting rules. This appendix describes the data that will be submitted under the federal and Washington State reporting rules as well as other sector-specific data sources (e.g., the Cement Sustainability Initiative).

US EPA’s Mandatory Reporting of Greenhouse Gases rule will require facilities to report greenhouse gas emissions for year 2010 by March 31, 2011 (US EPA 2009b). All facilities in the primary aluminum and cement sectors will need to report emissions, as will facilities in several other sectors (e.g., chemical industry sectors adipic acid, ammonia, HCFC-22, nitric acid, phosphoric acid, and others). In most other sectors, all facilities that emit more than 25,000 ton CO<sub>2</sub>e annually will be required to report. Emissions data will be public. Reporting of production data is also required. EPA (and, potentially, the courts) are expected to determine in 2011 whether production data will be considered “confidential business information” and therefore not available to the public (Davis 2010). Regardless, submitted production data could be used by agency staff.

The State of Washington’s Mandatory Greenhouse Gas Reporting Rule will require facilities that emit at least 10,000 tons of GHGs to start reporting in 2013 for year 2012 emissions. The reporting methodology for the Washington State rule will be harmonized with the federal rule.

Following is a discussion of reporting rule specifics for each sector that we addressed in Section 4 of the main body of this White Paper.

### Aluminum

Reporting requirements for the aluminum sector are summarized in Table 19. Most of the emission sources below apply only to primary aluminum. For secondary aluminum, the major sources of direct emissions are fossil fuel combustion for the furnace (if applicable) and equipment.

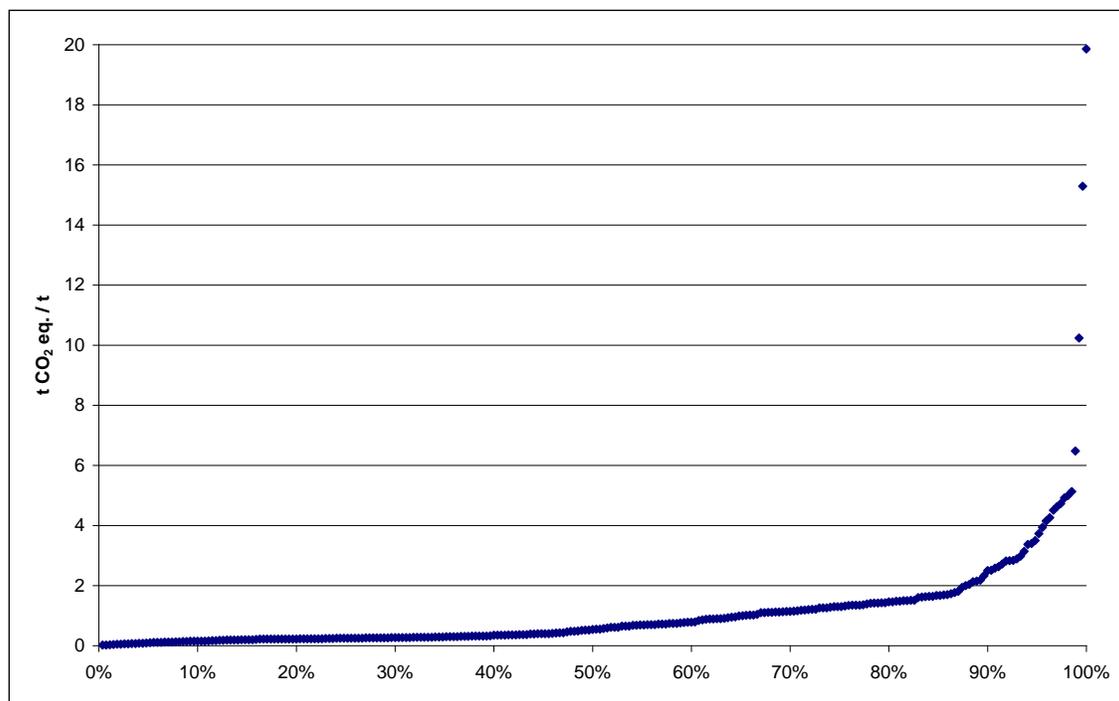
**Table 19. Summary of Required Federal GHG Reporting for the Aluminum Sector (US EPA 2009a)**

<b>Sources Addressed</b>	<ul style="list-style-type: none"> <li>▪ Aluminum smelting via electrolysis using either prebake or Söderberg anodes</li> <li>▪ Baking of anodes for pre-bake anodes</li> <li>▪ Stationary combustion of fossil fuel</li> </ul>
<b>GHGs Required to be Reported</b>	<ul style="list-style-type: none"> <li>▪ PFC – Perfluoromethane (CF<sub>4</sub>) and perfluoroethane (C<sub>2</sub>F<sub>6</sub>) – emissions from anode effects</li> <li>▪ Carbon dioxide (CO<sub>2</sub>) emissions from anode consumption during electrolysis in all prebake and Söderberg cells.</li> <li>▪ All CO<sub>2</sub> emissions from onsite anode baking</li> <li>▪ CO<sub>2</sub>, nitrous oxide (N<sub>2</sub>O), and methane (CH<sub>4</sub>) emissions from each stationary combustion unit</li> </ul>
<b>Methodology Highlights</b>	<ul style="list-style-type: none"> <li>▪ Perfluorocarbon emissions (CF<sub>4</sub>) and perfluoroethane (C<sub>2</sub>F<sub>6</sub>) emissions calculated based on frequency and duration of anode effects, monthly aluminum production, and a pre-determined coefficient that estimates emissions from these parameters</li> <li>▪ Process CO<sub>2</sub> emissions calculated based either on installing and operating a continuous emissions monitoring system (CEMS) or a mass-balance calculation</li> <li>▪ Process CO<sub>2</sub> emissions during anode baking of prebake cells estimated based on mass balance calculation</li> <li>▪ Carbon dioxide (CO<sub>2</sub>) emissions from each fuel combustion unit calculated using one of the four tiered methods outlined in the rule, as well as methane (CH<sub>4</sub>), and nitrous oxide (N<sub>2</sub>O).</li> </ul>
<b>Required Reporting</b>	<ul style="list-style-type: none"> <li>▪ Annual GHG emissions</li> <li>▪ Annual aluminum production in metric tons</li> <li>▪ Type of smelter technology used</li> <li>▪ Annual fuel use</li> <li>▪ Various parameters used to support calculations of process emissions</li> </ul>

## Other Data Sources in the Aluminum Industry

Internationally, the International Aluminum Institute (IAI) collects data on the specific emissions of PFC emissions from primary aluminum production. The IAI publishes plant specific data for most of the aluminium production plants worldwide (International Aluminum Institute 2009). Unfortunately, only very few installations from China reported their emissions. With the data of the reporting installations (representing approximately 60% of all installations worldwide) a benchmarking curve can be constructed and is depicted below as Figure 9.

**Figure 9. Benchmarking curve for PFC emissions from primary aluminum production**  
(X-axis is fraction of plants)



**Figure Source:** Calculations by Öko-Institut based on specific emissions reported by 270 primary aluminium smelters published by IAI 2009

In addition, the IAI's 2009 publication *Results of the 2008 Anode Effect Survey* includes additional detailed benchmarking data and curves that depict the performance of facilities with different anode technologies.

## Cement

For the cement sector, the rules will require reporting of GHG emissions and clinker and cement production, as summarized in Table 20.

**Table 20. Summary of Required Federal GHG Reporting for the Cement Sector (US EPA 2009b)**

<b>Sources Addressed</b>	<ul style="list-style-type: none"> <li>▪ Each kiln and each inline kiln / raw mill at any Portland cement manufacturing facility</li> <li>▪ Stationary combustion of fossil fuel</li> </ul>
<b>GHGs Required to be Reported</b>	<ul style="list-style-type: none"> <li>▪ CO<sub>2</sub> process emissions from calcinations at each kiln</li> <li>▪ CO<sub>2</sub>, methane (CH<sub>4</sub>), and nitrous oxide (N<sub>2</sub>O) emissions from combustion at each kiln or combustion unit other than kilns</li> </ul>
<b>Methodology Highlights</b>	<ul style="list-style-type: none"> <li>▪ For process CO<sub>2</sub> emissions, either operate and maintain a continuous emissions monitoring system (CEMS, as in Tier 4) or calculate process CO<sub>2</sub> emissions based on clinker production and kiln-specific emission factors</li> <li>▪ For fossil fuel combustion, calculate CO<sub>2</sub> emissions from each fuel combustion unit using one of the four tiered methods outlined in the rule and also report methane (CH<sub>4</sub>), and nitrous oxide (N<sub>2</sub>O) emissions</li> </ul>
<b>Required Reporting</b> <sup>85</sup>	<ul style="list-style-type: none"> <li>▪ Annual GHG emissions</li> <li>▪ Monthly clinker and cement production</li> <li>▪ Number of kilns and number of operating kilns</li> <li>▪ Annual fuel use</li> <li>▪ Additional, other data on cement kiln dust and raw material usage, as used to support calculations of process emissions if CEMS not used</li> </ul>

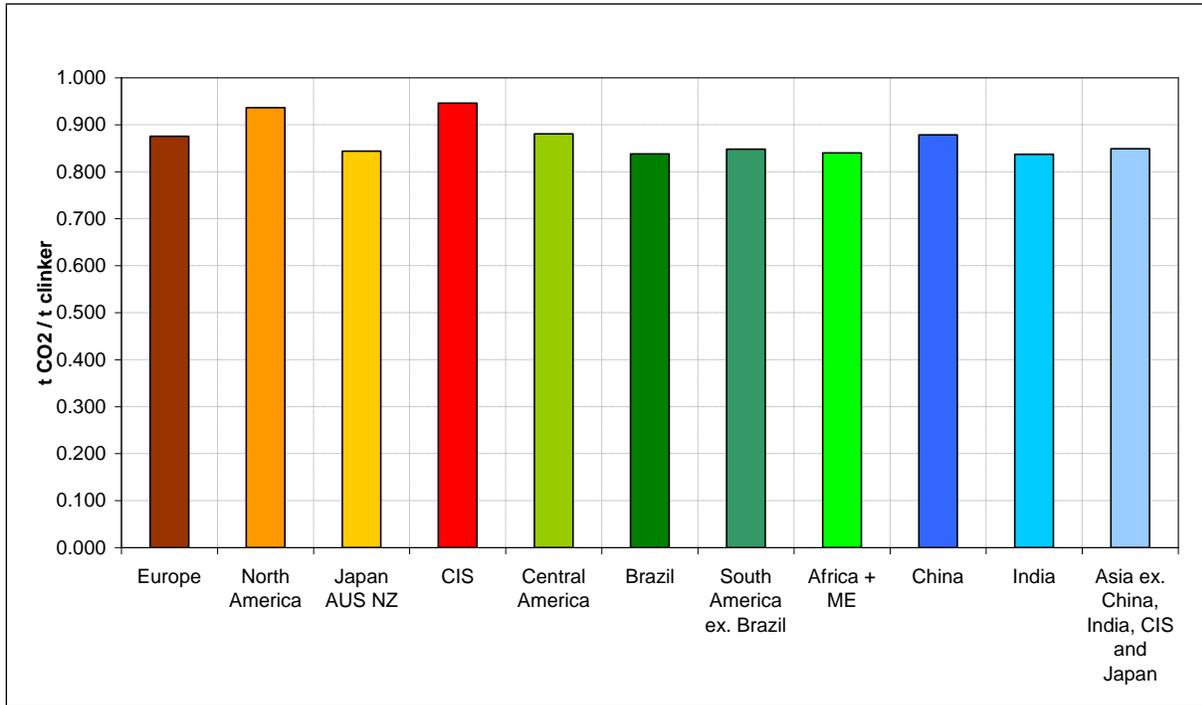
### Other Data Sources in the Cement Industry

The Cement Sustainability Initiative (CSI) collects GHG benchmarking data for the global cement industry. To provide an example of possible benchmark curve construction based on these data, we calculated emissions for cement clinker production based on direct emissions and production using data from the Cement Sustainability Initiative (CSI 2009). These data include statistics from (mainly) multinational companies that represent 40% of the world's cement production. Direct emissions are influenced by the following two components: CO<sub>2</sub> intensity of the fuel used and specific fuel consumption per ton of product. Data on clinker production was used to calculate specific emissions from direct emissions from clinker production and illustrates how the CO<sub>2</sub> emissions associated with the production of a ton of clinker varied amongst the different countries. Figure 10 displays these results based on Cement Sustainability Initiative data.

The fact that for China and India relatively low specific emissions are reported can be explained by the fact that only the rather new and efficient plants of multinational companies are reporting under CSI.

<sup>85</sup> Additional data are required to support the methodology chosen.

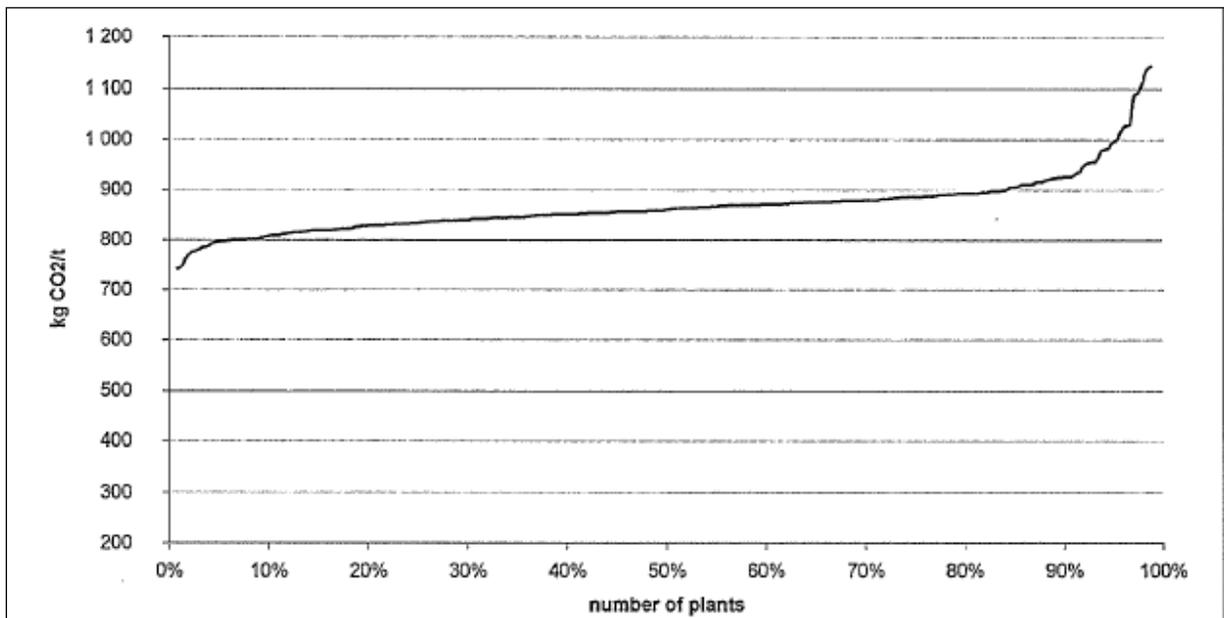
Figure 10. Average direct specific CO<sub>2</sub> emissions of clinker production in the year 2007 of those companies reporting under the CSI



Source: Öko-Institute based on CSI (2009).

In the EU, the preliminary benchmark for the third phase of the EU Emissions Trading System, derived from the average specific emissions of the 10 % most efficient installations, is about 0.78t CO<sub>2</sub> / ton of clinker (based on data in 2006, Figure 11). The final benchmark will be based on data for the years 2007 and 2008.

Figure 11. Benchmarking curve for cement clinker in the EU for the year 2006.



Source: Ecofys, Fraunhofer Institute, and Öko-Institut (2009c)

## Chemicals

The federal GHG reporting rule requires facilities in several chemical industry sectors to report emissions regardless of size. Other sectors (including hydrogen production) must only report if emissions exceed 25,000 tons CO<sub>2</sub>e annually. Since Solvay Chemicals produces hydrogen in Washington, Table 21, below, summarizes the reporting requirements for the hydrogen production sector. Emerald Kalama chemicals, which produces petrochemical food additives, would be required to report under the general requirements for facilities that emit at least 25,000 tons CO<sub>2</sub>e from boilers and possibly also due to the petrochemical requirements.

**Table 21. Summary of Required Federal GHG Reporting for the Hydrogen-production Sector (US EPA 2009b)**

<b>Sources Addressed</b>	<ul style="list-style-type: none"> <li>Process units that produce hydrogen by reforming, gasification, oxidation, reaction, or other transformation of feedstock</li> </ul>
<b>GHGs Required to be Reported</b>	<ul style="list-style-type: none"> <li>CO<sub>2</sub> process emissions from each hydrogen production process unit</li> <li>CO<sub>2</sub>, methane (CH<sub>4</sub>), and nitrous oxide (N<sub>2</sub>O) emissions from combustion at each hydrogen production process unit</li> <li>CO<sub>2</sub> either collected and used on-site or transferred off site</li> </ul>
<b>Methodology Highlights</b>	<ul style="list-style-type: none"> <li>For process CO<sub>2</sub> emissions, either operate and maintain a continuous emissions monitoring system (CEMS) or calculate process CO<sub>2</sub> emissions based on fuel and feedstock usage and fuel- and feedstock-specific emission factors</li> </ul>
<b>Required Reporting</b>	<ul style="list-style-type: none"> <li>Annual GHG emissions</li> <li>Fuel and feedstock consumption</li> <li>Annual quantity of hydrogen produced (metric tons)</li> <li>Annual quantity of ammonia produced, if applicable (metric tons)</li> <li>Additional data to support other calculations, as specified in the rule</li> </ul>

## Food Processors

Food processors are not in an industry sector specifically addressed in the federal greenhouse gas reporting rule (US EPA 2009b) nor in federal legislation passed out of the U.S. House of Representatives in June 2009 (the Waxman-Markey bill, H.R. 2454, but with the exception of malt manufacturing, wet corn milling, and rendering and meat byproduct processing, which were included in the benchmark-based allowance rebates to energy-intensive, trade-exposed industry sectors). Nevertheless, where facilities emit more than the minimum thresholds for reporting (25,000 tons CO<sub>2</sub>e in the federal reporting rule and 10,000 tons CO<sub>2</sub>e in the State reporting rule, SB 6373), then food processing facilities will need to report GHG emissions.

## Glass

For the glass sector, the federal rule will require reporting of GHG emissions from continuous glass melting furnaces, as summarized in Table 22.

**Table 22. Summary of Required Federal GHG Reporting for the Glass Sector (US EPA 2009b)**

<b>Sources Addressed</b>	<ul style="list-style-type: none"> <li>Continuous glass melting furnaces that manufacture flat, container, pressed or blown glass, or wool fiberglass</li> </ul>
<b>GHGs Required to be Reported</b>	<ul style="list-style-type: none"> <li>CO<sub>2</sub> process emissions from each continuous glass melting furnace</li> <li>CO<sub>2</sub>, methane (CH<sub>4</sub>), and nitrous oxide (N<sub>2</sub>O) emissions from combustion at continuous glass melting furnace or other fuel combustion units</li> </ul>
<b>Methodology Highlights</b>	<ul style="list-style-type: none"> <li>For process CO<sub>2</sub> emissions, either operate and maintain a continuous emissions monitoring system (CEMS) or calculate process CO<sub>2</sub> emissions based on usage of carbonate raw material (e.g., lime), mass fraction of carbonate in the raw material, and fraction of calcinations achieved</li> <li>Carbon dioxide (CO<sub>2</sub>) emissions from each fuel combustion unit calculated using one of the four tiered methods outlined in the rule, as well as methane (CH<sub>4</sub>), and nitrous oxide (N<sub>2</sub>O).</li> </ul>
<b>Required Reporting</b>	<ul style="list-style-type: none"> <li>Annual GHG emissions</li> <li>Fuel and feedstock consumption</li> <li>Annual quantity of each carbonate-based material used (tons)</li> <li>Annual quantity of glass produced (tons)</li> <li>Number of continuous glass melting furnaces</li> <li>Additional data to support other calculations, as specified in the rule</li> </ul>

## Pulp and Paper

For the pulp and paper sector, the federal rule will require reporting of GHG emissions from facilities that produce market pulp, manufacture pulp and paper (i.e., integrated mills), produce paper from purchased pulp, produce secondary fiber from recovered paper, convert paper into paperboard products, or operate coating and laminating processes (US EPA 2009b). Reporting requirements for pulp and paper facilities are summarized in Table 23.

**Table 23. Summary of Required Federal GHG Reporting for the Pulp and Paper Sector (US EPA 2009b)**

<b>Sources Addressed</b>	<ul style="list-style-type: none"> <li>▪ Chemical recovery furnaces at kraft and soda mills (including recovery furnaces that burn spent pulping liquor produced by both the kraft and co-located semichemical process).</li> <li>▪ Chemical recovery combustion units at sulfite mills.</li> <li>▪ Chemical recovery combustion units at stand-alone semichemical mills.</li> <li>▪ Systems for adding makeup chemicals</li> <li>▪ Lime kilns at kraft and soda pulp mills.</li> </ul>
<b>GHGs Required to be Reported</b>	<ul style="list-style-type: none"> <li>▪ CO<sub>2</sub>, biogenic CO<sub>2</sub>, methane (CH<sub>4</sub>), and nitrous oxide (N<sub>2</sub>O) emissions from each chemical recovery furnace at kraft and soda mills and from each chemical recovery combustion unit at sulfite or stand-alone semichemical mills</li> <li>▪ CO<sub>2</sub>, biogenic CO<sub>2</sub>, methane (CH<sub>4</sub>), and nitrous oxide (N<sub>2</sub>O) emissions from combustion of fossil fuels in each kraft or soda pulp mill lime kiln</li> <li>▪ CO<sub>2</sub> from stationary fuel combustion units calculated using one of the four tiered methods outlined in the rule, as well as methane (CH<sub>4</sub>), and nitrous oxide (N<sub>2</sub>O).</li> </ul>
<b>Methodology Highlights</b>	<ul style="list-style-type: none"> <li>▪ Methods generally involve measurement of fossil fuels, spent liquor fuels, and makeup chemicals and application of default or site-specific emission factors</li> </ul>
<b>Required Reporting</b>	<ul style="list-style-type: none"> <li>▪ Annual GHG emissions</li> <li>▪ Annual fuel consumption</li> <li>▪ Annual mass of spent liquor solids fired at the facility (short tons)</li> <li>▪ Annual steam purchases (pounds of steam per year)</li> <li>▪ Annual quantity of makeup chemicals (metric tons)</li> <li>▪ Annual production of pulp and/or paper products produced (metric tons)</li> </ul>

## Steel

For the iron and steel sector, the rule will require reporting of annual GHG emissions from both electric arc furnaces and basic oxygen furnaces (e.g., integrated mills), as summarized in Table 24. Note that to be consistent with the discussion above, this table addresses both integrated (BOF) and EAF steel. Only EAF steel is produced in Washington State.

**Table 24. Summary of Required Federal GHG Reporting for the Steel Sector (US EPA 2009b)**

<b>Sources Addressed</b>	<ul style="list-style-type: none"> <li>▪ Taconite iron ore processing</li> <li>▪ Integrated iron and steel manufacturing (production of steel from iron ore or iron ore pellets)</li> <li>▪ Coke making not co-located with an integrated iron and steel manufacturing process.</li> <li>▪ Electric arc furnace (EAF) steelmaking not co-located with an integrated iron and steel manufacturing process</li> </ul>
<b>GHGs Required to be Reported</b>	<ul style="list-style-type: none"> <li>▪ CO<sub>2</sub> process emissions from each taconite indurating furnace, basic oxygen furnace, nonrecovery coke oven battery combustion stack, coke pushing process; sinter process, EAF, argon-oxygen decarburization vessel, and direct reduction furnace.</li> <li>▪ For fossil fuel combustion, calculate CO<sub>2</sub> emissions from each fuel combustion unit using one of the four tiered methods outlined in the rule and also report methane (CH<sub>4</sub>), and nitrous oxide (N<sub>2</sub>O) emissions</li> <li>▪ CO<sub>2</sub>, CH<sub>4</sub>, and N<sub>2</sub>O emissions from flares (e.g., coke oven gas and blast furnace gas.)</li> </ul>
<b>Methodology Highlights</b>	<p>One of three methodologies:</p> <ul style="list-style-type: none"> <li>▪ Operate and maintain a continuous emissions monitoring system (CEMS) for process and combustion CO<sub>2</sub></li> <li>▪ Calculate the mass emissions rate using a carbon balance method</li> <li>▪ Use a site-specific emissions factor based on a performance test that measures CO<sub>2</sub> emissions from all exhaust stacks and processes</li> </ul>
<b>Required Reporting<sup>86</sup></b>	<ul style="list-style-type: none"> <li>▪ Annual GHG emissions</li> <li>▪ Annual production quantity (metric tons) for taconite pellets, coke, sinter, iron, and raw steel.</li> <li>▪ Annual fuel use</li> </ul>

## Heat

US EPA's Mandatory Reporting of Greenhouse Gases rule will require facilities that emit at least 25,000 tons CO<sub>2</sub>e from stationary fuel combustion sources (e.g., boilers) to report greenhouse gas emissions. Facilities that must report only because of stationary fuel combustion (for example, several food processing sectors but not other sectors that are specifically required to report) are not required to report production output, potentially limiting the utility of these data for benchmarking purposes.

<sup>86</sup> Additional data are required to support the methodology chosen.

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## Appendix B. Summary of Benchmarking Webinar

# BENCHMARKING INDUSTRIAL GHG EMISSIONS IN WASHINGTON STATE

## FEBRUARY 22, 2010

### WEBINAR MEETING SUMMARY

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### Meeting Purpose and Background

Under Executive Order 09-05 that Governor Gregoire signed in 2009 ([http://www.ecy.wa.gov/climatechange/2009EO/2009EO\\_signed.pdf](http://www.ecy.wa.gov/climatechange/2009EO/2009EO_signed.pdf)), the Washington State Department of Ecology (“Ecology”) is directed to work with businesses and other interested stakeholders to develop greenhouse gas (GHG) benchmarks for those industries that the Ecology believes will be covered by a federal or regional market-based program. The benchmarks are to recognize those businesses that have made investments in energy efficiency and could be used as a way to allocate allowances under a cap-and-trade program or as state emission standards.

This work will be completed in two phases: Phase 1, which will be completed by the end of June 2010, will consist of research on how benchmarks are established and used, the data that is needed, the industrial sectors where benchmarks make sense, and other relevant background information. The culmination of Phase 1 will be a white paper on the issues and options associated with GHG benchmarking in Washington State. Phase 2, which will start in July 2010, will be the creation of benchmarks for some industry sectors. Ecology has contracted with the Stockholm Environment Institute (SEI) in Seattle to conduct the needed research and otherwise provide technical support and analysis for Phase 1. SEI has contracted with Ross & Associates Environmental Consulting, Ltd. and the Öko-Institut to help in this process.

The purpose of this webinar is to lay out Ecology’s proposed approach for Phase 1 and get feedback from stakeholders. SEI prepared a scoping paper of Phase 1, which expands on the information presented during this webinar. This scoping paper and the webinar’s presentation can be found at: <http://www.ecy.wa.gov/climatechange/GHGbenchmarking.htm>.

### Meeting Presentation

#### Introduction

Janice Adair, Washington State Department of Ecology, began the webinar by providing background of the Executive Order that prompted this work and an overview of the phasing for this work, which is described in the above section. She noted that the focus for developing benchmarks will be on industries in Washington State, but that benchmarks will not be developed for all industries. In addition, as the universe of Washington industries is small, the analysis will look outside of Washington State for some information.

#### Overview of GHG Benchmarks

Pete Erickson, Stockholm Environment Institute (SEI), provided an overview of GHG benchmarks. A GHG benchmark is GHG emissions per unit of output; it enables comparisons across facilities using a common standard. Currently, GHG benchmarks are used in a variety of contexts, including:

- Voluntary industry performance comparisons;
- Allowance distribution in GHG cap and trade programs; and

- Performance standards for direct regulation.

**Voluntary Comparison:** Industry efforts to compare and track GHG emissions performance have been underway for several years, such as in the cement, aluminum, petroleum, and steel industries. In addition, the EPA ENERGY STAR program has provided a voluntary mechanism for industries such as food processing to develop industry benchmarks.

**Allowance Distribution:** The *American Clean Energy and Security Act* (“Waxman-Markey”), passed out of the U.S. House of Representatives in 2009, provides for rebates of emissions allowances to “emissions-intensive, trade-exposed” (EITE) industries on the basis of each sector’s average emissions intensity per unit of production output, which is a type of benchmarking approach. This approach allows industries with compliance obligations but that are energy intensive to compete globally. A federal analysis of the EITE provision of Waxman-Markey indicated that free benchmark-based allocations can reduce almost all costs to firms, as well as resulting changes in net imports and associated emissions leakage. However, free allocation of allowances via these output-based benchmarks, can substantially diminish the emissions price signal to firms to reduce GHG emissions.

**Direct Regulation:** Benchmarks could also be used as performance standards to directly regulate the release of GHG emissions from certain facilities. The U.S. Environmental Protection Agency (EPA) 2009 GHG emission endangerment finding may lead to the requirement that EPA regulate greenhouse gases under the Clean Air Act. One potential approach to implementing this regulation could be to set performance standards for large emitters of greenhouse gases. Washington State has direct regulation performance standards for other air pollutants, including particulate matter, nitrous oxides, and sulfur oxides.

### Process for Developing Benchmarks

Michael Lazarus, SEI, described the general process for developing GHG emission benchmarks, as follows :

- *Fully define the product or activity for benchmarking.* In defining the sector, there needs to be balance between specificity that enables meaningful comparisons across facilities and aggregation that allows for broad application. For determining the sectors to be benchmarked, this analysis will assess the relative contributions to Washington’s emissions, who the industry leaders are, and what interest exists for developing benchmarks.
- *Develop and collect data and establish transparent and rigorous measurement protocols for emissions.* There are a number of different protocols and guidelines that exist (e.g., The Climate Registry) that can help inform this protocol. This step will also include determining the boundaries for what emissions are included in a benchmark.
- *Choose the normalizing unit.* This unit is usually a physical unit (e.g., ton of steel), but is sometimes a physical unit of input (e.g., ton of crude oil refined), a monetary output (e.g., net value added), or a combination of factors (e.g., ENERGY STAR statistical approach).
- *Determine how ambitious the benchmark should be* (i.e., below average, average, above average).
- *Develop benchmarking curves and address any data gaps.*

### Workplan and Schedule

Over the next few months, SEI, in conjunction with Ecology, will develop a white paper on the issues and options associated with benchmarking. This paper will look closely at some specific sectors and may include case studies, if firms are interested in sharing information and perspectives on their industries. This paper will be available in draft in May, and will be discussed in detail at a symposium scheduled for May 19 in Seattle. This symposium will be held in conjunction with the Western Climate Initiative (WCI) meeting; a draft agenda will be developed and shared in the coming months. As needed in March and April, Ecology will provide status updates on this work.

## Meeting Discussion

During the presentation, attendees were encouraged to provide written questions through the webinar dashboard; following the presentation, attendees provided verbal questions to the staff from Ecology and from SEI. The following is a paraphrasing of these questions and the answers provided by SEI and Ecology.

**Q:** Which industries have agreed to participate in developing benchmarks so far?

**A:** The current phase of this project, Phase 1, does not choose the industries for benchmarks. Phase 2 will determine industries.

**Q:** Is there any chance that Washington State would delay implementation of reporting until any Federal programs are finalized?

**A:** There is legislation pending that Ecology requested which would reconcile Washington State reporting with EPA's reporting. The federal reporting rules are finalized, so there is no need for Ecology to delay its implementation. In addition, Washington State has statutory reduction targets and needs reporting to assess how well the State is meeting those reductions.

**Q:** If a business produces, packages, and ships a product and does not separate that energy use, how do you determine a benchmark for that industry?

**A:** This question is about common system boundaries issue, which would need to be evaluated as a part of this analysis. For example, in the European Union's benchmarking approach, a boundary was drawn around each product stage. If a firm has a particular activity within that stage occur outside their operations, that might need to be an issue considered in setting the benchmark. In some cases, benchmarks could be established for sequential phases of a product (e.g., one benchmark on pulp and another on paper: since pulp can be separately traded commodity, it could be two separate allocations for the industry).

**Q:** How do you address developing benchmarks for small industries in Washington or where the relative contribution to state emissions is low?

**A:** Many of the industries in Washington have only a few firms, and so developing benchmarks will need to be informed by firms outside of the state. In determining which industries should be benchmarked, Ecology will consider the relative contribution of the industry to Washington's emissions, whether there are benchmarks that might be useful, and interest from the sector.

**Q:** What are the advantages of an industry taking an early role in this effort?

**A:** Washington has many companies that are top environmental performers within their sector, and benchmarking is a way to get recognition for that work, particularly in light of likely Federal regulations around GHG emissions. In addition, Ecology is working with several companies on assessing their emissions and what strategy and actions can be used to reduce emissions. Benchmarks are a way to compare a firm to its peers, and can help assess what steps and emissions reduction strategies a firm should take.

**Q:** Is Washington considering using benchmarking to develop state-specific direct regulations?

**A:** Washington State is not considering using benchmarking to develop state-specific direct regulations at this time.

**Q:** Are there other mechanisms the State will consider and evaluate in this white paper for issuance of free allowances?

**A:** We are looking specifically at questions related to benchmarks, rather than questions of how allowances are distributed.

**Q:** If an industry has a benchmark identified (e.g., under EU ETS), would Washington State likely default to using that developed benchmark?

**A:** From a technical standpoint, the focus for this analysis will be on the United States and North America. While the analysis will look at what the European Union has done and how it could be applicable, the technology and development may be different.

**Q:** Is it a foregone conclusion that Washington will implement benchmarking rather than a system based on historical emissions for any market-based system?

**A:** No, it does not mean that the State would necessarily use benchmarking for allowance allocations or for every sector. However, during the last legislative session, it was clear that the use of historical emissions for distributing allowances was very unpopular, and that Ecology would need to understand benchmarking better, which is what this process is intended to accomplish.

**Q:** How detailed with this analysis be? For example, the cement sector is very complicated, and there is not agreement within the industry in how to measure and benchmarking GHG emissions.

**A:** It depends on which sector we end up focusing on for the analysis and where we develop detailed case studies. Industry sectors are encouraged to participate in this process as SEI and Ecology think through the issues and options and provide perspectives. It is important to note that participating in this process of sharing the issues and the complexities associated with a particular industry sector will not necessarily mean that the sector will have benchmarks developed in Phase 2.

**Q:** Have other benchmarking efforts taken into account upstream issues such as different fuel mixes across the country and how much it costs to get fuel to facility?

**A:** To our knowledge, other benchmarking efforts have not looked at these life cycle issues. This issue could be something we undertake under this effort.

**Q:** During the presentation, the definition of trade intensity was discussed as part of Waxman-Markey. Is part of the scope of this project to reevaluate those trade intensity metrics for Washington State, or will the benchmarks defer to those definitions in Waxman-Markey?

**A:** In order to reevaluation that trade intensity definition and look at different alternatives, this analysis would need a data source with resolution down to the Washington-state level, which can be difficult or impossible to find. At the national level, there has been some sensitivity analysis of changing the trade intensity threshold; so far, this analysis shows that altering the threshold does not significantly affect which industries are included or not in the definition.

## Appendix C. Summary of Benchmarking Symposium

### SYMPOSIUM ON UNDERSTANDING THE VALUE OF BENCHMARKING

MAY 19, 2010 – SEATTLE, WA  
MEETING SUMMARY



#### Key Meeting Themes

- Benchmarks have been used in a variety of contexts:
  - Voluntary industry performance comparisons
  - Allowance distribution in GHG cap and trade programs
  - Performance standards for direct regulation
- GHG and energy benchmarking can be useful for companies and facilities in identifying process and energy improvements and allows facilities to set achievable objectives for energy and GHG reduction. Benchmarking can also require resources in data gathering and analysis, and raise some challenges in comparing between facilities.
- Specific design details are important to consider when developing benchmarks, including ambition of the benchmark, scope of emissions to include, data sources to use, and level of aggregation.
- Washington State has an Executive Order directing it to establish GHG benchmarks for some sectors. In addition to addressing its own emissions, Washington State's work could help influence the design of benchmarks that could ultimately be used at the regional or federal level for allowance distribution under a cap-and-trade program or for performance standards under direct regulatory approach.

#### Meeting Purpose and Background

Under Executive Order 09-05 that Governor Gregoire signed in 2009 ([http://www.ecy.wa.gov/climatechange/2009EO/2009EO\\_signed.pdf](http://www.ecy.wa.gov/climatechange/2009EO/2009EO_signed.pdf)), the Washington State Department of Ecology ("Ecology") is directed to work with businesses and other interested stakeholders to develop greenhouse gas (GHG) benchmarks for those industries that the Ecology believes will be covered by a federal or regional market-based program. The benchmarks are to recognize those businesses that have made investments in energy efficiency and could be used as a way to allocate allowances under a cap-and-trade program or as state emission standards.

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support and analysis for Phase I. SEI has contracted with Ross & Associates Environmental Consulting, Ltd. and the Öko-Institut to help in this process.

More than 100 industry and government stakeholders attended the meeting in person and over the phone. Industry attendees represented a variety of sectors, including food processing, cement, petroleum refining, pulp and paper, electric and natural gas utilities, aluminum, and glass. Over half of the attendees were from Washington State. Others in-person and on the phone included those from California, Oregon, Pennsylvania, Utah, and various provinces in Canada.

The purpose of this meeting was to learn about benchmarking, the various policy approaches in which it has been applied, how benchmarks are developed, and the experiences that various entities have had with benchmarking. It was jointly sponsored by the Western Climate Initiative (WCI) and the Washington State Department of Ecology. For more information on Ecology's approach for addressing the Executive Order, see: <http://www.ecy.wa.gov/climatechange/GHGbenchmarking.htm>. The summary below highlights the key points of each presentation and the major points of discussion during the Symposium.

## Meeting Presentations – Morning

The objective of the morning session of the Symposium was to address the following questions:

- What are benchmarks?
- How are benchmarks constructed?
- What are the leading policy approaches for using benchmarks to reduce GHG emissions?

### Overview of Current Efforts in Industry Benchmarking to Improve Industrial Performance

Janice Adair, Washington State Department of Ecology, and Michael Gibbs, California EPA, on behalf of the WCI, began the Symposium with introductions and a welcome. Following their presentations, Michael Lazarus, SEI, provided a brief overview of current efforts in industry GHG benchmarking and of the White Paper that SEI is developing on the topic. His presentation can be found here: [http://www.ecy.wa.gov/climatechange/docs/GHGbenchmark\\_20100519\\_Lazarus.pdf](http://www.ecy.wa.gov/climatechange/docs/GHGbenchmark_20100519_Lazarus.pdf).

Mr. Lazarus emphasized the importance of defining benchmarks and he proposed the following for consideration during the Symposium: a GHG benchmark is GHG emissions per unit of output. Such a definition enables comparisons across facilities using a common standard. Currently, GHG benchmarks are used in a variety of contexts, including:

- **Voluntary industry performance comparisons:** Industry efforts to compare and track GHG emissions performance have been underway for several years, such as in the cement, aluminum, petroleum, and steel industries. In addition, the U.S. Environmental Protection Agency (EPA) ENERGY STAR program has provided a voluntary mechanism for industries such as food processing to develop industry benchmarks for energy use.
- **Allowance distribution in GHG cap and trade programs:** For example, the American Clean Energy and Security Act (“Waxman-Markey”) provides for rebates of emissions allowances to “emissions-intensive, trade-exposed” (EITE) industries on the basis of each sector’s average emissions intensity per unit of production output, which is a type of benchmarking approach.
- **Performance standards for direct regulation:** For example, the EPA 2009 GHG emission endangerment finding may lead to the requirement that EPA regulate greenhouse gases under the Clean Air Act. If so, benchmarking might prove useful in determining what level of emission reductions a regulated sector should achieve.

## Existing Policy Approaches that Use Benchmarking to Improve Industrial Energy Performance

This panel discussed the various policy approaches in which benchmarking has been or could be applied to industry sectors to address their energy performance.

### **James Bradbury, Senior Associate, Climate and Energy Program, World Resources Institute**

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*Presentation:* [http://www.ecy.wa.gov/climatechange/docs/GHGbenchmark\\_20100519\\_Bradbury.pdf](http://www.ecy.wa.gov/climatechange/docs/GHGbenchmark_20100519_Bradbury.pdf)

James Bradbury provided an update on the use of GHG benchmarks and carbon leakage provisions in proposed U.S. climate legislation. Dr. Bradbury discussed that there is growing consensus around output based allocation to EITE (“emissions intensive, trade exposed”) industries to address possible leakage resulting from economy-wide climate policy. Under this method, allowances are allocated to industry on a production output basis, based on each facility’s output and sector average. The current versions of the federal climate legislation (“Waxman-Markey” and “Kerry-Lieberman”) provide for allowances to EITE industries based on an output based allocation level. A U.S. interagency report prepared by EPA, the Energy Information Administration (EIA), and Treasury found that the free, output-based allocation of allowances to these industries “can eliminate almost all – and, in some cases, potentially more than all – of those cost impacts, as well as the resulting changes in net imports and emissions leakage.” In the current versions of the bills, these allowances and other assistance to industries could phase out sometime between 2025 and 2035.

How GHG benchmarking would be designed under federal legislation is still an open question; in Waxman-Markey, sectors are defined at the six-digit NAICS code. Under Kerry-Lieberman, EPA is given discretion on how to define industry sectors. Ultimately, the goal is to have harmonized international definitions for industrial sectors, but there is a need for better data and analysis to develop these definitions.

### **Judi Greenwald, Vice President, Innovative Solutions, Pew Center on Global Climate Change**

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*Presentation:* [http://www.ecy.wa.gov/climatechange/docs/GHGbenchmark\\_20100519\\_Greenwald.pdf](http://www.ecy.wa.gov/climatechange/docs/GHGbenchmark_20100519_Greenwald.pdf)

*Supplementary Handout:*

[http://www.ecy.wa.gov/climatechange/docs/GHGbenchmark\\_20100519\\_technologystandardsummary.pdf](http://www.ecy.wa.gov/climatechange/docs/GHGbenchmark_20100519_technologystandardsummary.pdf)

Judi Greenwald provided an overview of possible approaches to developing and using benchmark-based GHG performance standards under existing environmental law. Setting performance standards under the Clean Air Act and other environmental statutes, such as the Clean Water Act, utilizes benchmarking and provides some useful models for how it might be implemented for GHGs. The Clean Air Act has several technology-based performance standard setting provisions for limiting emissions, all of which have some role for benchmarking but have different objectives, definitions, and considerations. However, the potential application of Clean Air Act New Source Performance Standards for GHGs provides for some unique challenges. For example, determining which facilities would be covered, addressing the role of the states, and incorporating innovation and energy efficiency are all challenges. Section 111(d) of the Clean Air Act may be applicable to GHGs; it has been used in the past to address other pollutants for new and existing sources.

### **Betsy Dutrow, Director, US EPA ENERGY STAR Industrial Sector Partnership**

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*Presentation:* [http://www.ecy.wa.gov/climatechange/docs/GHGbenchmark\\_20100519\\_Dutrow.pdf](http://www.ecy.wa.gov/climatechange/docs/GHGbenchmark_20100519_Dutrow.pdf)

Betsy Dutrow provided an overview of EPA’s approach for benchmarking industrial plant energy performance and reviewed the successes and challenges of benchmarking plant performance. ENERGY STAR is a voluntary

government partnership with the goal to reduce energy use, which can have beneficial impacts in reducing carbon dioxide emissions as well. The Energy Star program helps manufacturers improve their strategic energy management and uses energy benchmarking (“Energy Performance Indicators”) to compare energy performance of facilities to similar or best performing facilities in their class. ENERGY STAR industrial benchmarks define the “best in class” for an industry or building type; are specific to the six-digit NAICS code or are more refined; and are normalized for key variables (e.g., number of heating days). These benchmarks enable companies to set competitive goals for energy performance and allow EPA to track industry energy performance over time. In addition to energy benchmarks, ENERGY STAR also works with the Lawrence Berkeley National Laboratory to produce energy guides, which provide information on existing and promising new technology to help facilities reduce energy usage.

## Panel Discussion

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Following the presentations on existing policy approaches, audience members were encouraged to address questions to the panel:

- A Symposium attendee asked whether there are there any practicable responses to address leakage. James Bradbury responded that proposed federal legislation includes a substantial number of allowances to prevent competitive disadvantage and leakage. Judi Greenwald noted that these allowances are a key advantage of implementing a cap-and-trade program to regulate GHG emissions, as Congress can provide this compensation. Under a regulatory program, this granting of allowances is much more difficult. Another attendee said that focusing too much on leakage can distort carbon pricing and that, in designing legislation, regulators should accept that there will be some uneven effects, but that there will also be resulting improvements in efficiency.
- An attendee cautioned WCI and Washington not to assume the Waxman-Markey definitions for EITE industries, as there will likely end up being a series of compromises to include or not include specific industries.
- James Bradbury and Judi Greenwald discussed the benefits and challenges of setting benchmarks at the industry average, rather than at a better-than-average level. Michael Lazarus mentioned that, per the Executive Order, it may be advantageous for Washington State to push for higher ambition in benchmarks, as the state has many high performing industries that could benefit.
- Bill Ross, the Symposium moderator, asked Betsy Dutrow about whether ENERGY STAR participants see a favorable return on investment from participating in the program. Ms. Dutrow responded that ENERGY STAR does not have financial data, but anecdotally, there seems to be financial benefits to companies in benchmarking their performance and then making appropriate investments to improve energy efficiency.

## Methods for Constructing Benchmarks

This panel discussed how benchmarks are constructed, including the models for establishing benchmarks and the design considerations one must address. *Due to time constraints, discussion was largely postponed to the afternoon panel.*

### Hauke Hermann, Research Associate, Öko Institute

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Presentation: [http://www.ecy.wa.gov/climatechange/docs/GHGbenchmark\\_20100519\\_Hermann.pdf](http://www.ecy.wa.gov/climatechange/docs/GHGbenchmark_20100519_Hermann.pdf)

Hauke Hermann discussed the process underway to establish industry GHG benchmarks for carbon-intensive, trade-exposed industries under the European Union’s (EU) cap-and-trade program (Emission Trading Scheme or ETS), for which he consults. The EU ETS includes 27 EU member states and is a downstream regulation (i.e., the point of regulation is the installation releasing the emissions into the atmosphere). The objective of GHG

benchmarks in the EU ETS is threefold: (1) Compensation, especially during the initial phase-in period, (2) Rewarding early action, and (3) Preventing leakage.

Benchmarking curves are submitted to the European Commissions and are externally verified; benchmarks will be developed for all major industrial processes listed in the ETS Directive. To set up benchmark curves, specific emissions are calculated by dividing emissions production in a reference period (e.g., 2007-2008). There is no correction on the benchmark curve for outliers, but imports and exports of heat and waste gases are corrected with the emission factor of natural gas. Mr. Hermann noted that the same monitoring method should be used to set up the curves as is used to monitor the emissions to ensure data quality and consistency.

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**Gale Boyd, Director, Triangle Census Research Data Center, Duke University title**

*Presentation:* [http://www.ecy.wa.gov/climatechange/docs/GHGbenchmark\\_20100519\\_Boyd.pdf](http://www.ecy.wa.gov/climatechange/docs/GHGbenchmark_20100519_Boyd.pdf)

Gale Boyd, as part of EPA's ENERGY STAR Industrial Team, constructs the models that form the basis for benchmarking the energy performance of industrial facilities in the U.S. Via telephone, Dr. Boyd described the data, methods, and challenges of benchmarking these plants. Facilities are distinguished for benchmarking based on the products produced for final shipment, the materials used to produce those products, and external factors that drive energy use (e.g., climate). A statistical model is used to normalize the differences by computing weights applied to shares of products, materials, and other factors to compute the energy performance of the plant.

These analyses typically use confidential plant level data from two sources: (1) Center for Economic Studies at the U.S. Bureau of the Census (Duke University is a partner) and (2) data provided by trade associations and directly from industry. The advantage of using this data is that they include all plants and does not require the collection of additional data; however, the data were not collected specifically for the purpose of energy benchmarking and may not include all details needed. ENERGY STAR uses stochastic frontier regression for its modeling, which identifies the best-performing plants by finding the line which "envelopes the frontier" of the data. This statistical method is useful because the distribution of energy efficiency may not be a normal curve, but may have a skewed distribution and it tests whether a normalizing factor should be included.

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**Peter Erickson, Staff Scientist, SEI**

*Presentation:* [http://www.ecy.wa.gov/climatechange/docs/GHGbenchmark\\_20100519\\_Erickson.pdf](http://www.ecy.wa.gov/climatechange/docs/GHGbenchmark_20100519_Erickson.pdf)

Peter Erickson, co-author of the SEI *White Paper* on greenhouse gas benchmarking, described key issues and options for developing GHG benchmarks in Washington and the U.S. The key design decisions when creating benchmarks are:

- **Ambition:** How ambitious should the benchmark be (e.g., top percentile, average)? Level of ambition depends on the policy context in which benchmarks are applied.
- **Scope and boundaries:** Should the benchmark only include direct emissions or total emissions (including indirect emissions)?
- **Data sources:** Which data should the benchmark use (e.g., from industry groups, government surveys, air permits)?
- **Level of aggregation:** What should be the balance between aggregation and specificity? Level of aggregation also depends on the policy context in which benchmarks are applied.

Other design issues to consider in developing benchmarks are: use of combined heat and power or of waste gases; feedstock quality and quantity; facilities that produce multiple products; integrated and non-integrated facilities; and alternative definitions of the final product (e.g., cement or clinker).

## Meeting Presentations and Discussion – Afternoon

The objective of the afternoon session of the Symposium was to address the following questions:

- ❖ What are the benefits and challenges of developing and applying benchmarks?
- ❖ What data constraints limit benchmarking and how might they be overcome?
- ❖ How do responses to these questions differ depending on how benchmarks are used?

### Key Issues for Industry GHG Benchmarking

Building on the morning’s presentations, this panel discussed the key issues that industry stakeholders should consider in light of the potential policy approaches for implementing benchmarking and the methods for constructing benchmarks.

*Presentation:* [http://www.ecy.wa.gov/climatechange/docs/GHGbenchmark\\_20100519\\_Martchek.pdf](http://www.ecy.wa.gov/climatechange/docs/GHGbenchmark_20100519_Martchek.pdf)

Ken Martchek, Alcoa, provided a national perspective of considerations in addressing this session’s key topics: benefits and challenges of benchmarking, data constraints, and striking a balance between detail and aggregation in benchmarks across industry sectors. Benchmarking can help facilities identify process and energy improvements and allows facilities to set achievable objectives for energy and GHG reduction. Benchmarking also requires significant resources in data gathering and analysis and raises some issues in facility comparisons such as different technologies, climate conditions, and demands for production.

### Panel Discussion

Following Ken Martchek’s presentation, a group of industry representatives gathered on a panel to discuss their experiences with benchmarking, potential data constraints, and how benchmarking might be applied in Washington State. The industry panelists were joined by most of the panelists from the morning sessions, who provided their research and policy perspectives to the discussion. Panelists for this session were as follows:

- Pam Barrow, Northwest Food Processors Association
- Anthony Chavez, Weyerhaeuser
- Jeff Jacobson, Cardinal FG
- Curtis Lesslie, Ash Grove Cement Company
- Ken Martchek, Alcoa
- James Bradbury, World Resources Institute
- Betsy Dutrow, US EPA ENERGY STAR
- Peter Erickson, Stockholm Environment Institute
- Judi Greenwald, Pew Center for Global Climate Change
- Hauke Hermann, Öko Institute

### Experiences with Benchmarking

Ken Martchek discussed in his presentation Alcoa’s experience with benchmarking. Alcoa focused first on energy benchmarking, as aluminum smelting is very energy intensive. Each producing facility in Alcoa records their energy use data; Alcoa’s headquarters can break the data down by technologies and total use to track trends. Normalizing against technology has helped bring energy reduction discussions to a deeper level, as producers cannot blame lack of a specific technology for higher energy use. This benchmarking data was needed to set voluntary quantitative objectives for the company.

Pam Barrow, Northwest Food Processors Association (NWFPA), discussed the benchmarking efforts underway in her industry. In 2009, NWFPA set an energy goal for participating members to reduce member-wide energy intensity by 25 percent in 10 years and by 50 percent in 20 years. NWFPA took this step because of the challenges facing the industry, in particular the volatility of energy prices, global competition, and the uncertainty of regulations. The association conducted a pilot using about 45 plants to develop a methodology. Using nondisclosure agreements, the association was able to collect confidential energy and production use data. Based on this information and the diversity of products in the association, NWFPA set the benchmark unit as pounds of production, developing methods to convert cases to pounds so that the denominator would be consistent. In addition, NWFPA determined that benchmarks needed to be broken out into process types, which they are currently in the process of doing.

Curtis Lesslie, Ash Grove Cement, said his industry's experience had been similar to NWFPA. The Cement Sustainability Initiative (CSI) pledged in 2002 to measure emissions from cement production, and now have a roadmap for emission reductions. Ash Grove Cement has been a member of CSI since 2004. Ash Grove noted that approximately 80 percent of cement production is controlled by international conglomerates and measuring and reducing energy use was a way for Ash Grove to compete globally. Ash Grove Cement has also participated in ENERGY STAR and EPA's Climate Leaders and their benchmarking efforts.

Jeff Jacobson, Cardinal FG, a glass company, mentioned some of the particular challenges that the glass industry has with benchmarking its emissions and reducing energy. With the economic recession, many glass manufacturing facilities have shut down. For those that remain in operation, it is difficult to reduce production due to the nature of the furnaces; often, it is more cost efficient to keep running the furnaces rather than shut them down, as shutting them down completely can be damaging. For the glass industry, this constant need to have production equipment running, without necessarily shipping product, can skew its results if the benchmark is not constructed properly.

### **Data Challenges**

A Symposium attendee discussed the economic recession and the impacts that it will have on the ability to do adequate data collection, ensure data quality, and impact future benchmark baselines. Betsy Dutrow said that ENERGY STAR would be changing the baseline to capture these lower production years, and will be working with industry partners to capture any changes that it will have on resulting ENERGY STAR performance. Ken Martchek discussed a concern that he has for data collection is the number of people needed to accurately collect and track data. With the implementation of cost-cutting measures across industry sectors, having enough capacity to manage energy and emissions data is a challenge. Judi Greenwald discussed that it is important to have staff at companies be accountable for that data and for companies to invest in that information collection to ensure its quality and consistency.

The six digit NAICS codes have been the unit of measurement for industry in many benchmarking efforts, but they are often not refined enough to capture specific important production differences that can have a large impact on benchmarks. The need for more nuanced data is a challenge; a perfect benchmarking formula is probably not possible for all industries and all facilities.

For allowance distribution, there is a tension between transparency in methodology and confidentiality of facility data. Hauke Hermann noted that the EU faced this same issue, but faced with deadlines to implement a regulatory program, worked out a series of compromises to move forward. Similarly, Judi Greenwald noted that the focus of the current legislative efforts is on getting the best technical approach, though transparency will likely still need to be addressed in the future. Betsy Dutrow said that in a benchmark approach for distributing allowances under a

cap-and-trade program, the methodology and analyses would need to be thoroughly documented for people to understand and reference. A representative from the food processing industry said that the data from ENERGY STAR, while high level, was useful to his company, but using this data for allowance distribution is more problematic, and would need to be improved for any allowance distribution.

### **Facility Improvements**

Michael Lazarus asked the panelists how incentives could be created to encourage companies to invest in more efficient technologies. Anthony Chavez, Weyerhaeuser, said that his company feels that a national cap and trade system provides the most flexibility for companies that are interested in adopting new technologies, without limiting them to a specific path as a regulatory system might. Referring to a recent [Pew Center report](#) on corporate energy efficiency, Judi Greenwald said that large investments needed for significant technology improvements need to come from the top leadership of a company, with energy reduction being declared a priority by management or else they will not happen in tough times.

An attendee asked how the panelists see benchmarking integrating with declining availability of allowances over time. James Bradbury said that there is a historic trend of industry emissions declining in the U.S., partly due to increased efficiency and partly due to having less energy intensive industries. He said he thinks that industry will be able to manage toward the declining allowances, but that eventually the price of carbon will need to be reflected in products. The eventual vision is that there is a more harmonized international framework. Judi Greenwald mentioned that EITE industries are not being excluded from the proposed regulations, and will still have incentives to reduce their energy use in line with declining allowances. Michael Gibbs, WCI Co-Chair and California EPA, noted that there is a dual objective in these discussion—price carbon appropriately, yet keep the carbon price from impairing industry sectors—and the dilemma is figuring out a method for integrating both of these goals.

Some companies have many facilities, some more efficient than others, and would likely move allowance allocations around their facilities, rather than looking to buy and sell externally. Michael Gibbs brought up the issue of WCI implementing a market-based program, and how WCI is addressing the potential impact of companies moving production from WCI regions to elsewhere in North America. Pam Barrow noted that, for food processing, the profit margins are very low, and a regional approach could be damaging to their association's members if other areas of the country or even internationally could avoid having carbon-based cost impacts.

### **Potential Action for Washington State**

Given that there is an Executive Order in Washington State that requires Ecology to set benchmarks for some industry sectors, panelists and attendees discussed what would be the best path forward for Washington State.

Matt Cohen, Stoel Rives, said that it seemed that applying Clean Air Act provisions to new and modified sources was easier than for existing sources. He cautioned that in a slow economy, existing plants would have a difficult time meeting new GHG performance standards and suggested that a regulatory objective could be applying benchmarks only to review of new sources and hope for an international agreement with a broader consensus on standards for existing facilities. Judi Greenwald responded that the Clean Air Act has successfully prompted existing facilities to make progress, such as under US EPA's Acid Rain Program and the new particulate matter standard. She said that only applying GHG performance standards to new and modified sources could be quite limiting, as there is some evidence that facilities defer upgrading equipment to avoid falling under the New Source Review process.

Anthony Chavez said that Washington State could position itself and its industries as early actors, and get credit for that work under a national approach. For example, he said the U.S. Senate Kerry-Lieberman bill has specific language granting credit to early actors. Pam Barrow said she also supported a national approach to GHG emission regulation and allocation. She expressed concern about Washington State expending effort and resources to undertake benchmarking for its own industries if it was anticipated that the federal authorities would also take action. Judi Greenwald responded that past federal efforts, such as the GHG reporting rule, were influenced by the work done at the state level, including Washington State. She said that efforts such as Washington's help inform the process and give specific real-world examples of industry involvement to the federal government. Similarly, Hauke Hermann mentioned that the countries that were first active in the EU on the emission scheme now have their industries better incorporated in the EU-wide directive than other countries.

## Observations and Next Steps for the Benchmarking Project

Janice Adair, Washington State Department of Ecology, provided some closing observations of the Symposium's discussions. She thanked everyone for their attention and attendance at the Symposium.

Through this effort, Ecology has met with the industry sectors that it believes likely would be covered under any federal greenhouse gas reduction program. This exercise has been useful for understanding the opportunities and resource constraints that Washington industry has. It has also helped Washington State be more informed if there is federal action on climate legislation that includes GHG benchmarking or if EPA were to take regulatory action involving benchmarking. Finally, by being one of the leading states on learning about GHG benchmarking, Washington has the potential to influence any federal legislation and its impact on Washington State industries.

Ms. Adair reiterated that the white paper, *Issues and Options for Benchmarking Industrial GHG Emissions* ([http://www.ecy.wa.gov/climatechange/docs/GHGbenchmark\\_whitepaper\\_20100511.pdf](http://www.ecy.wa.gov/climatechange/docs/GHGbenchmark_whitepaper_20100511.pdf)), was available for review and comment. This white paper was drafted by the Seattle office of the Stockholm Environment Institute (SEI) and examines a number of industrial sectors in detail including aluminum, cement, chemicals, food processing, pulp and paper, steam, and steel. SEI worked with representatives from each of those sectors as it prepared the paper, which is a preliminary draft. Building on the insights gained from the benchmarking symposium and stakeholder input, SEI and Ecology plan to issue a final draft in late June, and will include recommendations for how Washington State should move forward implementing benchmarks for industries. Ecology invites comments on this draft, submitted via email to [benchmarking.wa@sei-us.org](mailto:benchmarking.wa@sei-us.org) by Friday, June 4, 2010. In particular, Ecology and SEI posed the following questions to stakeholders:

- What issues do you think are common in benchmarking across industries?
- What would make a Phase II effort on benchmarking (July 2010-June 2011) most useful for your industry and for Washington State?
- Are there other key issues and opportunities for GHG benchmarking in your particular industry that you would like to see discussed further in the White Paper?