Additional Topics
Submitter's Name/Affiliation: Eileen Claussen/Pew Center on Global Climate Change

If there is an additional topic related to the design of a mandatory market based program that you would like to address, please submit comments on this form.

The Pew Center respectfully wishes to submit material on two additional topics: cost containment and recent climate science.

Additional Topic #1 – Cost containment: a function of the whole package

The Pew Center and most of the over 30 large corporations surveyed by the Center believe that, rather than focusing on any one design element in isolation, any bill must be evaluated as a whole, especially in minimizing the costs to covered entities and the economy. The issue is raised by a design question not specifically mentioned in the White Paper: the concept of a "safety valve." Under a safety valve provision, exemplified by the recommendation of the National Commission on Energy Policy (NCEP), covered entities would be allowed to pay the implementing agency a specified amount per ton of GHG instead of submitting emissions allowances, thus capping the cost per ton at the specified "safety valve" level. In fact, a safety valve is only one tool for providing cost containment. Moreover, it is one that could limit environmental effectiveness of the program and present complications for linking to other trading programs (as discussed in response to Question 3). A GHG cap-and-trade program can be designed to minimize costs using a variety of other approaches:

- selection of moderate targets and timetable;
- advanced notice of policy;
- banking of allowances and offsets;
- borrowing of allowances;
- staggering compliance deadlines;
- extending compliance deadlines;
- providing consumer dividends (payments made to energy consumers to compensate them for any increased energy costs);
- providing relief for individual emitters;
- inclusion of offsets;
- linkage with other trading systems; and
- complementary policies that drive energy efficiency and technological innovation

Additionally, low price caps act as a tax. Taxes have been shown to be fairly ineffective in the short term at eliciting significant results. (See attached chart on cost containment mechanisms.)

The companies surveyed by the Pew Center hold a wide range of opinions about the policy benefits of a safety valve, though most say that a safety valve may be politically necessary. Of companies that favor a safety valve, or at least think it might be politically necessary, several note that \$7/ton of CO_2 (the initial level recommended by NCEP) is too low to

achieve significant emissions reductions or to drive market-based transition to a wide range of low-carbon technologies. If a safety valve is used, it should be set high enough to encourage meaningful change. For instance, integrated gasification combined cycle (IGCC) coal or supercritical pulverized coal electric power generation combined with carbon capture and sequestration (CCS) may only become economically viable on a self-sustaining basis (without continued government subsidy) with CO_2 values at or above $25-35 per ton. This does not necessarily mean the safety valve should be set immediately at $25-$35 per ton. Rather, the starting point and growth curve of the safety valve must be such that the net present value of paying it will be more than what companies project will be that of investment in IGCC-CCS.

One company notes that mere inclusion of some reasonable cost limit may be more important for getting legislation enacted than the limit's specific level. The presence of a safety valve, even at a high dollar level, could undercut assertions that GHG regulation will bring about the "end of the economy," since it would remove from consideration the modeling results that posit extreme cases of unlimited cost. Another company notes that, when GHG regulation is viewed as inevitable and may affect upstream energy producers, financial structuring for large new oil and gas production projects may not be possible without a price cap, since otherwise these projects would involve a large unknown liability that constrains equity value and cash flows.

A few companies oppose a safety valve altogether because of its distortionary effect on the market, or only favor a safety valve with a sunset clause. Companies express concern that a safety valve would complicate linkage between the U.S. carbon trading market and the cap-and-trade programs of other countries, which likely would increase the cost of U.S. reductions and reduce the economic efficiency of the system. Some companies point out that the market, left to develop without interference, will develop a range of financial products and services that provide cost certainty to firms but are less distortionary than safety valves. Under a mature carbon emissions trading market with adequate certainty about cap levels beyond the short term, financial services firms will offer hedging products such as forward call options that allow companies to lock in a maximum cost.

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Additional Topic #2 – Recent Climate Science

The Pew Center commends the Senate Energy Committee for addressing the climate change issue and urges a continued high level of effort – especially in light of recent developments in climate science. In the past 3 years, and especially in 2005-06, the science attributing global warming to human enhancement of the greenhouse effect has become very compelling. At the same time, globally distributed impacts of climate change have occurred in patterns that are readily explained by global warming, and not by natural variations in regional climate. Many changes that have been predicted by models are now occuring.

1. Attribution of global warming to the enhanced greenhouse effect. Scientists have tested alternate hypotheses of natural versus anthropogenic forcings to explain observed climate change. Two recent studies illustrate the state of the science in this endeavor, but represent a small fraction of the studies that have produced similar conclusions.

   a. *Physical simulation of 20th century surface warming*: A study (Meehl et al. 2004. Journal of Climate 17:3721-3727) by scientists at the National Center for Atmospheric Research (NCAR) examined a variety of natural (solar, volcanoes) and anthropogenic (GHG, ozone, sulfate aerosols) forcings on global surface temperature, comparing model output with observed changes during the 20th century. The study found that all of these factors act additively and all must be included as forcings in the model in order to closely mimic the observed temperature change. During the last half of the 20th century, the largest forcing explaining warmer global temperatures was anthropogenic GHG. These and many other results directly contradict claims that models fail to mimic observed changes.

   b. *Physical simulation of heat penetration into the oceans.* Scientists at Scripps Institution of Oceanography, Lawrence Livermore National Lab, the UK's Hadley Center, and NCAR produced a study (Barnett et al. Science 309:284-287) showing that the global ocean basins are warming simultaneously as a result of global greenhouse warming. Whereas natural variations occur at different times, and often in direct opposite patterns, in different ocean basins, there has been a simultaneous warming of all the major ocean basins over the past 40 years. Moreover, the pattern of penetration of warming at different ocean depths varies from basin to basin. Modeling of natural internal variability alone did not reproduce these complex patterns, whereas combining internal variability with GHG forcing did. Hence, using a very different approach from the study above, scientists once again find that observed patterns of climate change can only be mimicked when anthropogenic GHGs are included as a climate forcing.

   c. *Physical simulation of the increasing height of the tropopause*. The tropopause is a region of the atmosphere that separates the lower atmosphere (troposphere) from the upper atmosphere (stratosphere). Its height is determined by physical conditions in the troposphere and stratosphere, among them being the temperature of the troposphere below and the stratosphere above. As these conditions change, the height of the tropopause changes in response. Forcings that either warm the troposphere or cool the

stratosphere tend to increase the tropopause height, whereas those that cool the troposphere or warm the stratosphere decrease troposphere height. Changes in solar radiation and volcanic particles are natural forcings and changes in stratospheric ozone and tropospheric greenhouse gas concentrations are anthropogenic forcings.

Scientists from the US, UK, and Germany teamed up to test whether they could simulate observed changes in the height of the tropopause based on changes in the natural and/or anthropogenic forcings and their physical understanding of atmospheric dynamics (Santer et al. 2003. Science 301:479-483; Santer et al. 2004. Journal of Geophysical Research 109:D21104). Observations revealed a 620-foot increase in tropopause height between 1979 and 2001. The scientists obtained a similar increase in the simulated tropopause height when their model was forced by anthropogenic GHG and stratospheric ozone depletion (from man-made chemicals). About 40% of the effect was from GHG and 60% from ozone depletion. Including natural variability of solar input and volcanic emissions in the model had little effect on this outcome, suggesting that enhanced greenhouse warming and stratospheric ozone depletion were the main causes of global tropospheric height increase (Santer et al. 2003. Science 301:479-483; Santer et al. 2004. Journal of Geophysical Research 109:D21104). Because of the Montreal Protocol, ozone depleting substances will decline in the future. GHGs, however, are expected to increase. Hence, the model predicted that tropopause elevation will continue to rise in the future mainly because of anthropogenic GHG.

2. Linking major climate change impacts with global warming. In recent years, several important impacts have been observed that are readily explained by human-induced global warming. In some cases, global warming plus regional variability combine to produce impacts, but natural variability alone cannot explain the observations.

   a. Global ice cover – In recent years, glaciologists and oceanographers have been surprised by the unprecedented rates of change in global ice cover, both for Arctic sea ice and land-based glaciers and ice sheets.

   Greenland: The second largest land-based ice sheet, with enough water to raise the global sea level by 6 meters if melted, covers the Greenland continent. Fifteen years ago, glaciologists believed that the Greenland ice sheet was in balance (i.e., not losing or gaining ice). Over the past decade, glaciologists documented rapid melting around the coasts of Greenland and adjusted their estimates to reflect a net loss of ice due to melting. In February 2006, new satellite-based measurements of ice flow were published, revealing that Greenland is losing ice even more rapidly than realized as a result of ice flowing into the sea at high rates. This work doubled the estimated rate of ice loss from Greenland and its contribution to the rate of global sea level rise (Rignot et al. 2006. Science 311:986-990).

   Antarctic ice sheet. Western Antarctica is losing ice rapidly. Until recently, East Antarctica was thought be gaining ice, but now is thought to be just in balance, such that future warming could quickly shift it to net ice loss. Overall, Antarctica appears to have

lost about 450 km^3 of ice just in the past three years (Velicogna. 2006. Science Online, March 2). Because these results are from the GRACE satellites launched in 2002, we do not know how long Antarctica has been losing ice. Antarctica holds enough ice to raise sea level by 70 m if melted.

Arctic sea ice: Arctic sea ice is being lost at an unprecedented rate, reaching a record low area during summer 2005. Some scientists estimate that by the end of the 21st century the Arctic Ocean will be completely free of ice during the summer, a condition that probably has not existed for at least a million years (Overpeck et al. 2005. EOS 86:309-312). This loss of ice has important implications for global climate change and for Arctic ecosystems and wildlife (Arctic Climate Impact Assessment. 2005. Cambridge Univ. Press, New York).

Mountain glaciers. For several decades, glaciologists have documented a continuing worldwide loss of mountain glaciers, which continue to dwindle at an accelerating rate (Dyurgerov. 2006. AAAS Symposium, St. Louis; Dyurgerov, 2005. INSAAR Occasional Paper No. 58, Univ. of Colorado). Billions of people around the world depend solely on glaciers for their water supply. In Central Asia, mountain glaciers are retreating rapidly and may be virtually gone within decades, creating a billion environmental refugees (V. Aizen, 2006. AAAS Symposium, St. Louis).

The global trend. There is a clear pattern of globally distributed loss of ice indicative of global greenhouse warming, and not isolated regional losses of ice resulting from natural regional variability, as asserted by some. While some regions of the globe may presently be in a phase of natural warming, in addition to enhanced greenhouse warming, other regions are in natural cooling phases that will also reverse at some point. Hence, the overall loss of ice is a fingerprint of global warming.

b. Hurricanes – In 2005, two independent studies found that hurricanes were becoming more intense worldwide (Emanuel, 2005. Nature 436:686-688; Webster et al. 2005. Science 309:1844-1846). All ocean basins where tropical cyclones develop exhibited this change in recent decades. Immediately, some responded that this upswing resulted from natural variability, rather than from greenhouse warming. However, they overlooked the well-established knowledge that natural cycles do not occur in sync across the various basins. In fact, they tend to vary in opposite phases, for instance, in the North Atlantic and North Pacific basins. The existence of a trend of intensification in all six of the tropical cyclone-producing ocean basins thus represents a fingerprint of global warming, consistent with the enhanced greenhouse effect and not with natural variability alone.

c. Species changes – Two recent studies have documented apparent connections between changes in species and anthropogenic climate change. One study (Root et al. 2005. Proceedings of the National Academy of Sciences 102:7465-7469) found that 130 species, including many different plants and animals, have responded to earlier spring temperatures between 1970 and 2000. The power of this study, however, was that it linked these changes statistically to a climate model, demonstrating that the relationship between the timing of spring biological events (such as timing of flowering or migration)

was well correlated with GHG-driven climate change, but not with natural variability alone. The species were distributed throughout Europe, North America, and Asia, thus representing a large portion of the Northern Hemisphere and not a particular region. Hence, the same type of response occurred regardless of differences in regional climate variability, again suggesting a global driving mechanism. The correlation with anthropogenically driven climate demonstrates that this global response can be explained by enhanced greenhouse warming, but not by natural climate variability alone.

A second study (Pounds et al. 2006. Nature 439:161-167) linked widespread mass amphibian extinctions in the tropics to the timing of climate change events associated with sea-surface and atmospheric temperatures. Warm years, which have increased in frequency over time, are followed closely by extinction events. Also, the majority of recorded extinction events are associated with warm years. While extinction rates correlate with the large-scale warming trend, they do not correlate with local variability associated with regional El Nino events, once again demonstrating that a global trend, rather than regional variability, is the more likely explanation for the impact. The authors explained this relationship as a function of pathogen outbreaks fostered by the observed warming and moistening trend in tropical mountain environments as a result of climate change.