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JUNE 2018

RESOURCES FOR THE FUTURE

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Abstract

Interest in a hybrid carbon tax that provides some assurance that emissions reduction targets will be met has emerged recently. To better understand how such a hybrid tax could work, I describe a prototype emissions assurance mechanism (EAM) to provide policy certainty that is practical, simple to implement, and easily understood. I outline an EAM that would lead to a 45 percent reduction in energy-related carbon dioxide emissions by 2035 relative to emissions in 2005. In 2035, an assessment would be made about a target reduction in emissions for the next 15 years.

Emissions are compared with an emissions pathway in each year. So long as cumulative emissions since the first year of the carbon tax do not exceed cumulative emissions along the emissions pathway, the carbon tax rate would increase at a standard escalator of 5 percent per year (plus inflation). If cumulative emissions exceed cumulative emissions along the pathway, an accelerated escalator of 10 percent would be used to increase the tax rate each year. Similarly, if cumulative emissions fall well below the pathway, the tax rate would be held constant (in real terms). The emissions pathway and EAM would be built into the carbon tax legislation.

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1. Introduction

When the United States gets serious about tackling its greenhouse gas emissions problem, policymakers should turn to a carbon tax as a proven market-based instrument to cut our emissions in a cost-effective and efficient manner. Economists have advocated this for decades, and increasingly, major companies, politicians, and environmental leaders are expressing their support as well. The shift toward the use of efficient, cost-effective policy tools is evident in the Climate Leadership Council's (CLC's) bipartisan proposal for a carbon tax.

The CLC's proposal rests on four pillars: (1) a gradually rising tax rate; (2) carbon dividends for all Americans; (3) border carbon adjustments; and (4) regulatory simplification. The last pillar is especially important if the plan is to garner broad-based, bipartisan support. While many business groups may be reluctant to support a carbon tax if US Environmental Protection Agency (EPA) regulations of emissions (e.g., the Clean Power Plan) are still in play, many environmental groups may be reluctant to support such regulatory simplification without assurances that the tax will lead to emissions reductions that exceed what could be achieved over time under regulatory oversight.

This paper proposes the inclusion of an emissions assurance mechanism (EAM) to ensure that regulatory simplification does not come at the cost of environmental integrity. This built-in mechanism would adjust the carbon tax rate automatically in response to changes in the economy to ensure that long-term environmental goals of emissions reductions are achieved. In contrast to approaches that require Congress to enact new legislation, the EAM would be included in the initial legislation passed by Congress and thus would significantly reduce the policy risk that a future Congress may fail to raise the carbon tax rate if emissions are not falling as rapidly as envisioned in the initial legislation.[1] Specifically, the proposed EAM component of a carbon tax would have the following features:

- A 15-year target for emissions reduction specified in the carbon tax legislation. Specifically, energy-related carbon dioxide emissions would be reduced by 45 percent below 2005 levels by 2035.
- An emissions pathway established beginning the year the carbon tax goes into effect and ending in 2035. The emissions pathway would be designed as a constant annual percentage reduction in emissions that achieves the 2035 target.
- An assessment undertaken before 2035 to set a target for the next 15 years out to 2050 and to set an emissions pathway to achieve that target.
- A tax rate that increases in a predictable way and that ensures progress toward the long-run emissions target.

The rest of this paper provides the rationale for and further elaboration on this mechanism. Section 2 discusses the academic literature on reducing uncertainty over emissions with a carbon tax and describes key design considerations that should be addressed when designing an EAM. Section 3 describes a specific EAM, and Section 4 offers a summary assessment and concluding thoughts.

[1] Policy uncertainty cannot be entirely eliminated. Congress cannot pass a law that is immune from repeal or amendment by future Congresses. The EAM reduces the policy risk of future Congresses not taking steps to adjust the carbon tax rate when higher rates are required to keep emissions reductions on track toward a long-term goal.

2. Literature Review and Design Considerations

An EAM is designed to provide greater certainty over environmental outcomes when a carbon tax is used to drive down carbon emissions. While a carbon tax has many desirable features that have led most economists to favor it as an efficient means to reduce carbon pollution (see, for example, the long list of economists who belong to Harvard economist N. Gregory Mankiw's Pigou Club[2]), a carbon tax does not explicitly limit emissions as regulatory oversight might. Murray et al. (2017) sketch out three broad approaches to reducing emissions uncertainty in a carbon tax: (1) tax rate adjustments, either predetermined or ad hoc in response to future congressional action; (2) the use of regulatory authority as a backstop to the carbon tax; and (3) the use of carbon tax proceeds to finance reductions in emissions (either emissions covered by the carbon tax or emissions in sectors not subject to the carbon tax). The Murray et al paper is a useful reminder that multiple options exist and that a strategy involving more than one approach could be sensible.[3]

Aldy (2017) proposes an approach similar in intent to that described in this paper. Assuming a carbon tax is enacted, Aldy lays out a process for revising the tax rate schedule in what he calls a "structured discretion" approach. Every five years, the president would convene a process involving the Departments of the Treasury and State along with EPA to recommend changes to the carbon tax rate schedule. That process would conclude with recommendations sent to Congress that would be considered in a process similar to the Congressional Review Act process for expedited review of new regulations, in which Congress holds a straight up or down vote on the recommendations with no opportunity for amendment or filibuster. Aldy's streamlined process for changing future carbon tax rates provides clarity in the policy process for changing rates but does not fundamentally address the issue of policy risk, which could undermine the effectiveness of the carbon tax. Elements of Aldy's approach do hold promise as a way to set a subsequent target for the next control period of the mechanism described below.

With respect to mechanisms for tax rates to adjust automatically based on explicit criteria set out in legislation, little has been written on the topic.[4] In my 2009 article "Cost Containment in Climate Change Policy: Alternative Approaches to Mitigating Price Volatility," I sketched out one of the first EAM-type mechanisms in my Responsive Emissions Autonomous Carbon Tax (REACT) proposal. The REACT proposal has the following features:

- An initial tax rate and standard rate of growth for the tax are set at the outset.
- Benchmark targets for cumulative emissions are set for a control period, which could be 1, 5, or 10 years or some other time interval.
- If cumulative emissions exceed the benchmark targets at the specified interval, the growth rate of the tax is increased to a higher rate until cumulative emissions fall to or below their benchmark targets in subsequent years.

[2] https://en.wikipedia.org/wiki/Pigou_Club.

[3] A similar taxonomy is provided by Kaufman et al. (2018).

[4] This section draws in part on Hafstead et al. (2017).

I ran some simulations to illustrate how the mechanism could operate but did not carry out an in-depth assessment.

The Swiss carbon tax law provides a precedent for an automatic tax rate adjustment conditioned on environmental factors.[5] The tax, which covers emissions from electricity and heating, had an initial rate of 12 Swiss francs (CHF) per metric ton of CO_2 in 2008 and 2009. By 2012, the tax rate had been raised to 36 CHF. The 2011 revision of the law specifies that if emissions in 2012 were greater than 79 percent of 1990 emissions, the tax rate would increase to 60 CHF as of January 1, 2014. The law specifies two additional milestone years (2014 and 2016) with tax rates to adjust (in 2016 and 2018, respectively) if the milestones were not met. The law put in place two different higher tax levels for 2016 and 2018, depending on the level of emissions 2 year previous. The tax rate rose to 120 CHF in 2018 as 2016 emissions exceeded 76 percent of 1990 emissions. This was the higher of two possible rates for 2018.[6]

The Whitehouse-Schatz American Opportunity Carbon Fee Act of 2015 (S. 1548) has a feature that is similar to an EAM but covers a far greater time span. It specifies that the tax rate should rise at 2 percent (over inflation) annually until emissions fall to 80 percent below 2005 levels, at which point the tax rate would be held constant in real terms. No US carbon tax bill, to my knowledge, has an explicit EAM-type provision to ensure that environmental targets are met.

A recent paper by Hafstead et al. (2017) lays out a number of key design choices for policymakers to consider in developing a mechanism to provide some environmental assurance to the tax. Below, I list these design choices along with my own views on how each should be resolved:

- *Rules versus Discretion*. Should the tax rate change be automatic or subject to discretion on the part of lawmakers? Given that the purpose of the mechanism is to reduce policy risk and provide greater assurance that environmental goals will be achieved through the tax, it is important to take a rules-based approach and embed conditional tax rate changes into the implementing law.
- *Control Period*. The control period is the period of time during which the EAM is in effect and tax rates are adjusting to meet an environmental goal. Hafstead and colleagues argued that the control period should be sufficiently long to provide policy certainty to investors, given the long-lived nature of many energy investments (e.g., power plants), but not so long that any end-of-period target becomes entirely speculative. Setting a target for 2100, for example, would require heroic assumptions about energy technologies and the state of the economy, making any environmental goal tied to policy meaningless. A policy going out 15 or 20 years does not require such heroic assumptions. The year 2050 has taken on the status of a focal point in environmental policy discussions as a midcentury point of reference for policy goals. If a carbon tax went into effect in 2021, setting an environmental target for 2035 with a legislated assessment for a

[5] For an overview of the Swiss carbon tax law, see Sopher and Mansell (2013).

[6] *Ordonnance sur la Reduction des Emissions de CO_2*, Le Conseil Federal Suisse, enacted on December 23, 2011 (RS 641.71), http://www.news.admin.ch/NSBSubscriber/message/attachments/31399.pdf (accessed August 13, 2016). According to a July 13, 2017, article in the Swiss newspaper *Le News*, the tax rate was to rise to 96 CHF on January 1, 2018. See http://lenews.ch/2017/07/13/tax-to-rise-as-switzerland-misses-emissions-target/.

subsequent target for 2050 would provide a balance between flexibility and policy certainty.

- *Targets and Interim Benchmarks*. Hafstead and colleagues refer to a target as the desired emissions reduction at the end of the control period (e.g., 2050). However, there is great uncertainty in modeling regarding the costs of deeper emissions reductions two, three, and four decades from today, suggesting that setting a nearer-term target may be preferable. A nearer-term target of a 45 percent reduction relative to 2005 by 2035 would lock in major emissions reductions and allow for an informed judgment on a subsequent target that accounts for information gained over the next two decades regarding both technology costs and damages from ongoing emissions.
- *Types of Adjustments*. Adjustments to ensure that emissions stay on a path toward a long-term goal can take various forms. One approach would be to set out a schedule of tax rates over time, with rates in any given year contingent on progress toward interim targets for emissions in various years. This is the approach taken in the Swiss carbon tax law, which legislated two or three changes in the tax rate for subsequent two-year control periods out to 2020, with the expectation that tax rates for control periods beyond 2020 would be enacted later. The Swiss approach illustrates that setting contingent tax rates can become very complicated (and probably unfeasible) for control periods going out more than a decade.

In my 2009 essay, I suggested a simpler approach: set a "standard" tax rate escalator in the enacting legislation that would increase the carbon tax rate each year by a fixed percentage, then set an "accelerated" tax rate escalator that increases the carbon tax rate by a higher percentage when emissions are not falling as rapidly as desired (and specified in the legislation). I suggested a standard carbon tax rate increase of 4 percent plus inflation each year and a 10 percent rate (plus inflation) when emissions reductions fall short of the target. Hafstead et al. (2017) note that economic theory does not favor an approach based on the Swiss model over my tax rate adjustment approach. The authors stress that clarity and certainty in how the tax rate adjusts is the most important consideration for the business community as it plans long-term energy investments. Below, I follow an approach similar to my earlier approach with one modification: if cumulative emissions fall well below cumulative emissions along the emissions pathway (as specified below), the tax rate is held constant (in real terms). When and if cumulative emissions grow and begin to approach cumulative emissions along the pathway, the tax rate adjustment mechanism again goes into effect.

- *Frequency and Size of Adjustments*. Tax rate adjustments can occur frequently in small increments or less frequently in larger increments. Hafstead and colleagues argue for more frequent, smaller adjustments as emissions deviate from any desired path. In their words, "A balance must be struck between an adjustment process that provides credibility in the environmental outcomes and a process that does not lead to abrupt and large economic costs" (2017, 50). In my 2009 essay, I envisioned adjustments occurring on the order of three to five years. But that approach risks large jumps in the tax rate that might be responses to transitory fluctuations in emissions. Below, I propose a process that in each year compares cumulative emissions since the carbon tax was put in place with cumulative emissions along the emissions pathway. If cumulative emissions exceed those along the emissions pathway, the tax rate increases based on the accelerated escalator for the coming year; if not, the rate increase is based on the standard escalator.

- *Adjustment Trigger*. The adjustment to the tax rate can be discrete (as described above) or continuous, with the tax rate increase depending on how far emissions diverge from the target in a given year. While a continuous target may be attractive because of its ability to fine-tune the tax response to emissions, any gains are likely to be offset by greater complexity and less transparency. Since my proposed adjustment is to the percentage increase in the tax rate rather than large changes in the tax rate itself (as is the case with the Swiss carbon tax), a simple rule with two possible tax rate percentage increases (standard and accelerated escalator) would provide clarity to the business community, be easy to implement and oversee, and provide the environmental assurance we seek in the mechanism.

More recently, Hafstead and Williams (2018) constructed a simple reduced-form model of emissions that captures cyclical and trend uncertainty around emissions as well as uncertainty around the responsiveness of emissions to carbon pricing. They use their model to assess many of the elements of mechanisms to build emissions certainty into a carbon tax as described above, including many elements of the EAM proposed in this paper.

3. Description of a Proposed Emissions Assurance Mechanism (EAM)

In this section, I describe a simple, pragmatic EAM that would provide greater certainty of achieving significant emissions reductions by midcentury. The mechanism does this in a two-stage process. Assuming a carbon tax goes into effect in 2021, I set a 2035 target of a 45 percent reduction in energy-related carbon dioxide emissions from the 2005 level. A reduction of this magnitude would be a considerable achievement that would put the United States on a credible path to significant emissions reductions by midcentury. Sometime before 2035, a government process would be put in motion to set a subsequent target for 2050.

The subsequent target-setting process could be designed along the lines of the proposal by Aldy (2017), which begins with a government process involving relevant administration agencies (e.g., EPA and the Departments of Energy, State, and Treasury) to consider the state of technology and new information about damages from ongoing emissions and propose a midcentury emissions reduction target. Congress would then vote on the new target as an update to the carbon tax legislation, perhaps using a process similar to the Congressional Review Act process, which requires a straight up or down vote with no opportunity for amendment or filibuster. Such a process would provide discretion to a future administration and Congress to set a new target going forward that takes account of new information gained over the next two decades, while structuring the decision process in a way that reduces policy risk. The original legislation could also specify that if Congress does not affirmatively vote on a new emissions reduction target in 2035, then the existing policy through 2035 would automatically continue through 2050, with a midcentury emissions reduction goal setting the emissions path for the second control period set forth in the initial legislation.

An EAM could be constructed to operate over a 30-year time horizon rather than two 15-year windows. The advantage of a single window is that a 2050 target would be built into the initial legislation and would align with midcentury goals discussed in both national and international climate policy circles. The disadvantage is that there is no scope for updating targets as we gain experience with the economy's response to a carbon tax. One advantage of two shorter control periods is that green technology innovation driven by carbon pricing between 2020 and 2035 could reduce the expected cost of a more stringent 2050 target and allow for greater ambition in the 2035 to 2050 window.

Going forward, I focus on the 2035 target. The EAM consists of a standard tax rate escalator and an accelerated tax rate escalator. The idea is simple: If emissions are falling over time consistently with an emissions pathway, as described below, the carbon tax rate would increase annually at the standard tax rate escalator of 5 percent plus the rate of inflation. If emissions, however, are falling more slowly, the carbon tax rate would increase annually at the accelerated tax rate escalator of 10 percent plus inflation. Once emissions return to the emissions pathway, the carbon tax would revert to the annual tax rate increase of 5 percent. If, on the other hand, emissions fall more than 10 percent below the pathway—perhaps because of an unexpected technological innovation—the tax rate would be held constant in real terms so long as this significant overcompliance persists. Subsequently, if emissions exceed 90 percent of the pathway, the tax would revert to the annual tax rate increase of 5 percent. For the first five years of the tax, the standard tax rate escalator would be kept in place regardless of actual emissions. This provides a grace period for the economy to respond to the new tax and begin to set in place the investments and changes in behavior that will lead to long-term emissions reductions.

An *emissions pathway* is specified in the carbon tax legislation. The pathway describes target emissions in each year following implementation of the tax to 2035 and sets out the specific environmental goals for the legislation. Table 1 shows a suggested pathway constructed by setting a first-year target of a roughly 17 percent reduction in emissions in the year following implementation of the tax relative to the US Energy Information Administration's (EIA's) *Annual Energy Outlook 2018* reference level emissions for 2021, as well as subsequent targets that are a constant percentage reduction from the first-year level such that emissions hit the goal of 45 percent below 2005 emissions in 2035. The initial year target (a target for emissions in 2021 if the carbon tax goes into effect in that year, as I assume in Table 1) is a conservative target based on modeling that suggests substantial initial emissions reductions when carbon pricing is put in place.[7]

The emissions pathway need not be precisely the one given in Table 1. A pathway could be chosen with different criteria for the initial year target (2021, in the example above) and could allow for different percentage reductions in emissions for different years between 2020 and 2035. The pathway could also be determined through economic modeling that informs the tax-writing process. Whatever pathway is chosen, however, it is important to ensure that the final year target would be achieved on the pathway (the 45 percent reduction from 2005 emissions) and that there would be a smooth decline over time.

While the emissions pathway is described in terms of annual emissions that achieve a given long-term goal (a 45 percent reduction in emissions by 2035 relative to 2005, as described here), the tax rate adjustment

[7] Resources for the Future's E3 carbon tax calculator, for example, estimates a roughly 20 percent initial reduction in emissions in response to a $40 per ton carbon tax implemented in 2018. http://www.rff.org/blog/2017/introducing-e3-carbon-tax-calculator-estimating-future-co2-emissions-and-revenues. Similar results are shown in Hafstead and Williams (2018).

mechanism is triggered by comparing cumulative emissions since the tax went into effect with cumulative emissions along the emissions pathway. Basing the tax rate adjustment trigger on cumulative emissions has several advantages over a trigger based on a single year (or an average of a few years) of emissions. First, basing the trigger on cumulative emissions reflects the scientific reality that greenhouse gases accumulate in the atmosphere and persist for hundreds of years; as a result, it is cumulative emissions that matter rather than emissions in any given year. Second, basing the trigger on cumulative emissions provides flexibility in the policy. If emissions fall more rapidly than expected in early years but less rapidly in later years, the policy will not overcorrect by pushing the tax rate up so long as cumulative emissions do not increase. Third, a trigger based on cumulative emissions will be less sensitive to business cycle fluctuations and thus provide price stability, an important factor for the business community. This also improves the ability of businesses to predict future tax rates. Fourth, greater price certainty provides a clearer signal for firms engaged in research and development of new carbon-free technologies. The more clarity there is about future carbon prices, the more innovation is likely to occur that will accelerate the transformation to a carbon-free economy.

Carbon tax legislation will set an initial carbon tax rate.[8] Under the EAM, the tax rate would initially increase at the standard tax escalator of 5 percent per year for the first five years. After that, the EAM trigger provision would go into effect.[9] The accelerated rate escalator would be triggered if cumulative emissions from the year the carbon tax goes into effect exceed cumulative emissions along the emissions pathway.

In general, a new carbon tax rate that adjusted by this EAM would be a function of cumulative emissions through the year two years before the new tax rate goes into effect. Specifically, consider the timeline for setting the tax rate in 2028. The tax rate needs to be set sometime in 2027 and thus can use information on cumulative emissions only through 2026. Energy-related carbon dioxide emissions are available with a three-month lag, so Department of Energy officials would have a preliminary estimate of 2026 emissions as early as March 2027. Cumulative emissions since 2021 can then be computed and compared with cumulative emissions along the emissions pathway. If actual emissions exceed the target, the 2028 tax rate would be set at the 2027 rate plus 10 percent. If actual cumulative emissions do not exceed the threshold for triggering the higher tax rate, the 2028 tax rate would be set at the 2027 rate plus 5 percent.

[8] The CLC has proposed a tax rate of $40 per ton carbon dioxide in 2017. Assuming a 2 percent per year inflation rate, this translates to a carbon tax rate of $43 per ton in 2021, the first year of the tax's operation.

[9] The standard and accelerated escalators are both expressed in real terms; the actual tax rate increase is 5 percent (or 10 percent in the case of the accelerated escalator) plus the rate of inflation.

The 2028 tax rate would be announced by Treasury no later than June 1, 2027.[10] But since monthly emissions data are published by EIA with a three-month lag, firms would have a good idea of the likely tax rate for 2028 by at least January 2027—a full 12 months in advance. By January 2027, there would be 9 months of data on emissions from 2026. As time goes on, firms would have greater certainty about the path of the future tax rate as an additional year of emissions has a smaller and smaller impact on cumulative emissions. Figure 1 illustrates the timeline for setting the tax rate in 2028.

Because the EAM would only be adjusting the rate of growth of the tax rate (as opposed to forcing a major jump in the tax rate), there is no need for a phase-in. If cumulative emissions exceed the target based on the emissions pathway, the rate would rise by 10 percent the following year; if emissions do not exceed the target, the rate would rise by 5 percent. Such a process whereby a provision switches on or off depending on a price threshold has considerable precedent in the tax code.[11] The EAM accelerated escalator is unlikely to be triggered given an emissions pathway like the one suggested in Table 1. The accelerated escalator is available, however, as an insurance mechanism should the expected emissions reductions fail to materialize.

4. Conclusion

A carbon tax is a simple, transparent market-based instrument that can incentivize the US economy to reduce its carbon emissions in a cost-effective manner. An environmental assurance mechanism (EAM) along the lines of the one described in this paper would add strong assurances that an ambitious but technologically and politically ambitious emissions reduction target of 45 percent reduction by 2035 would be achieved; a onetime reassessment at that point could set a new target for emissions reductions through 2050. Alternatively, a longer-term target to 2050 could also be set in the initial legislation, though given the greater uncertainties in projecting technology innovation and costs in later years, a nearer-term target with a onetime reassessment may be a preferable approach.

Falling short of that pathway would trigger the accelerated rate escalator being used to increase the carbon tax rate. Based on the framework outlined in this paper for achieving a 45 percent reduction in emissions by 2035, economic models consistently show that in all likelihood, the accelerated rate escalator would not be triggered and the tax rate would grow according to the standard rate escalator. Building the higher escalator into the carbon tax legislation would reduce concerns about policy uncertainty that could undermine support for a carbon tax. Similarly, a pause in escalation if cumulative emissions fall well below the target emissions pathway would give the program flexibility to respond to unexpected technological or economic shocks.

The EAM proposed here is simple, easily understood, and straightforward to administer by the Departments of Energy and Treasury. Enacting a carbon tax with this feature would move the United States into the forefront of climate leadership while positioning businesses to be competitive in a carbon-constrained world.

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[10] EIA initially publishes annual data in the March *Monthly Energy Review* (published toward the end of the month). The April edition may revise the data slightly. This gives the Department of the Treasury ample time to write and release a notice with the next year's tax rate by June 1. EIA periodically revises its energy-related carbon dioxide series based on new information. Since the tax rate trigger would be based on cumulative emissions, the Departments of Energy and Treasury should develop guidance on what measure of historic emissions would be used to set future tax rates. Whether the rule uses preliminary or final estimates of emissions and whether revisions to the historic emissions series would be allowed are unlikely to have a major impact on tax rate setting. Clear guidance should be developed, however, so that everyone understands how the process works.

[11] An example is the marginal wells tax credit, which is allowed when prices fall below a threshold price (26 U.S.C. § 45I [2007]).

FIGURE 1. TIMELINE FOR SETTING CARBON TAX RATE (2028 RATE)

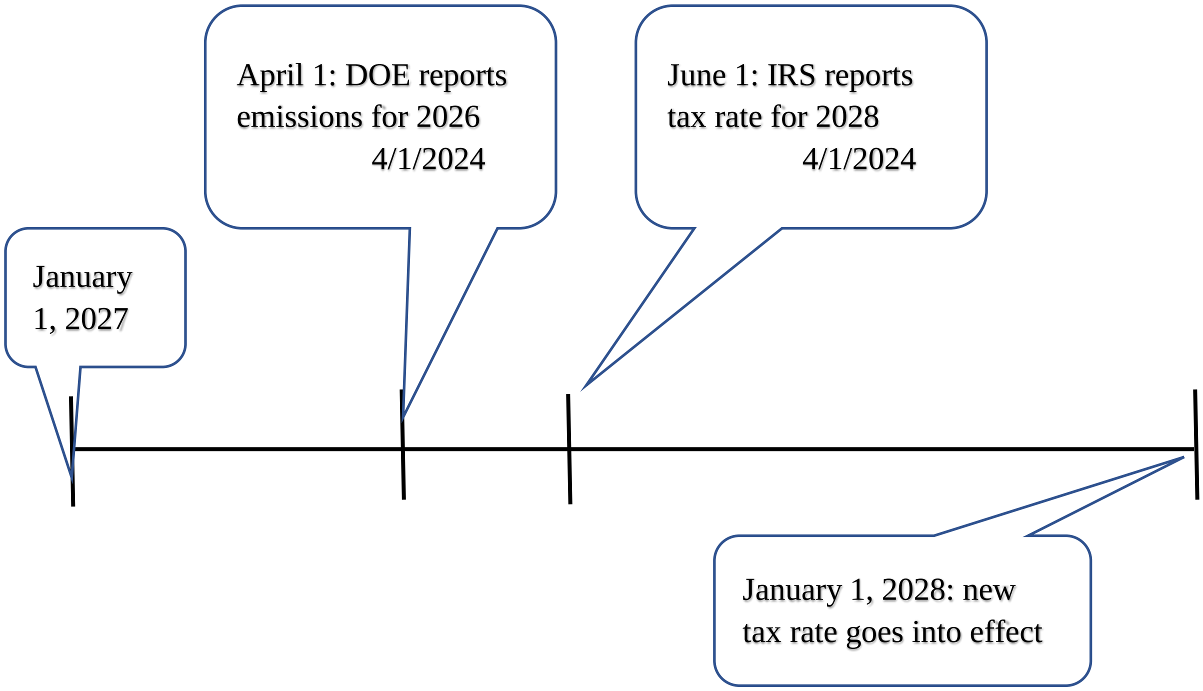

TABLE 1. EAM EMISSIONS PATHWAY

Year	Emissions Pathway	Percentage Reduction	Cumulative Target
2021	4,250	29%	4,250
2022	4,173	30%	8,423
2023	4,098	32%	12,522
2024	4,025	33%	16,546
2025	3,952	34%	20,499
2026	3,881	35%	24,380
2027	3,811	36%	28,191
2028	3,742	38%	31,933
2029	3,675	39%	35,608
2030	3,609	40%	39,217
2031	3,544	41%	42,761
2032	3,480	42%	46,241
2033	3,418	43%	49,659
2034	3,356	44%	53,015
2035	3,296	45%	56,311

Note: Emissions are millions of metric tons of energy-related carbon dioxide. Percentage reduction is the reduction relative to 2005 emissions.

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