Transcript of CleanLaw: Joe Goffman Interviews Alex Barron about Climate Models, January 13, 2020

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Robin Just: Welcome to CleanLaw from the Environmental and Energy Law Program at Harvard Law School. In this episode, our executive director, Joe Goffman, speaks with Smith College professor of Environmental Science and Policy, Alex Barron. Alex is a former senior official in EPA policy office, and discusses his work with economists and other experts, to understand the strengths and weaknesses of the economic models we use to analyze carbon pricing policies. We hope you enjoy this podcast.

Joe Goffman: Well, hi, Alex, it's great to talk to you again, and thank you very much for agreeing to record an episode of the CleanLaw podcast.

Alex Barron: Thanks so much for having me on, Joe. I'm really looking forward to chatting.

Joe: As you probably know, from our years of working together, I consider you to be one of the unsung heroes or hidden stars of environmental policy. Would you mind giving us a brief resume of your career, before you took your current job at Smith College?

Alex: I'd be happy to do that. I think we're probably going to get into a lot of conversations about economic modeling today, and so, I can just start at the outset by pointing out that I'm not an economist, I was pushed and led into this work by circumstances and interest. So, by training, I'm a scientist, in particular, an ecologist. I did my graduate work at Princeton University, where I studied the nitrogen cycle in lowland tropical rain forests in Panama. And I think I'm typical of a lot of ecologists who are now in the policy space, in that, I was working in Panama and looking at a landscape that was outside of the boundaries of the national park I was working in, being transformed by land use change, with forests being cleared, and then, all of it collectively being impacted by the early stages of climate change.

Alex: And I thought, there must be other ways for me to work on this issue, besides digging up tree root nodules. And I was trained as a system scientist, and so, I thought, "Well, clearly, the challenge in the system here doesn't seem to be that we need more science to understand that climate change is a threat to humanity and it will have tremendous impacts on our health and wellbeing, and in particularly unjust ways to society, both domestically and globally." And so, the problem clearly lies in the policy space. And so, if I want to work on this sort

of whole, or system, then it's the policy component of these big social ecological systems that I need to know something more about.

Alex: And I was lucky enough to get a fellowship through a program that's run by the American Association for the Advancement of Science, they publish Science Magazine. And I was sponsored by the American Chemical Society, and they run a bootcamp for scientists, that lasts a few weeks, and then they place you directly into a congressional office. There's a separate program that also does this in the executive branch. And so, I had a crazy fall, where, in mid-August, I was in Panama collecting a few extra samples and training in a postdoc, to continue on my research. And then, about a month later, I found myself interviewing in offices in Congress, to try and find a placement.

Alex: And in an illustration that it's better to be lucky than smart, I happened to show up right at the time when the Senate was starting to get really serious about climate policy. And in particular, at that time, Senator Joe Lieberman was serving on a subcommittee on Environment and Public Works, with then Senator John Warner, Republican of Virginia, and they were crafting the Lieberman-Warner Climate Security Act. And I was lucky enough to be hired on to that staff as a fellow for the year, including by the legislative director Joe Goffman at the time. And that started my work in the policy space.

Alex: So, I was able to work on a whole bunch of different aspects of that bill, and I found that it was a tremendously exciting time to be working on climate policy, that it was exactly what I wanted to be doing. And that, actually, intellectually, I found it tremendously satisfying to work on these really tough climate problems. I worked on the nitrogen cycle, which is the most baroque of the nutrient cycles. It's incredibly complicated, it's incredibly hard to study. But I find that understanding what a policy will do in the real world of our electricity sectors and markets, is equally, if not more challenging, with the added co-benefit that you get real reductions in greenhouse gas emissions, if you can solve that problem.

Alex: And that position in the Senate, led to an opportunity to work on the professional staff of the House Committee on Energy and Commerce, just as the climate legislative activity was switching over there. So, I was actually originally a staffer for John Dingell, and then, for Henry Waxman, when he took over chairmanship of that committee. And so, I worked for Chairman Waxman and Subcommittee Chairman Markey on the American Clean Energy and Security Act, also known as Waxman-Markey, all the way through House passage of that legislation. And then I worked on a number of related climate and energy issues while I was there.

Alex: And then, in 2011, I had another fantastic opportunity to move over to the Environmental Protection Agency as a senior advisor, and then, later, deputy associate administrator in the office of policy, in the administrator's office at EPA, right at the time when EPA was really working to develop and then implement the Climate Action Plan. So, a series of federal rules to reduce greenhouse gas emissions, including light duty vehicle rules for tailpipe standards, the various pieces of the Clean Power Plan, new source performance standards for methane, and then a host of other related rules, that also, for example, impacted the power sector.

Alex: And while I was there because of my technical background, I also worked really closely with many of the technical experts in the agency on general themes in environmental economics. So, it was a tremendously productive run in federal policy making, from my perspective. Sometimes I think of the movie, Forrest Gump, where Forrest Gump is winding up at all these tremendous moments in history. And so, it was really great to have those opportunities. And so, my experience and thinking about the use of modeling and policy design, comes from having to learn on the fly, as we developed these various kinds of policy proposals and refined them.

Joe: Well, Forrest Gump should only be so lucky. The period of time you were talking about, I think, spans from about 2007, to about 2015. Which, I would argue, was the most productive period in, at least, the intellectual aspects of developing climate policy at the federal level, both in Congress and in the executive branch. And I think, if anything, your description of your role was excessively modest, having worked with you in the Lieberman shop, and then worked with you as a counterpart on the Senate side, while you were in the House, on Waxman-Markey, and then having worked with you with EPA, I can attest to the fact that you really made absolutely stellar contributions to policy development in every single stop that you described.

Joe: Just to flag a couple of things, I think most listeners to this episode, probably have very strong views about Senator Lieberman, and don't necessarily recall that from the moment he entered the Senate in 1989, through the end of his Senate career, he was widely considered to be, and I think justifiably so, to be a real powerful leader on climate policy and environmental policy more broadly, which is why we were able to recruit somebody of your stellar talents. The other thing I wanted to do, is to call out the AAAS Fellow's program. I think your story is not atypical, a lot of AAAS fellows spend a year in a government post, and then, either remain in public policy, and/or government, for most of their careers, or do so for a big chunk of their careers.

Joe: And I have crossed paths with maybe a dozen or more AAAS fellows, and each and every one of you stands out as really the finest of the policy and

government professionals I've ever worked with. And that, I think is a nice way to pivot into our main subject, which is, what really interests me about your experience-based expertise, is the fact that, in every single post that you had in government, again, both in Congress and in the EPA, you were a master craftsman applying a variety of policy tools, including economic models. And it's from your craftsmanship, that I think you have a distinctive qualification to talk about what economic models can or can't do.

Joe: And one of the reasons we're, I think, so interested in economic models now, is that, well, actually, it's twofold. First, a number of proponents of climate policy on the federal or at state level, focus their policy proposals around what are called pricing mechanisms, in particular, carbon fees or carbon taxes. And, of course, the other reason that economic models as tools are interesting, is that, the EPA, under both Republican and Democratic administrations including this administration, use economic models, not so much to set policy, but to provide an evaluation of what their programs or their rulemakings are projected to do. And there's been a fair amount of controversy about what the current EPA is doing with its Regulatory Impact Analyses.

Joe: In fact, we've had other guests on the CleanLaw podcast who have talked with us about that and about the sometimes suspicious way the EPA has used its RIAs. So, if we can get to all that in the next little bit or so, it would be great to cover that. But let's double back to the question of, what is our experience using economic models, not to evaluate policy, but to set policy? And in this case, I'm thinking about, what do we know about how economic models perform, or what the limits of their performance are, in terms of using them to prospectively say, set the level or inform the design of a carbon tax?

Alex: That's a great question. My perspective on the use of models for policymaking is really informed by my background as an ecologist. I think that for a lot of people who are not coming from the either the science or the economic realm, when they hear the word model, it conjures something incredibly complex that has thousands of equations and lines of computer code, and that runs on a supercomputer. And that's true, there are many models that work that way. But, in scientific parlance, a model can be a mental model of how you approach and think about problems, or it can be an analytical model where you're doing calculations. But the complexity can really range from something as simple as a spreadsheet.

Alex: And, in fact, there are some models that people think of as being very complicated that run on spreadsheets, to much more complicated things. And in the ecology space, people will distinguish between different kinds of models. So, at one extreme, you have what we might call a toy model, which is just a couple of simple equations that you put together to try and get a sense of the dynamics

of a system. And at the other end, you have what we would consider a predictive model, which is that a model that you think is robust enough, and ideally, mechanistic enough, that it can give you a good sense of what might happen in the future, under a given set of assumptions. And I think, ecologists in all this space, when they're working well, like economists, bring a lot of humility to this exercise.

Alex: Both in ecology and economics, you're working with quantities that are really hard to measure. Sometimes you might even have a metric, but it's not exactly the thing that you would really want to measure in the environment. And the systems are complex adaptive systems. All of the pieces are connected and responding to each other, and that can make the dynamics very hard to predict, even if you had perfect information, which you don't. And so, I guess the first thing I want to say, just to underscore the point, is that, models are really essential for policymaking, because, when we're talking about intervening at the scale of the economy, or a very large sector like the electricity sector, those spaces are generally too complex for people to fully understand the dynamics, without the aid of some kind of modeling framework.

Alex: And I think you had Kathy Fallon Lambert on, in an earlier episode, talking about the Affordable Clean Energy rule, and her analysis of that rule is a perfect example of that. A policymaker might not necessarily expect that making a power plant more efficient could actually lead to an increase in emissions, but that's exactly what happens when you couple those power plants up to electricity markets. So, you get this counterintuitive result, that, small measures to increase the efficiency of a facility, actually lead to emissions increases in lots of locations. And a model can help you see that pattern, and get a sense of the magnitude. And so, when we think about using models, we can use them to do things like figure out what the key levers are in policy design, how sensitive the outcomes are to various kinds of assumptions, and use them to calibrate the cost and ambition of a policy.

Alex: And so, in theory, there's a lot that you can do with models, to try and understand policy design. In reality, it's a little bit more challenging because you're almost always making these decisions under sub-optimal circumstances, where you're having to turn around the modeling relatively quickly, where, a model platform may not have all the current information that you would like to figure out how to use it, and a whole host of other factors that can make it hard to do exactly what you want to do. But, I think, models can tell policymakers those kinds of information, like, how much does adding this feature to a policy alter the outcome? How much do I have to worry about variability in key parameters? Which parameters do I have to worry about? And then, what's the rough order of magnitude that you might expect from a policy?

Alex: Those are some of the kind of key impacts, and you could add on to that list, things like the distributional impacts of a policy, which is another kind of thing that it could be hard to get at without some kind of modeling analysis.

Joe: Thanks. That was a good overview, Alex. A couple months ago, you shared with me a paper and a PowerPoint presentation of some work that you had done with Noah Kaufman, and, at least, one other co-author. And I thought that was a really illuminating aspect of, again, the larger question of what models can or can't do. Why don't you give us an overview or a walkthrough of that?

Alex: This is work that I've been doing with Noah Kaufman and Pete Marsters at Columbia, and Haewon McJeon and Wojciech Krawczyk at the University of Maryland. And we all have our different entry points to this project, but, for me, it stems from this, what I like to think of as a deep Midwestern pragmatism, which is that, we need to be setting policy right now, to deal with greenhouse gas emissions. But, our modeling capacities are not at this perfect stage that you would want to do that really, really well. And so, this work actually channels a paper from Baumol back in 1972, where he talked about choosing effectiveness over theoretical nicety.

Alex: And the work is basically focused on this idea that economists have been really focused on first best policies. And the discipline as a whole, is, I think, to some degree, rightly focused on trying to figure out what's the most efficient way to get to a given policy outcome. And I think, doing that search is an important thing, the more efficient we can make a policy, the more cost effective it is, we can reduce the overall burden on society, by engaging in those pieces. But, efficiency is only really one criteria that a policymaker might consider when designing a policy, and I share your earlier guest, Gernot Wagner's criticism that economists probably don't spend enough time looking at second best policies or alternate implementations of their first best policies, in ways that answer the questions that policymakers actually have.

Alex: And so, the question that we were focused on, with this project, is, it's a new Congress, we need to move forward aggressively on climate change, there's a lot of momentum and a number of pieces of legislation around carbon pricing. And so, where would you set a carbon price, in one of these proposals? How should you think about setting this? And a lot of the focus in the literature and historically, has been on using the social cost of carbon to arrive at an estimate where you would want to set the carbon price. And this is deeply rooted in theory. If you have a Pigouvian tax, then, if you set that tax at the social damages of a pollutant, then the economy will magically equilibrate and control those emissions to the appropriate level.

Alex: And I want to be clear that I think we need estimates of the social cost of carbon. They provide useful information about the damages of climate change, and it's the right tool to get, for example, the avoided climate damages associated with a regulation in a benefit-cost analysis. We need some number to put on the damages of climate change. The courts have been very clear that, saying that that number is uncertain, is not a good basis for using zero in those estimates. And there's a bunch of really good work going on, including at Resources for the Future, under the University of Chicago and the Climate Impact Lab, refining our current estimates of climate damages.

Alex: But, if you actually want to pick a number for a carbon pricing policy, say, in Congress, you do face the challenge that those estimates are really uncertain. Because, there're so many things that are uncertain that go into that estimate, and that includes exactly how large changes will be, for a given level of greenhouse gas emissions, how those translate to various kinds of biophysical impacts, how those biophysical impacts translate into impacts on economies in society, how much people will adapt to those things, and what dollar value we should place on all of those things. Each of those terms comes with some aerobars, which end up magnifying the uncertainty.

Alex: And then, there's other things like the discount rate, where people end up baking in, from my perspective, some value judgments about how much weight we should place on future generations. And all of that ends up in a number, and the range of numbers that you get from social cost of carbon estimates is really quite broad. And so, it doesn't act as a very effective pointer to where exactly you would want to set a carbon price. And so, we've taken this alternate approach, which is that, for many policymakers, they are not entering the conversation, saying, "How can we balance costs and benefits to society as a whole? And what's exactly the right number there?" Policymakers like to think in targets.

Alex: And they're pretty justified in doing that here, because, the scientific community has worked over the last few decades, to give a bunch of target-related information to policymakers, and we've negotiated international treaties around that. And so, there's this widespread agreement that we're going to try and keep temperatures below two degrees C, with the goal of keeping them closer to 1.5 degrees C, and we now have windows, and we can use our models to understand when greenhouse gas emissions or CO2 emissions have to come to zero, in order to be consistent with those targets. And so, we're still looking for a snappy acronym for this, but we think of this approach as near-term to net zero approaches to setting carbon prices.

Alex: And, it basically, instead of trying to work through the social cost of carbon with all that uncertainty and value-laden assumptions in it, instead, you just focus on

asking the question, what carbon price would we need to achieve a given net zero targets? And so, for example, you could say, "We want to get CO2 emissions in the U.S. to zero by 2040, or 2050, or 2060." The policymaker dictates that. But, you figure out, what's the emissions' trajectory that is consistent with getting down to that target. And then, what you do is you ask the model to really focus in on, what are the carbon prices that are consistent with getting on that trajectory through 2030? So, that's the near-term. To net zero is where you're heading, that's the long-term target that calibrates the emissions' trajectory. And then, the near-term is just through 2030.

Alex: And the reason that we do it just through 2030, is because these models are not very good at long-term predictions. When I talk to policymakers about modeling carbon pricing policies, I often compare it to weather forecasts. There was a time, not too long ago, when you could look at the three-day forecast. And that was basically about as far out as you could trust a weather forecast. Now, you can look on your iPhone and get a weather forecast for the 10-day forecast. And it's not perfect, but it can give you a sense about whether you might want to keep your plans for going hiking next weekend, or you might really want to think about canceling them. And you can't open your phone and look at the 20-day forecast, because that's not a thing.

Alex: Forecasters who work on the weather, basically say that beyond that 10-day window, the uncertainties just get too large, and the models might produce outputs, but they're not reliable. My entree to this work, came in from a separate effort with the energy modeling forum, and we wrote a paper that came out of that, where we basically said the same thing, that you should focus on this first decade. That the uncertainties are too large to make quantified results useful in those out years. And so, in this approach, we focused on just looking through 2030, and getting a carbon price trajectory with the idea that policymakers could come back later, and then update their prices going forward, based on new formation.

Alex: And that's basically the approach, is, we just asked the model this very constrained question, "What prices do we need, to get through to 2030, to be on a trajectory consistent with getting to zero?" And I'll pause there.

Joe: And you've paused just at what I consider an important knob, which is, reframing the question, if I understand it correctly, is, is what you just stated, what prices do we need to set by a way of, say, again, a carbon fee or a carbon tax, to get to a certain emissions level by 2030? Or maybe, what I really mean to say, get on a certain trajectory between now and 2030. And so, I think that begs a question along these lines, what's the brief, what's the case for an interested citizen or a group of policymakers, for trusting the carbon price number that the models come up with, by a way of answering the 2030 trajectory question?

Joe: That question comes from many number of places, but one place it comes from is this, when we've historically, as a society, set our collective minds to achieving pollution reduction, air pollution reduction, we've concentrated on a certain set of tools, either technology-based emission standards, or emissions' caps. We've made the emission reduction target an explicit part of the legal mandate, or we've made the technologies that we think we can count on to produce emissions reductions, to be an embedded part of the explicit mandate. We have a lot of experience with that, and we also have a collective political instinct that brings us again and again to those kinds of policy tools.

Joe: Now we're basically asking ourselves to look to a tool that we've never used before in the air pollution context, which is, setting of fear attacks on the pollutant, and expecting that, at the going in moment, when we write the law, we'll be doing so with the same level of confidence that we had, when we, say, set the Acid Rain, Sulfur Dioxide Emission Cap in 1990, or, set the control technology standards for mercury and air toxics in 2011. So, that's the threshold of persuasion, that is a practical matter, interested citizens and policymakers have gotten used to. So, that's the context for my question, what's the brief for saying, we've gotten our modeling tools up to a level of sophistication and reliability, so that the carbon tax value, or a number that they spit out, meets that same threshold of confidence?

Alex: I would tweak your response a little bit. It's true that, we, in the U.S., have not deployed an economy-wide carbon price, to deal with environmental pollution. Fundamentally, as a scientist, I'm an empiricist. So, my whole graduate thesis was basically looking at some theoretical arguments in the literature, and deciding that I had to spend five years digging up tree roots, so that I could actually have hard data on which model to trust. And so, when I try and figure out these policy tool questions, I'm always looking for empirical data. And I think, we can look to other countries that have included carbon prices in the suite of policies that they're using to address the climate crisis, and look at the literature that's analyzed those responses.

Alex: And we do see in those cases, that, these countries have not done a perfect job of reducing emissions, but that the price signals have led to reductions in emissions, and in some cases and in some sectors, reductions that are larger than the models would have predicted. So, I think we can combine that, with the fact that, although we'd haven't used, for example, carbon taxes as a tool on a widespread basis in the U.S., we use a lot of instruments that are price-based. And so, I think an argument can be made, that, under a cap in trade system, it's not so much the cap as the permit price, that shapes the behavior of various power plants in making decisions. They have an expectation about what the cap is going to do, and what that's going to do to permit prices, and they plan accordingly.

Alex: If, for renewable portfolio standards, actors in the market are responding to expectations about where prices for RECs are going to be in the future, and that calibrates the actions that they take to comply with that standard. So, obviously, those other tools are more complicated than just price, but I think, the fundamental underpinnings of a carbon price are very well founded both theoretically and in practice. And then, I think the next part of your question is, what kind of track record do we have, modeling these kinds of policies? And unfortunately, we haven't had so many examples where there's been a considerable amount of analysis of a previous carbon price to know what's going to happen, but I can give you a couple of examples. There was a recent paper by Andersson, looking at the impact of a carbon price on the use of, I think it was transportation fuels in Sweden.

Alex: And they found that, actually, the responsiveness of people in Sweden to the carbon price, the so-called elasticity of their response was about three times larger than you would have expected, had you used the historical relationships that we use in the models right now. And there's been similar patterns found in British Columbia, looking at transportation fuels and natural gas responses to carbon pricing. And it's another way that we can have a little bit more confidence, is that, there are lots of different modeling teams building very different models of how a carbon price would impact the U.S. economy. And I was lucky enough to work on this effort led by Stanford, called the Energy Modeling Forum, where we took 11 different models, all with different kinds of structures and assumptions, and they won and we were able to look across all those models and find a bunch of very robust results, so that, all of the models are tending in the same direction.

Alex: And while it's still possible that all those models could have the wrong assumptions based into them, when you see that much alignment against models that had been built by different teams, using really different structures, then you can have a little bit more confidence. And so, for example, all of those models are showing that you could expect an emissions reduction on the order of 30% or 40% by 2030, using the data that we were using from 2016. And I think, if you were to run them again today, that range would shift up more towards 40% to 50% by 2030. And they're showing the reductions coming out of, largely the same sector, which is the electricity sector, where we have real time markets that we understand well enough, to believe that they really can deliver the shift between coal and natural gas and renewables that can lead to a bunch of emissions reductions very quickly.

Alex: And so, the behavior that we're seeing in the models is both consistent across the models, and grounded in a sector where we feel like we understand the dynamics pretty well.

Joe: Now, that sector, I think, represents about roughly 35% of the CO2 emissions inventory. Let's just use that number for the sake of argument. There is a concern that I'm familiar with, and I think it's pretty common place that other sectors may or may not respond as vigorously as the electricity sector. Related, I think, to that concern, is the analysis that has come into focus, that, thinking about trajectories, say, between now and 2030, and then, beyond 2030, if you're looking at a net zero outcome by mid-century, entails, not just replacing high emitting infrastructure at the end of its life, with clean infrastructure, but replacing existing infrastructure or accelerating the replacement of currently midlife infrastructure that's associated with high emissions, with low emitting infrastructure.

Joe: In other words, that's a really convoluted way of asking a simple question, which is, is it possible to see, when you look at the modeling you described and the emissions reductions results you described, an acceleration of infrastructure replacement in any of the key sectors, whether it's the transportation sector, or the building sector, or the electricity sector? Or is that just not an apropos question?

Alex: No, I think, thinking about the impact of a carbon price as being very different across sectors, and as that carbon price doing different work across a bunch of different sectors is actually really critical and helps in the policy design. So, in the EMF 32 study that I participated in, about 70% to 90% of the greenhouse gas emissions reductions occurring under carbon prices between now and 2030, came out of the electricity sector. And so, the way I like to think of that, is that, this is a sector where there's a bunch of already existing, well developed, low carbon technologies, and there's a real time power market that can distinguish between the operating costs of those different technologies.

Alex: So, if you apply a carbon price, for example, coal-fired power plants are going to lose out, if you apply it on day one, then on day two, coal-fired power plants are losing out on bids to dispatch, and you're having real time changes in the emissions. So, it's this combination of a lot of technologies, that are relatively mature, and a real time market for effecting differences in those technologies. So, that leads to this really big response in the electricity sector. And that's good news, because it means that we can use a carbon price to decarbonize the electricity sector relatively rapidly, and that sets us up well to work on other sectors, through electrification.

Alex: So, once you have a low or zero carbon electricity sector, then, anything that you electrify is going to move into that camp of very low emissions. What's interesting for me is that the models don't really agree on what happens in the rest of those sectors. So, for a lot of the models, about 25% of the emissions reductions occur outside the electricity sector, there's just a few models like

EIA's NEMS Model, where 90% of the reductions come out of the electric. So, for the rest, it's about 25%. Which is nothing to sneeze at, that might be on the order of 700 million metric tons of emissions, at like a 2% or a 3% emissions reduction. And some of those models have larger reductions from the transport sector, some, larger reductions from the industrial sector.

Alex: But, I think here, it's really important to explain what's going on in these models, which is that, to my understanding of it as a non-economist, they're basically dividing it up maybe into a couple of sub-sectors, and then using historical relationships between the changes in price and the changes in demand, for things like transportation fuels, or the use of fuels in industry. The other sectors are not like the power sector, where a model might have a representation of almost every power plant in the country. These are much more stylized relationships of the way in which economies respond to prices. So, I guess the first part of that good news story, is that, the carbon price leads to reductions in that way. So, just applying a little bit of a price or a significant price in the industrial sector or the transport sector, does lead in the models to reductions in those sectors, but they're not nearly as large.

Alex: And it's for all the reasons that you would expect. So, stock turnover is a really big thing. People are buying new electrons on the electricity grid every day, but you might buy a new house every 30 or 40 years, and a new car on a more decadal timescale. And so, it takes time for people to hit those big decision thresholds. And, in the short-run, people have much less flexibility to respond to that price signal. You would always expect a smaller response in that sector. But, it's also the case that these models tend not to have very good representation of things that might happen in these other sectors to reduce emissions. And I can give you just an extreme example of that, which is in EIA's NEMS Model, some modeling that they did a number of years ago, applied, I think it was a carbon price starting around maybe $25 a ton and rising, to about $80 a ton.

Alex: And the response that you get in the electricity sector, in coal consumption, is about a 98% decline. So, these carbon prices are robust enough to basically displace coal in the electricity sector and replace it with natural gas and renewables. But, if you look at coal consumption in the industrial sector, in that version of EIA's NEMS Model, the industrial coal consumption only declined about 5%. So, it seems like, from the model dynamics, that the carbon price could actually get into $100 a ton, or $200 a ton, and you would still get this really small response. So, there was something structurally going on in the model, that just prevented it from responding to a carbon price, even though, outside of a few select applications like making steel, there are a lot of sectors that are currently using coal, that could switch to natural gas or some kind of renewable thermal, and make that shift.

Alex: And so, in general, we have not represented a lot of electrification, renewable thermal and things like that for these other sectors. That may mean that we're missing some of these other responses.

Joe: It sounds like what the results you just described, let's just say the low responsiveness of the non-power sector, may be as much an artifact of the model's capacities and its inputs as being predictive of what would actually happen in those sectors, at a given carbon price.

Alex: Right. I think that this is an area where it's really important to distinguish model world from reality.

Joe: Yes.

Alex: And those nuances become really important when you move into these other sectors outside the power sector. And so, to me, it tells me two things, at least. One is that we're uncertain about what's going to happen in these other sectors. And two, in these other sectors, because of these issues like stock turnover and all of the other market failures, that we probably need complimentary policies to actually get to our long-term greenhouse gas reduction goals, in addition to a price.

Joe: So, essentially, I'm going to put some words in your mouth and say that the uncertainties about the non-power sectors, the non-electricity sector, are roughly symmetrical, in the sense that the model may be underpredicting the carbon friendly response, or it may be "right" that a low responsiveness in those sectors may actually be what happens. And then, again, the stock turnover problem only gets solved so much by a price. I mean, it sounds like the way of thinking about climate policies to think about an ensemble of policies to which pricing can easily, in fact, should be central or semi-central, but it's not anywhere near sufficient, if you're thinking about truly getting an economy-wide response.

Alex: Yeah, I think that, in the carbon pricing space, there can be a natural tendency to think about the problem as, climate change is an externality, it imposes costs on society that are not reflected in the cost of goods. And that if we fix that externality, then we've solved the climate problem. And I think that that framing, much of it is true, we do need to reflect the externality in the cost of goods, but, it's also true that when we think about all of these sectors, there's a bunch of other market failures that prevent the markets from working in the perfect, efficient way that might happen in a model, and that's things like, lack of provisioning to information, and split incentives, spillovers from RD&D, research and development that don't accrue back to the people that invest in it.

Alex: And then, you can layer on top of that, the non-economic parts of the real world, where people have values and norms and institutional inertia that lead them to make decisions that might not be even economically optimal. And so, for all of those reasons, I think of carbon pricing as an incredibly powerful tool in the climate toolkit, but, you don't want to show up with that being the only thing in your toolbox, if your job is to work very hard and very fast on a machine, before things totally run off the rails. You want to have all your other complimentary policies to make sure that the carbon price can work as intended, and also that you're setting yourself up, to allow the carbon price to work in the future. And so, doing things like, avoiding building buildings now, that will not be cost effective under a future higher carbon price. A building code can help you do that.

Alex: Investing really heavily in research and development, so that, when you're getting to the point where the model is trying to decarbonize those last few sectors, the hard to get at industrial sectors, things like aviation, that public funding has delivered some technology options. They can actually allow that to happen through technology change, instead of just demand destruction. Which, if you follow these models out to 2050, and watch what some of them do, they just crank the carbon price up to a very, very high level, to suppress the use of fuels in those sectors. And that's not the trajectory that anyone wants to be on, we want to be in a place where the carbon price is a useful nudge, and there's available technologies that people can transition to, in a way that is not as economically painful, in a way that just feels like the natural progression of the improvement of technologies and lifestyles over time.

Joe: Well, that was a really useful kind of summation of this discussion, Alex. And if you can stand it, I want to do a little epilogue, and it goes something like this. Going back to your Forrest Gump analogy, and the privilege I've had of working with you at various stages in your policy career, I think it's still really hard to capture what an unusual, even unique role you've played in advancing climate policy at the federal level in two different branches of government. So, with that, I'm dying to ask you the question of whether or not, in a few minutes, you could share any lessons you learned as a policy practitioner or a policy professional, during that part of your career, that you think would be useful going forward, or, at least, would be fun to share.

Alex: I don't carry around with me a long list of lessons from my time in policymaking, but I do get an opportunity teaching at Smith College, to talk to my students about careers in policymaking. And so, I think about it a little bit. And I think one of the first things that I always try and do in conversations with others, is just encourage people to get practice, engaging with the policy making process. There's a huge ecosystem of smart people who are trying to support policymakers in making good data and analysis-driven decisions. And that

includes people who are working in federal agencies, who are working at NGOs, academics, and there's just a lot. I was always struck, at every point along my process in D.C., by how many questions I had that were unanswered by work, out in the literature, or by people working on the outside.

Alex: When I started out in the very early days, I just operated under this assumption that this was an obvious policy question, and economists must have worked out the answer to this, a decade ago. And that often turned out not to be the case. And so, I just always encouraged, for maybe the academics who are listening to this podcast, making sure that you're having conversations with policymakers, so that you're really understanding what their actual questions are, and how they think about the problems, so that you can be delivering work that's relevant to what they're doing. And then, for everyone else, just that there are lots of opportunities to influence the policymaking process. And the more you do of it, the better you get at it.

Alex: For me, the core skills of working in my job, I used to joke at the time that I was just a displaced college professor, my job was to take really complicated subject material, and distill it down to the essence of that material, and be able to share that with people who are not subject matter specialists, in a way that was easy for them to digest. I try and do that in the classroom here, I try and do it in my research papers, and I think, just building those communication skills, both verbally and in writing, are really critical to success. If you can build that skill set, and then just build relationships of trust around that dialogue, I think those are just really critical to being successful.

Alex: The people that I worked with, including you, needed to trust that I was going to give an honest answer to the best of my ability, and say I didn't know, when I didn't know the answer. And I think, bringing that humility to the process, is also really critical. That's true with the micro-level of just briefing people about these kinds of analysis, and then it's true at the macro-level in policy design. The history of environmental policy and climate policy in particular, is littered with surprises and failures. And so, as we're designing our policies, we need to do what we can, to make them resilient to a future where it's going to turn out that many of our assumptions were wrong, and we don't know which ones, yet.

Alex: And so, I think, as we're building this next wave of climate policies, building mechanisms for transparency, for accumulating data about how policies are working, for feedback, to make sure that something like a carbon price stays on the trajectory it needs to be on, in order to deliver the environmental outcomes we need. Those are all things that come out of understanding that this is just messy work, and it's always going to be that way. So, we should design for that, rather than engage in the urge to push that uncertainty away.

Joe: Well, I really appreciate the many moving parts in the answer you just gave. I'll highlight two of them for my own purposes. One is what you said about understanding how many different ways there are to affect public policy and to practice in the world of public policy. That is, practice and a sense of gaining experience, I think is really useful to our respective current situations. Because, I bet, like me, you, Alex, have plenty of opportunity to provide informal advice for students who want to spend, at least, part of their lives working in environmental policy. You shared a great insight that I assume you share with them and that I like to share with students that I'm lucky enough to work with.

Joe: And the other really important point you made, is that, it's important to design policies that work and deliver the results you expect, even in suboptimal situations. So that, even if a lot of the components of the policy are performing in inadequate or suboptimal ways, or performing in unexpected ways, you're still ultimately seeing the results.

Alex: I'd like to add one more lesson, as you were talking, which is that, reaching out to other experts is an incredibly important part of working in this space. I came in knowing essentially nothing of what I should have known, in order to do this work. And I got to where I am today, because of the incredible patience, in particular, of a number of scientific and technical experts at places like the Environmental Protection Agency, who spent a lot of time explaining things to me. But, it's a general feature that these climate problems are so complex, that, everyone comes into this conversation with huge blind spots. And we need to deploy as much as possible, the reflex to go out and ask others, who might have spent more time thinking about that aspect of the problem, just to make sure that we're not wasting time. Because, that is one commodity that is in increasingly limited supply when we're working on this problem.

Joe: Well, Alex, you are a national treasure. It was one of the great privileges of my professional life to be able to work with you, both on the Hill, and at the EPA. And I certainly hope your colleagues and your students at Smith College, appreciate how lucky they are, to have you as part of the community. And, we, here, at the Environmental and Energy Law Program, and the CleanLaw podcast, are equally grateful that you chose to share your time and your wisdom with us. Thanks very much.

Alex: Thanks so much for having me, Joe. You know you are one of my heroes, and so, it was really great to have this opportunity to chat.

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