Harnessing Vulcan and Hestia: How the Latest CO_2 Emissions Tracking Systems Can Help Tackle Climate Change across the US

Crucial FEWSION podcast Episode 8

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Intro Montage (Kevin Gurney): Imagine if we had a CO_2 emissions report– just like the weather report that you'd see on the evening news. Such a capability would be hugely useful in targeting the most important CO_2 sources; it, would create jobs, it could lead to instrument development in the US. Its just not helpful to have inaccurate emissions estimates. There's lots of financial implications of doing it right – or wrong. Because the private sector just will not invest in any offsetting if they don't trust the numbers. Imagine buying a stock that was priced at $5 plus or minus $5 – nobody would buy that stock – well that's the situation we're in now. We have a pilot system developed. It's been tested somewhat on a national scale and in real detail in 5 cities at this point. With greater accuracy investors will trust the numbers, will trust the value and will be far more willing to invest. The US tax payers have actually funded these prototypes, so now we need to go the last step, and provide that payback. To turn that into a real operation system we have to scale it up – its not that hard – we just need to do it now. This is about human health and planetary survival. Is that enough emphasis? Or do you need more?

Narration: President Biden's administration has pledged to reengage the Paris climate process and cut US greenhouse gas emissions by a massive 50% by the end of this decade. It's a reduction that's vital in the global effort to avoid the worst impacts of climate change. Knowing where those emissions are being generated – the location of the biggest sources – and how they change over time, is an instrumental part of optimizing the US's efforts to halt the rise in atmospheric CO_2 levels – says FEWSION project researcher and carbon scientist Kevin Gurney… in this episode of *Crucial FEWSION.*

Kevin Gurney: My name is Kevin Gurney. I'm a Professor in the School of Informatics, Computing and Cyber Systems at Northern Arizona University. I do research on the global carbon cycle – everything from deforestation, to running climate models to quantifying greenhouse gas emissions all across the planet. I've been doing this type of research for about 30 years.

Imagine if we had a CO_2 emissions report – much like let's say a weather report that you'd see on the evening news. It'll tell maybe us on a daily basis – or frequently, how much CO2 is being emitted into the atmosphere from all the sources on the ground and particularly from our cities. Such a capability would be hugely useful in targeting the most important CO2 sources; it, would create jobs, it could lead to instrument development in the US. And NOW is really the perfect political window to get this done given the renewed interest in climate change and engagement from the Biden administration – AND the pending infrastructure investments.

Narration: That would be great! Are you telling me that FEWSION researchers *already have* this kind of a monitoring system? …

KG: We have a pilot system developed. Its been tested somewhat on a national scale and in real detail in 5 cities at this point. But to turn that into a real operational system we have to scale it up. We're gonna need interagency collaboration from multiple agencies in the federal government. We're gonna need to bring in private actors and even non-governmental environmental groups, who've done a lot of work on this problem. We need to bring them all together.

The pieces are there for a system, and the players are there for a system. But we need leadership to bring all this together and make it happen.

It's not that hard – we just NEED to do it NOW!

It's gonna need multiple tiers of government involvement from the local to the state all the way up to the federal level – and its gonna have to be arranged under national umbrella – at least that seems the most logical way to do it.

It has to be politically neutral – much like we think of the National Weather Service. Where you just report data and make it available. Its probably gonna need to involve the National Ocean and Atmospheric Administration (NOAA), NASA since they have satellites measuring CO_2. NIST – the National Institute of Standards and Technology – there the folks that do standardization for everything across the US – and the Environmental Protection Agency to incorporate the data as part of a national inventory and regulatory system.

US tax payers have actually funded these proto-types. So now we need to go the last step and provide that pay back – to get an operational system.

Narration: *What exactly have the FEWSION project's carbon scientist been doing? Well, it involves a couple of Ancient Greeks – Hestia, goddess of the hearth and Vulcan … not the home planet of Star Trek's Spock – but the god of fire. It's no accident that these deities of combustion were the names that Kevin Gurney and his team at NAU chose for the* CO_2 *emission tracking systems that they've developed and deployed.*

KG: The Vulcan Project quantifies **all** fossil fuel CO_2 emissions for the entire United States. It does it coast to coast at about a 1km grid spatial scale, every single hour, every year, going back to 2002.

Narration: I'm really amazed it's been going *that long?*

KG: Yeah its been 15 years now. We constantly update the system. And we've been starting to provide it more and more to assist decision makers – at multiple levels, local and state - in the last few years. We published a paper in *Nature* Communications recently and we compared what Vulcan estimates for city emissions to what cities have generated for themselves. Many cities across the US create what we call self-reported inventories and so we compared our system to theirs in 48 different cities.

Narration: That's intriguing - how did that comparison go?

KG: Yeah it wasn't that great. There were lots and lots of differences between what we estimated within the cities and what they reported themselves. We found on average cities were under-reporting CO_2 emissions by about 18%. But that's really in some ways not the most useful number. Because there was a massive range – some cities were over-reporting by 60%, some were under-reporting by 145% - so the estimates were all over the place. And that under reporting by the way, that 18%, its an amount that's more than all of the state of California's CO_2 emissions,

Now the Earth's atmosphere doesn't respond to what we'd *like to report* – climate responds to the amount of CO_2 that's actually IN the atmosphere. That's why measuring the atmosphere is so crucial. Lots of things can happen on the ground but unless we see it in the atmosphere its basically irrelevant. You know its gotten so political, like a lot of problems when you talk about it, people don't really see what you're talking about, they just immediately associate the tribal affiliation. "Climate change is about a bunch of lefties tryin' to tell us what to do" which is just so sad. And so

you lose the ability to communicate with people, because the minute they put up that tribal affiliation, their ears turn off.

Narration: So - to reduce atmospheric CO_2 concentrations – we need the real data. Were you able to pinpoint the source of this discrepancy between your tracking and the city reportings?

KG: Yes – the differences arise mainly because city inventories omit particular fuels and source types and estimate transportation emissions differently from the way we do it. And typically, they often under-estimate them. So, the results raise concerns about these self-reported inventories. What we need is the accurate, impartial urban greenhouse gas information system, that's we've developed prototypes for in the scientific community.

Narration: And you've got two systems for doing this – named after ancient Greek gods of combustion – Hestia and Vulcan. How does Vulcan measure CO2 emissions?

KG: Vulcan estimates CO_2 using a large number of datasets – mostly at the federal level but also some local datasets as well. It includes things like carbon monoxide emissions reporting which is a locally generated pollutant, some direct CO_2 emissions monitoring at for example power plants, and lots of other data such as traffic data and building data, done at about the census block group scale. Where needed, we transform the data into CO_2 using known characteristics of fuel combustion and the carbon content of fuel and we put all of that information together to generate this coast-to-coast estimate at about a kilometer scale every hour.

Narrator: So, Vulcan gives us the broad-brush national picture. We haven't talked about the 'Goddess' model yet – what about Hestia? Where does she come in?

KG: Hestia is similar to Vulcan but it goes down into an individual city in extreme detail, far beyond what Vulcan does. And done this in FIVE urban areas. When we do this, we get more local data such as tax assessor data on every single built structure, we get all the local traffic information, the road base maps, and so far we've done this 5 different cities, including the LA basin megacity which is actually 80 cities, the city of Indianapolis, Baltimore, Salt Lake City, and we're currently working on the Washington DC – Baltimore urban corridor. We estimate CO_2 emissions down to every single building, every single road segment, every road intersection, all the factories, power plants, airports everything that burns fuel within the urban landscape…

Narrator: That sounds like quite a challenge. How the heck do you do all that?

KG: Hestia starts from where Vulcan leaves off – it adds additional detail with local data sets such as the traffic data, tax assessor parcel data, and local utility data, and that allows us to make a detailed and accurate CO_2 emissions estimate with that information, down to a fine spatial scale.

Narrator: Can you be sure that's accurate though? Is there any way of checking how real your emissions tracking data are?

KG: Yes - it this is a really important aspect of the work that we do. We also in addition to the emissions coming from the surface, we *measure* atmospheric CO_2 concentrations *in the atmosphere* and turn that into a flux of CO_2 using simulations of atmospheric motions … much like a weather reporting system. We measure the concentration of CO_2 over the city, using a combination of 3 types of different measurement, instruments mounted on cell towers, or even mobile mounted instruments on cars, we'll use aircraft that will do transects over a city, and also satellite remote sensing. What we do is measure something called the mixing ratio, which is the amount of gas that we care about, in this case CO_2, relative to the mass of background air. We then invert that, which

means we use a simulation of atmospheric motion to identify what emissions of CO_2 from the surface have to be in order to give rise to the amount of CO_2 in the atmosphere. This inverted amount is then compared to the Hestia estimate. And the Hestia estimate is adjusted as needed.

Narrator: … So you're effectively doing a comparison from the bottom up and then from the top down?

KG: That's right. And we really combine the two. It really takes the best attributes of both these methods and puts them together. The atmospheric method has lots of accuracy but isn't that good on identifying specific details at the surface – while our ground-based estimate is not so good at accuracy but gives lots and lots of details. So we know things like what type of building, we'll know what type of vehicle on what type of road, where and when. So, what we're proposing to the Biden administration is a system that can do this type of thing EVERYWHERE … EVERY hour – all across the United States.

Narrator: What will the consequences be if this isn't funded?

KG: What'll happen is that:

1. cities and states will make inventories to meet lower Carbon emissions targets ... but those inventories will probably be inaccurate – it's just NOT helpful to have inaccurate emissions estimates.
2. As well as practical and scientific accuracy, there's lots of financial implications of doing it right – or wrong –because the private sector just will NOT invest in any offsetting if they don't trust the numbers. Imagine buying a stock that was priced at $5 plus or minus $5. Nobody would buy that stock. Well - that's the situation we're in now. With greater accuracy investors will trust the numbers, trust the value and be far more willing to invest.
3. For cities considering passing municipal green bonds for example, based on reducing their emissions, which is beginning to happen, these can't be highly rated if you have no confidence in the emissions tracking process. So this will not only stimulate private investment but give cities far more leverage on raising internal funds to do the type of things that we know they do to reduce their emissions.

Narrator: What do you need to do this properly?

We're gonna need infrastructure. Governments aren't going to be able to fund the mitigation measures to lower emissions to zero over next few decades. There's no question that the private sector has to be involved, most likely through market mechanisms, that's the way we've tackled a lot of similar problems in the United States. We don't even have the basic CO_2 currency to measure all this. But the Government <u>can</u> put the infrastructure for the nationwide tracking system in place.

Being able to see where major CO_2 emissions are coming from can really help plan to reduce those emissions. I'll give you an example: in Los Angeles just 10% of all the road surfaces account for 65% of the emissions – the major emitting spots are congested intersections and highway sections. It's the same for buildings especially commercial buildings – often there are a few big buildings that are the big emitters in a landscape – if you can target your reductions on those large emitters, and not target the entire landscape, you get the best reduction impact for every dollar invested in CO_2 emissions reduction.

Narrator: We need to have a scalpel approach, not be using a mallet?

KG: Yes – currently most city emission inventories are just lumped too much to have that scalpel! And you know, cities could do this for themselves but would be ***really really*** expensive. It's simply *crazy* NOT to have a country-wide system. Imagine when weather reporting and forecasting began back in the 1940s. IF the idea was that every single locality would measure and come up with models to create their own forecast, that would be a ridiculous thing to do. We realize that this is must better solved collectively. Now that doesn't mean that localities won't be involved – to build a system like this we need local information, but it really needs to be done in a centralized fashion and then be distributed to localities so they can use it. Self-regulation **simply doesn't work**.

Narrator: *I really wanted to find out one last thing from Kevin Gurney. Because he's been trying to build a real time capability to look at the impact of covid on CO_2 emissions. It's proved a littledifficult to do – because there's a delay in the data sources becoming available, but Kevin did have some answers.*

Kevin, were you able to measure how much lower were CO_2 emissions were across the US due to covid? And if you were, how much lower was that?

KG: We've been able to measure that for the whole US – and now we're getting that down to state scale. No surprise aviation-generated emissions – jet fuel, saw one of the biggest declines. In April and May 2020 those emissions were 60% below normal for those two months. Emissions from road traffic were down 30%, electricity production emissions were down by between 15-20% - these were biggest 3 areas of CO_2 declines. However, commercial surface transport and delivery, so bringing packages to your door, or container ships across the ocean, showed almost no decline in their CO_2 emissions.

Narrator: Have emissions gone back up since we started coming out of lock-down mode?

KG: Sadly, yes! Starting in January and Feb of 2021, US CO_2 emissions essentially came back to what they were prior to the covid pandemic, in just about every sector – except in aviation, which is still a little bit low but rapidly returning to normal. So what we saw was a decline over a few months and then a fairly rapid rebound towards the end of 2020. .

Narrator: So … we've essentially returned to pre-covid CO_2 emission levels as of the early part of 2021.

KG: That's right.

Narrator: Which is WHY we need a national system to track CO_2 emissions across the US and its cities – so that CO_2 reduction practices and technologies can be effectively and economically targeted to get most bang for the buck!

KG: Its wasteful and inefficient for individual cities and consulting firms to be measuring CO_2 emissions in an uncoordinated and unstandardized way – and often clearly not getting the right answer.

The other thing that people often forget is that – lowering emissions will not lower the amount of CO_2 in the atmosphere. We have to go *negative* if we want to bring CO_2 emissions *down.* If we lower them its gonna keep going up, it just goes up slower. And that's really frightening – the idea that the only way to make CO_2 levels go is for us to have negative emissions. Now, its possible for us to have negative emissions – but incredibly difficult. I mean, we're having a hard time stopping our increase, let alone, actually removing CO_2 from the atmosphere. In other words, we have to stop all emissions, and then have mechanisms that remove it. Or … the levels that we have now are what we're stuck

with. ‘Cos it just takes CO_2 so long to naturally get removed from the atmosphere. The lifetime of CO_2 is 100 … 200 years, depending on how you calculate it. This is about human health – and planetary survival – and I’m not overexaggerating that!

Narrator: You’ve been listening to episode 8 of *Crucial FEWSION*, produced by me, Diane Hope.

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