Industry Notes

The Environment

Questions to have concrete answers to by the end of December:

- What exactly is the climate/energy crisis? What's the science? What are common misconceptions?

- To what extent is climate change/energy crisis a pressing problem for humanity?

- What are the biggest obstacles in solving this problem?

- To what extent can it be solved by deep technology (as opposed to policy)?

- What exactly are the routes we would use to solve this through tech innovation?

For example, if the Earth's energy imbalance comes from solar radiation in VS out, you'd have to start a tech company that directly or indirectly reduces energy in or reduces greenhouse gas output. This could be directly, via sequestration tech, solar shielding via aerosols or research based via fourth-generation nuclear fission, or a software company helping one of these other companies achieve their aims, or helping consumers improve energy efficiency on a personal level, or a hardware company looking at new types of renewables or, indeed, a think tank doing policy research. The solution can take many forms, but ones you've narrowed it down to the general *structure* of the form it can take, you're positioned to see if it's something *you're* equipped to tackle.

- To what extent does the mission resonate with me? Why?

- To what extent has my background/upbringing/experience equipped me with a competitive advantage in tackling this problem?

Climate & Energy

"the best thing humanity has done in the last century for the climate is to undergo two global financial crises"

"the top 25 oil & gas companies on earth alone account for 50% of humanity's CO2 output"

"people will listen to religious figures before they listen to scientists" (on Pope Francis appeal on climate change)

Videos

Democratic candidates debate: Climate change (ABC News)

You see the candidates presented with questions on climate change; and each, unequivocally and passionately argues that this is the pressing challenge of our time, that quick, decisive action will be taken under their administration. But that's what *every administration said*. And none have taken action; as soon as they get sworn in, they're victim to re-election pressures, compromising to special interests, blocking by Congress and Senate, so there is indeed a stark disparate between words and action.

It's also hilarious to watch these candidates talk about climate change using the very same buzzwords—it's clear they understand very little about the science or reality of the crisis. They reference "scientists" as if those people are some rare, foreign breed that you have to accept at face value. Shows how little politicians understand science. That said, you can viscerally feel how their rhetoric is less powerful when sprinkled with facts and figures as opposed to anecdotes or emotive imagery, and so I, in that sense, appreciate why they aren't incentivised to look into or understand the science of any of this.

The democrats also collectively vilify their Republican counterparts (and vice versa), making it almost a finger-pointing game as opposed to understanding they're all part of the problem. Even politicians seem to acknowledge (or atlas pretend to, for votes) that Washington is overrun with corporate interests.

Why humans are so bad at thinking about climate change. (Vox)

A lot of scientists are employing alarmist rhetoric; perhaps because it's appropriate, perhaps not. Either way, I personally don't think individual humans care very much. Even if you outline, with vivid imagery, the changes that will happen on an individual level, people just don't really *believe* you. It's a complex, esoteric issue that they haven't begun to experience the impacts of themselves greatly enough to care. But they pretend to, since everyone else is. People feel like the impact is distant in both time and space (in the US).

Another view is that the alarmist perspectives are creating an atmosphere of doom & gloom, encouraging people to withdraw from the issue, and not think about it, for fear of being paranoid and worried (like the girl who approached me on the BART). It's easy to respond by leaving it to someone else.

Climate change is a "policy problem from hell". It's hard to design a more challenging problem for human psychology and political structure.

Examine how we responded to the "hole in the ozone". First, scientists identified the problem exists and explained why it's a problem to the individuals in a convincing way (you're going to get cancer, yes, you). Then, they explain a simple solution (stop using hair spray, which contains CFCs), to give people easy, actionable ways to fix it. Problem solves. Except with climate change, we it's difficult to explain a clear impact on individuals, as well as one clear way they can take action, since much of it has to do with corporate emissions (see stat at top).

An interesting take on this is the behavioural science approach to look at what and how humans respond to stimuli asking them to change. There has been research done to look at how we might encourage individuals, households, communities to take action to save energy where they can. They found that sending emails about money savings possible was ineffective, but emails about health concerns were effective, and social pressures—public displays of how people are doing were also very effective. There was even a startup that just worked with power companies to get social competition to be embedded in the bills those companies provide, which helped energy consumption drop by a good margin.

Why Bill Gates Is Funding Solar Geoengineering Research

This is an approach where many planes release reflective particles to mimic a volcanic eruption, sans the devastation. This essentially buys time for us to stop greenhouse emissions as it prevents additional energy input into the Earth, but is not a solution to the problem, since if we stop doing this but continue releasing CO2, we now have lots and lots of CO2 but no reflective layer, and it warms up extremely fast. Some believe it's too early to be thinking of brute force tech solutions when we can so easily change this by altering our behaviour.

There are also more nuances wrt int'l cooperation—it affects different geographic climates in different ways, so if one country deployed it, it would affect other countries, triggering disputes, even conflict, if not everyone is on board. Mr Tomasi would abhor this solution—the Earth is a complex adaptive system, and this is putting a band-aid on the problem by fixing the first order problem (temperature from incoming solar radiation) without thinking of all the second, third order effects (which we don't understand well enough yet). Instead, we should seek to minimise human impact to this already stable complex system (the Earth), by simply reducing emissions—which we're going to have to do, one way or another.

The Biggest Lie About Climate Change (AsapScience)

Exxon (a member of the Big Oil companies that make money by drilling for oil/gas) hired scientists to study the effects of oil on the Earth for future projections of how they might provide energy. As early as 1970-1980, scientists got convincing evidence that burning fuels was worryingly causing climate change (the greenhouse effect is straightforward). At that point, Exxon could've played the long-game, publishing those papers and divesting into alternative sources, making tons of money in the future with a monopoly in the industry as a result, but continuing to rake in money by providing industries with the energy they need. In the 1980s, people were starting to become climate aware, and it was not a political issue. In response, Exxon, and other similar orgnisations, took stark, decisive actions to actively convince the public and lobby governments that climate science was very much still under debate and not settled, and that their fossil fuels will drive technological growth into the future. Exxon is particularly bad because they made climate change a political issue by lobbying George Bush Jr (which is a big reason he took CO2 off the four big pollutants list, as Hansen notes in his book).

The Greenhouse Effect Explained (Sixty Symbols)

Stefan's law says that power output is proportional to the temperature of a body raised to the fourth power. But why do things emit energy at all when raised in temperature? After all, being raised in temperature means gaining kinetic energy. Well, that's because the bodies gaining energy are made of electrically charged particles—particles that interact with the EM field. And so jiggling them causes them to cause the field to move—emitted waves of EM light, which is also the case with gravitational waves being emitted. Thus, when you heat the Earth, it radiates energy outwards.

When you start with an Earth exposed to no radiation, it heats up until the power output radiated away matches the power input. This is what people talk about when thinking about "energy balance" and is what's disrupted by climate forcings. If you calculate, based on power input from energy the sun radiates, where the EQM should be for a blackbody Earth, you get -18 celsius. This is about the temperature of the moon. Deviations from this are because of the atmosphere—which is why the Earth is warmer than might be theoretically expected. If the atmosphere stops some radiation leaving (but doesn't change incoming radiation), EQM temperature at which energy balance will occur, rises.

[rest on iPad]

Can We Block the Sun to Stop Climate Change (Real Engineering)

Standard "block the sun" method to mimic eruptions. Tall towers to disperse SO2 and balloons were considered, but planes are cheapest right now. Sulfuric acid particles absorb (then radiate outwards) shorter wavelengths, which are what we get from the sun. Upon absorption by Earth, Earth re-radiates longer wavelengths, which correspond to the absorption spectra of greenhouse gases. We'd disperse SO2 in the stratosphere, above the bottom layer we're in of the atmosphere, the troposphere. That layer is characterised by no vertical motion of layers, and no precipitation, so once it goes up, it'll stay there. But again, this is a band-aid fix in an otherwise complex system—we have no idea how it will affect photosynthesis, transpiration, atmospheric dynamics with other chemicals, and more.

One climate scientist takes on a room of sceptics (Insight SBS)

Scepticisms included:

"Haven't seen convincing evidence it's man-made. It's alarmist rhetoric by scientists to get more funding."

"There are natural variations much larger than the changes we're seeing today!"

"The Earth has its own methods of cooling itself if the temperature gets too high."

There is decade to decade “noise”. Saying X decade wasn’t warm and so climate change isn’t occurring is as ridiculous as saying 2000-2010 was the warmest decade on record so we’re all going to fry in a few decades. There are large variations in short term temperature due to local, chaotic, factors, and these are at least as large as the overall trend. So, to get an idea for warming, you take a look at centuries, not decades. And from 1850 to now, the temperature trend over those centuries has unequivocally been warming.

It’s interesting to see these “lay-people” listen to a scientist. I’m at the right level to understand what he’s saying, and the nuances and context of his statements—but for most of them, it’s going over their heads, and so if, to them, he’s just dropping jargon, how can they be convinced? The most convincing part for many of them was when he used an analogy to a bathtub. That speaks volumes.

One of the reasons people are so reliant on models is because the alternative, paleoclimate, wasn’t measured using a thermometer, so isn’t “direct”. Instead, it was measured using various proxies, some of which we know aren’t very accurate—like snowflake structure, tree rings, bubbles in tundra, etc. And so, understandably, many people think our paleoclimate understanding—what Hansen’s whole argument is predicated on—is potentially inaccurate and unfair to rely on. The alternative, our models, are demonstrably not great because we struggle to computationally model complex adaptive systems properly.

An effective tactic when challenging sceptics is to tell them they’re asking a good question—and that you can see why they would think or ask that, and that you asked yourself that in the past, and came to this different conclusion. When a sceptic asked about the sensors measuring global climate being positioned near cities (urban heat island effect) where it’s hotter due to decrease in transpiration cooling & increase in machine use, Schneider explains how scientists correct for that by plotting population of a city against average temperature higher than suburbs, then subtracting that amount from the measurements, to find that things are *still* heating up, hence the conclusion of warming.

Many sceptics worry about the actions that will be taken in response to climate change. They worry that it will require us “throwing ourselves back into the stone age” by slashing what they perceive to be power output, instead of simply replacing our current power with renewables.

The ice age cycles due to changes in the Earth’s axis of rotation as well as it’s orbital eccentricity are called the “Milankovitch Cycles”.

“if the effect of CO2 is logarithmic, how can 30% increase in the coming decades possible make a difference?”

Interesting to note that the effect of CO2 on warming is logarithmic. That is, the more CO2 we add, the smaller the effect of each additional amount in terms of pure greenhouse warming. The problem, of course, is feedbacks. This logarithmic effect has been known for decades, and is a part of any climate model we have. Despite this, we are on a track to being fucked.

Land use is an important contributor to CO2 emissions—on the order of fossil fuels. This is because methods to clear land include burning trees (releasing CO2) as well as the very fact those trees are not absorbing CO2 anymore means that more CO2 is released than would otherwise have been.

“I’m worried about the extent of alarmist rhetoric being employed”

I would agree. I actually think many scientists who, themselves, have gaps in their understanding, are somewhat hiding behind the veil of knowledge and seeming expertise, and misusing their positions of power to say the world is ending. This doesn’t diminish the magnitude of the problem

we face, but I think the fact that scientists are human beings means they can fall victim to irrational biases that make them more likely to emphasise certain facts that would scare over others. So it isn't a clear cut issue.

In large ice sheets in Greenland, Alaska, Antarctica, and more, there is a race between increasing ice on the tops as temperature increases, and melting ice near the water. Which is winning? NASA sent satellites to do remote analysis looking at gravitational changes at different points (high res) to get at an answer—the loss of ice is 4x faster than the buildup.

It's also admittedly true that there does exist "scientific reticence" to go against the pseudo-populist stance that the world is ending and we have to do something about it. There are very few scientists who will go against the media and politicians who are saying the world will end and saying "well, hold on, this is in fact a problem, but it's not that bad"—because they want action to be taken and they think the propaganda will be an important part of that!

Carbon Capture - Humanity's Last Hope? (Real Engineering)

It's interesting that, as an organism, we have the behaviour of a single celled fungus, Yeast, which poisons its environment until it dies due it its own doing. There are several existing methods for pre and post-combustion carbon capture in power plants and factories—all involving chemical reactions a chemist or chemical engineer would dream up. The CO2 is then isolated, and storage methods include pumping it into the large reservoirs from which we extracted natural gas, or to store it at the bottom of the sea, under whose pressure it would become a liquid. The store of this CO2 is called sequestration. Problem is, though, if it comes back up, both we and the climate are screwed. This technique could remove up to 80-90% of the CO2 that would otherwise be emitted by power plants producing electricity. Sadly, these power plants only make up around 25% of total CO2 emissions—with transport and land use comprising most of the rest. How might we reduce emissions there?

There is another approach, though, called direct air capture, which literally pulls CO2 out of the air, by using a giant fan to pump air into a chemical chamber, form carbonates and then pull out the CO2—again, Carbon Engineering, the startup pioneering this, is headed by chemical engineers. There is not much room for algorithmic or software innovation in the main product. This has been prototyped, and for around $150 a ton they can convert CO2 back into fuel that can be re-used. Still too expensive, but the first company to really make a step towards it making financial sense. This way, no more oil has to be dug up and we can be carbon-neutral moving forwards—this is an important technology that could be useful, alongside policy changes to reduce CO2 output.

Can We Terraform the Sahara to Stop Climate Change? (Real Engineering)

So, we need lots of land in which to reforest. The best candidates are desert areas, since you can't take countries' agricultural land. Deserts have low populations and producitivites. We would choose a certain few species of trees, and be able to plant billions in the Sahara and Australian outback. With advances in desalination tech, we can cheaply use seawater to irrigate these forests, which, if implemented, would increase the total number of trees in the world by 50%. This would halve the world's CO2 output as the trees grew for a century or so, before balancing out. Remember corollary benefits include us harvesting the trees for fuel, setting up new industries for economic health, and more.

But all is not as it seems. Irrigation costs work out to only $2B, not so bad, but the upfront infrastructure will cost trillions to plant them and clean up the land to be able to do this. No-one will be willing to pay this enormous cost. More importantly, forests reduce albedo, and when replacing deserts, would actually make temperatures go up due to the enormous decrease in worldwide albedo these massive forests create. Thus, sure, CO2 would decrease drastically, but the thing we're actually concerned about—temperature, wouldn't change in any meaningful way.

Climate change is already irreversible (Simon Clark)

Carbon in the atmosphere stays there longer than nuclear waste. By the year 3000, only 40% of the peak CO2 concentration would've disappeared. So, if we stop at 500ppm (optimistic—we're at 410ppm right now), then we'd be at 370 ppm in the year 3000, which is manageable; slightly cooler than today—but still markedly higher than pre-industrial values.

The name of a common climate model is called the Earth System Model of Intermediate Complexity, or EMIC. There are many different types of EMIC, made by different people, by they rely on the same algorithmic approach to modelling weather. And concretely, by 'model', it is meant that we write code to simulate real world objects and process—like thermal expansion, cooling, and chemical cycles, and then run out models into the future to see what happens to those objects if we tweak the values of certain variables. You can see how these models would be useful, but fallible, since they account for only a small portion of the variables that manifest in real life.

Using Carbon Engineering's CO2 extraction tech, it'd cost $3T p.a. to become a carbon-neutral society. This is somewhat promising through, because the fact that CO2 will be around for thousands of years to come makes carbon sequestration technologies important to create, and it's exciting that in the future, it might go from $90 per ton of CO2 extracted to, say, 90 cents. Such is the power of innovation. That would make the annual cost go down from $3T to a more reasonable 30 billion, which world governments would be able to collectively contribute to, especially as the situation becomes more dire. Action item—look more into the potential of carbon capture technologies.

Climate change will also cause permanent changes like species extinction, and changes to the 'thermohaline cycle'.

Articles

What are the sources of greenhouse gases?

29% comes from transportation.
28% comes from power plants generating electricity.
22% comes from industry (making clothes, computers, tables, etc.)
12% is commercial and residential (civilian living)
9% is agriculture (growing food)

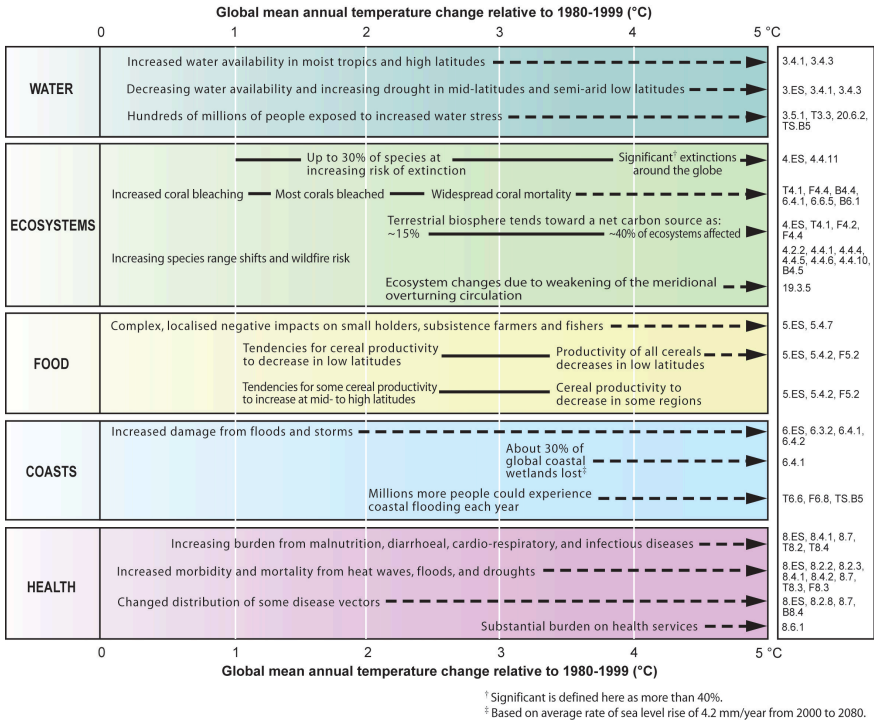
Note that while only 9% of the US's contribution if agricultural, about 25-33% of the world's is (big countries like India and China produce a *lot* of food). And of that agricultural contribution, a significant chunk of it, around two thirds, would be removed if everyone on Earth were to become vegan. That means world CO2 output would go down by 20% if we all went vegan. That's a big difference—not nearly the 50% reduction we need in a mere one to two decades, but a big step in the right direction. That, of course, means that poorest 1-2 billion, who feed themselves by consuming cheap, calorie-dense foods, would be expected to switch diets to a more "eco-friendly" alternative.

What happens if temperatures rise?

We compare the average temperature to pre-industrial times. Right now, we're 1.1 degrees above pre-industrial, aiming to cap emissions off at a 2 degree rise, though really we should be capping it off at 1.5 degrees. At current rate of following through with legislation/promises, we're heading towards a 3-3.5 degree rise in worldwide average temperature compared with pre-industrial times.

A two degree rise, an optimistic take for our world's trajectory, *seas rise 5 meters*, causing a few hundred million to be displaced, and thousands to die. Prices of raw materials will rise, as

agriculture becomes more expensive to conduct in a harsher atmosphere, killing off many due to starvation since they won't then be able to afford food. Ocean acidification increases, starkly reducing *ecosystem biodiversity*, causing compounding effects since it's a complex adaptive system.



A three degree rise, as is expected, would mean we reach Hansen's "great tipping point". Sea levels rise by 25 meters, which displaces over a billion humans, causing them to have to relocate, like a few million did out of Syria during the civil war. Thousands that can't relocate die to starvation, disease. Others live a nomadic existence. Drought and forest fires wipe about about half of the Amazon and similar rainforests, releasing unprecedented amounts of carbon into the atmosphere, accelerating warming. We see more *freak hurricanes and floods* than ever before, alongside these *droughts and heatwaves*. Collectively, these disasters kill hundreds of thousands every year. Many areas of the planet near the equator that are now "hot" will become uninhabitable, further causing mass migration.

A world of four or five degrees looks dystopic. Millions die, billions are displaced. London and Vancouver look like Baghdad and Dubai. The equator is uninhabitable. There are natural disasters of unprecedented scope. Humanity struggles to thrive.

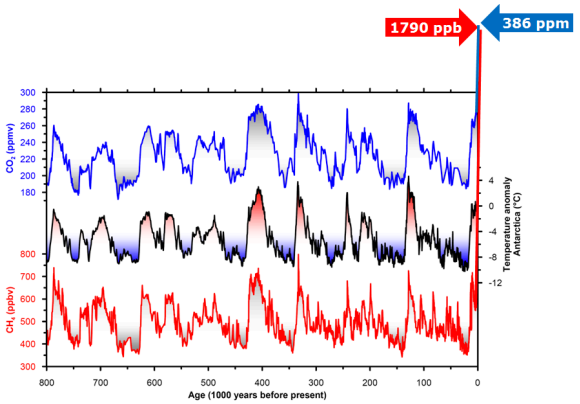
What difference does half a degree make? Why are people trying to limit warming to 1.5 degrees instead of 2 degrees?

This is close to the thermal limit for growth of many crops. Yes, effects would be about a third worse in general, but this is where feedbacks come in. You reach a soft tipping point, where agriculture becomes much harder, and many species will barely be able to survive (coral reefs will certainly die at 2, but probably not at 1.5). So agriculture and biodiversity are the main reasons for wanting to limit that, beyond even more sever effects otherwise.

Addressing climate myths

"Climate naturally changes throughout history"

The world "should be" heading towards an ice age now. But we aren't. And sure, temp and CO2 have been higher millions of years ago, but humans weren't around then, and don't think we'll survive those conditions now, either. Past examples of the rise we see on the right have had disastrous effects.



"Climate change and global warming are synonymous"

Climate change includes global warming, as well as ocean acidification, increased freak storms and droughts.

“We only emit a small portion of CO2 compared to the Earth”

It’s about net emissions, not gross. Also, humans emit mostly Carbon-12, and we’re seeing how, over time, cumulatively, the proportion of Carbon-13 in the atmosphere is decreasing as a result.

Book Notes

Storms of my Grandchildren (climate science & policy inaction)

Energy for Future Presidents (energy technology & policy reflection)

10 Technologies to Fix Energy and Climate (promising energy/climate innovation)

Talking to academics and entrepreneurs

Resources & Waste Management (population, world hunger, recycling, etc.)