HONR 229L: Climate Change: Science, Economics, and Governance

Discussion #19: Possible Solutions

Ross Salawitch

rjs@atmos.umd.edu

Class Web Site: http://www.atmos.umd.edu/~rjs/class/honr229L

ELMS Page: https://myelms.umd.edu/courses/1269254

5 November 2019

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https://www.cnn.com/2019/06/26/business/lightyear-one-solar-powered-car/index.html

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AT18, Q1. William Nordhaus, recipient of the 2018 Nobel Prize in Economics, is quoted as stating the most damaging aspects of climate change lie well outside the conventional marketplace.

a) name the four specific areas of concern;

b) what other concerns does he add to this list?

a) William Nordhaus identified four areas outside the conventional marketplace: hurricane intensification, sea-level rise, ocean acidification, and loss of biodiversity.

b) As an addition to this list, William Nordhaus points out the importance of "*tipping points*". These are events that can change very suddenly and without warning. People are therefore *often surprised by these events* and can be ill-prepared. Two examples of this for climate change include *reversing ocean currents* or *unstable ice sheets*.

The most important thing he mentions, I think, is that *although it is hard to measure the impacts of these events in economic terms that does not mean they should be ignored because they will be dangerous in the long term*.

The fact William Nordhaus is now a Nobel Laureate resulted in much greater visibility to this message.

HONR 229L: Climate Change: Science, Economics, and Governance

AT18, Q2. This week's reading describes three differences between the Stern Review and earlier work of Nordhaus.

a) What are the three differences?

1. **Discount rate- The Stern Review uses a low discount rate, causing the estimated benefit of aggressive action to combat climate change to be much higher. It causes the present cost of action to appear lower than it does in the Nordhaus report.**
2. **Uncertainty- Stern's approach applies the Precautionary Principle, giving more weight to potentially catastrophic events, even if they seem unlikely.**
3. **Economic Costs- Stern suggests much higher carbon taxes, necessitated by his higher calculations of long-term damages. However, the reading states that though Stern and Nordhaus advocate for different levels of carbon tax, they agree that drastic measures need to be taken.**

b) Pick one of these differences and explain why it is important for society to consider this issue, when deciding how to address climate change.

1. Whereas Nordhaus argues for a slow and gradual approach, *I think as a society we need to take Stern's strategy of immediate and substantial action*. Climate change is no longer a slow and gradual problem, instead, global carbon emissions are rising fast. Therefore, we can no longer be slow to act to solve the problem we are creating. I think we have waited long enough. I believe that in order to solve climate change and in order to really mitigate its effects, society needs to take significant action now.

--

***People have a strong tendency to not think long-term*, evidenced as much by our society's continued refusal to wean ourselves off of fossil fuels. But *the long-term effects of climate change are indeed catastrophic*, and we need to make ourselves care more about them so we can take more action to avert them.**

Sadly, I am not sure there is an easy answer for getting society to think "long-term" other than electing politicians who are able to pull this off. Much easier said than done

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2. The second difference in the weighing of uncertainty is very important for society to consider, because that is really one of the largest issues when it comes to assessing the climate and modeling the climate. There is an extremely high level of uncertainty, and as we have discussed in previous classes, *there is uncertainty on the level of uncertainty*. This is important, because this causes discussion to be had. I agree with Stern, where we must take into account worst-case scenarios and should weigh them because the most disastrous events are the ones that would have the highest impact. This being said, there is a valid argument to be made that more likely events should be weighed heavier because we do not want to waste money and other resources to take unnecessary action. My counter to this is *the fact that we are uncertain about the level of uncertainty, so having a precautionary approach is in my opinion better*.

Sadly, the climate modeling community has not understood how to properly assess uncertainty on the projections of global warming in a quantitatively meaningful fashion, which greatly complicates the use of modern risk analysis.

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3. **The economic impacts of implementing climate policy range from 3.4 % annual decrease to 3.9% annual rise in global GDP. So if we realize this analysis, we can stop the stigma that implementing climate policy will destroy the economy of the world. This is a particular concern of Americans and we need to be more informed that climate policy is not terrible for the economy, especially as we are the worst emitters on a per capita basis.**

The possible 3.4% annual decline in GDP is of concern to many, which is why global participation is tantamount.

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AT18, Q3b.Write a short essay comparing and contrasting Carbon Taxation and Cap & Trade of carbon emissions, and conclude by noting which policy option you think should be pursued to transition society away from fossil fuels.

If you conclude that neither option should be pursued, then please select some Other Policy Tool from page 42 to 43 of the reading, and state why you would prefer to see this other option implemented.

Carbon taxes would consist of *taxes* on carbon or *carbon dioxide emissions per unit per ton of the substance*. This tax could greatly reduce coal emissions, because… the tax on coal would be the highest [on a percentage basis]. According to the reading, the taxation on fuel used by individuals in everyday life would not have a large impact on consumption immediately, but reduce carbon emissions overtime.

For cap and trade, there is a *unwavering limit on the total amount of emissions allowed*. This means that no matter who is polluting or how many corporations are polluting, there will only be a certain number of emissions that were allowed at the end of the day. The second pro of cap and trade is that it *provides more freedom for corporations, so it might be easier to implement*. In fact, *a cap and trade bill was actually passed in the House of Representatives before (although it died in the Senate) which indicates that it may be a more attractive option to politicians and corporations*. One con of the cap and trade system is that it still allows some emissions without significant incentive not to. For example, one company may decide that it is better for them to buy all of the emissions rights from a different company rather than try to pollute less. This behavior is not punished by cap and trade and thus for some companies, there will still be significant incentive to pollute, meanwhile a carbon tax makes any amount of emissions unfavorable. Another con is that the entire system hinges on what the cap is. If it is a significantly low enough cap, then everything is fine, but if it is too high then the problem won't really be solved at all.

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Preference:

I believe that cap & trade should be pursued further. While it may have longer-term gains, a tax on carbon would most likely gain the opposition of many businesses and consumers, who would subsequently elect officials also in opposition who would just roll them back; cap & trade seems more palatable to politicians and businesses, should the reading's assertions still hold. In addition, cap & trade allows the collective action problem of CO_2 emissions from many, independent parties to be centralized in the form of the government, allowing for more granular control over emissions policies and how much can be emitted by whom. *Allowing the government to coordinate a previously uncoordinated activity directly is a logical step to reducing carbon emissions across the board*.

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Preference:

I think that we should pursue a carbon tax. We should pursue a carbon tax because they are so *simple to understand* compared to a cap and trade system. They are way less complex and *won't need new bureaucratic systems* in order to operate. Not only that, but *the tax will further reduce carbon emissions unlike the cap and trade on top of the technological advancements*. For cap and trade, technological advances will reduce the price of permits, which could actually result in even more carbon emissions. Also, carbon taxes *can be introduced and implemented more readily than cap and trade*. We need change as soon as possible, so the faster option seems most logical. We can't waste any time. Lastly, carbon taxes allow for better price predictability. Permit prices within cap and trade are more volatile, which make them harder to predict. *With carbon taxes however, we can easily predict future cost*, which allow businesses and households to plan accordingly.

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In terms of a carbon tax, please note that as I have tried to explain in class, if the implementation was based on per ton of CO_2 released, the impact on the cost of coal (large), natural gas (medium), and automobile gasoline (small) would be disproportionate.

I believe a hybrid approach, with Cap and Trade policy directed at power plants and a gasoline Tax directed at consumers provides the best option for meaningful, near term change.

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AT18, Q3a.

Page 26 of the reading states “the effects of climate change will fall most heavily upon the poor of the world.” Figure 12 shows past and projected emissions of CO_2 from the developed world [light blue, and the developing world [dark blue]. OECD stands for the Organization of Economic Cooperation and Development and is often used to denote the Developed world.

a) What was emission of CO_2 in 2015 from the OECD (Organization of Economic Cooperation and Development) group nations (you will have to read this information off of Figure 12)?

b) What was emission of CO_2 in 2015 from the non-OECD group of nations?

In year 2015, the total population of OECD nations was 1.28 billion people, and the total population of non-OECD nations was 5.92 billion people.

c) What was the per-capita emission of CO_2 for people living in the OECD nations in year 2015? Please express the answer in units of metric tons of CO_2 per person.

d) What was the per capita emission of CO_2 for people living in non-OECD nations in 2015, again in units of metric tons of CO_2 per person?

e) If the economy of non-OECD nations were to expand such that the per-capita emission of CO_2 of folks living in these nations were to equal to that of the developed work, compute the resulting global emission of CO_2.

Finally, compare your computed emission of CO_2 in e) to the values shown in Figure 15, and comment in a sentence or two on the moral obligation of the developed world to assist the developing world in seeking better lives for their inhabitants, while at the same time keeping global emissions of CO2 somewhere between RCP 4.5 (50% chance of limiting warming to 2°C) and RCP 2.6 (nearly certain to limit warming to 2°C pathway) shown in Figure 15.

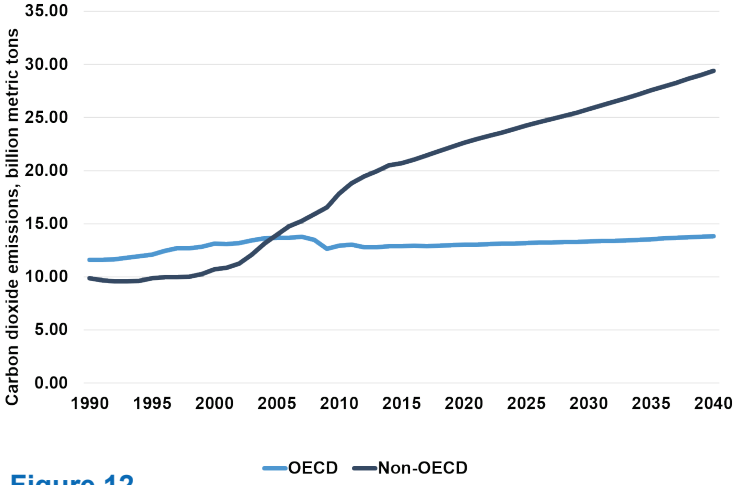

Figure 12

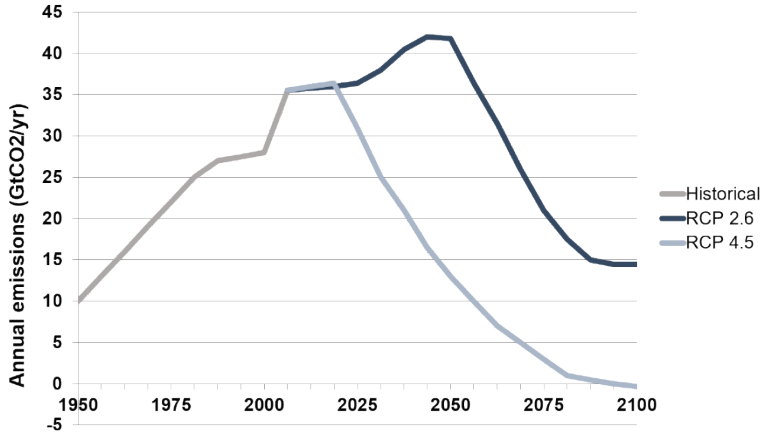

Figure 15

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a) OECD nations collectively emitted approximately 13 billion metric tons of CO_2 in 2015

b) Non-OECD nations collectively emitted approximately 21 billion metric tons of CO_2 in 2015.

c) Per-capita emissions of CO_2 for people living in OECD nations in 2015 was about *10 metric tons of CO_2 per person*.

d) Per-capita emissions of CO_2 for people living in non-OECD nations in 2015 was about *3.5 metric tons of CO_2 per person*.

e) If the per-capita emissions of CO_2 in non-OECD nations reached the per-capita emissions of OECD nations then (assuming no change in population) the non-OECD nations would emit around 60 billion metric tons of CO_2 annually. Combined with OECD countries, around 73 billion metric tons of CO_2 would be emitted annually.

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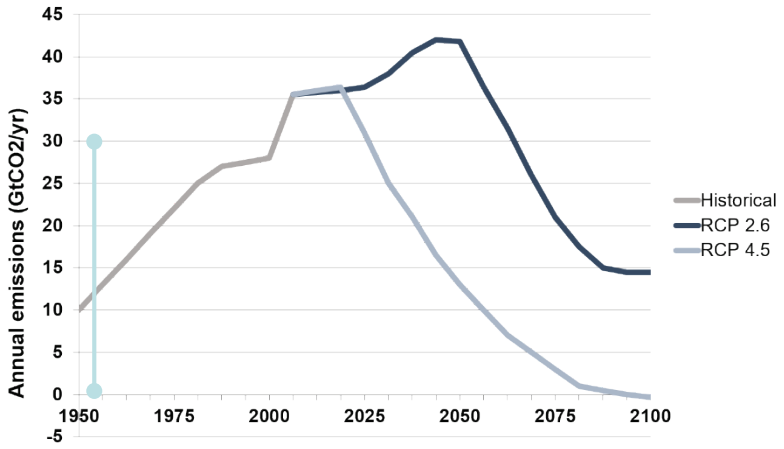
Figure 15



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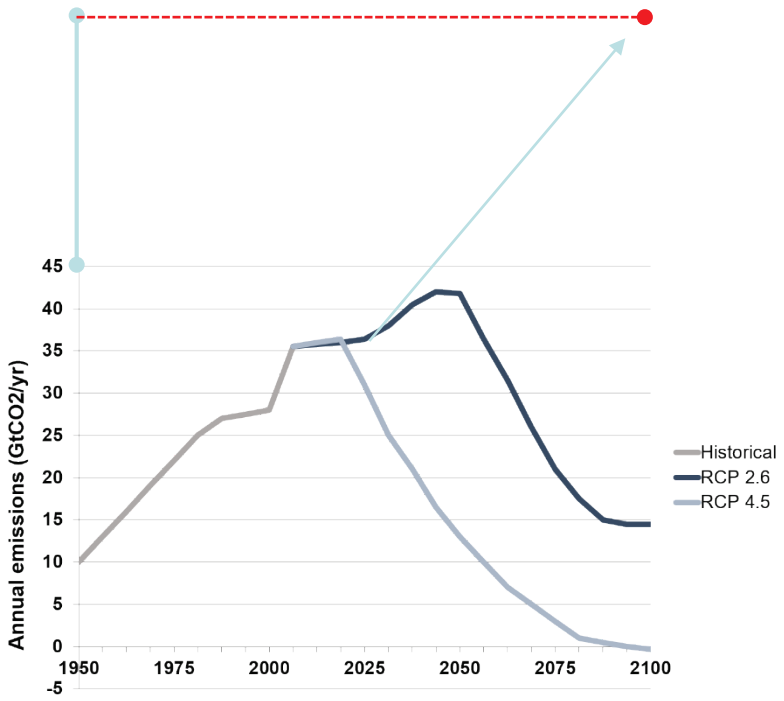

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In order to even meet RCP 4.5, global emissions cannot exceed 43 billion metric tons of CO_2 annually. Considering this value is less than 60% of the value found in part e), it is fair to say that not everyone can live like people do in industrialized countries today. Considering this fact, the best moral decision that meets climate goals is to reduce emissions in developed sections of the world while subsidizing massive technology booms in industrializing nations that ensure their development has a small carbon footprint. These subsidies are the industrializing nation's responsibility because these nations are the ones that until recent history contributed the most to greenhouse gasses. *In short, these nations caused the problem and have the technology to solve it*. Now it is their responsibility to use this technology to solve the problem.

Although we have a moral obligation to assist developing countries, our [first] moral obligation to decrease our own emissions and global emissions as a whole takes precedent during this crucial period in climate history. Better lives for people in developing nations needs to go hand in hand with green and energy efficient technology if we want our planet to have a long term future.

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The intention of this exercise is to help students realize that as the developed world aspires to a great standard of living, the challenge to reduce global carbon emissions grows. It is incumbent on the so-called "first world" nations to take responsibility and share technology and capital to facilitate improvements in the standard of living in other parts of the world via sources of energy and production of food that do not release large amounts of greenhouse gases, while at the same time, reducing our own emissions to demonstrate that this is feasible without suffering severe economic hardship.

Possible Solutions

Aaron Mendelsohn

5 November 2019

Herculano Porto

https://media.gettyimages.com/photos/herculano-porto-de-oliveira-stands-amid-palm-fronds-that-were-spread-picture-id113101828

Cap and Trade

- Brazil and Indonesia (now #5 and #6)
- Deforestation
- ”Forest Protection Credits”
- pros/cons?

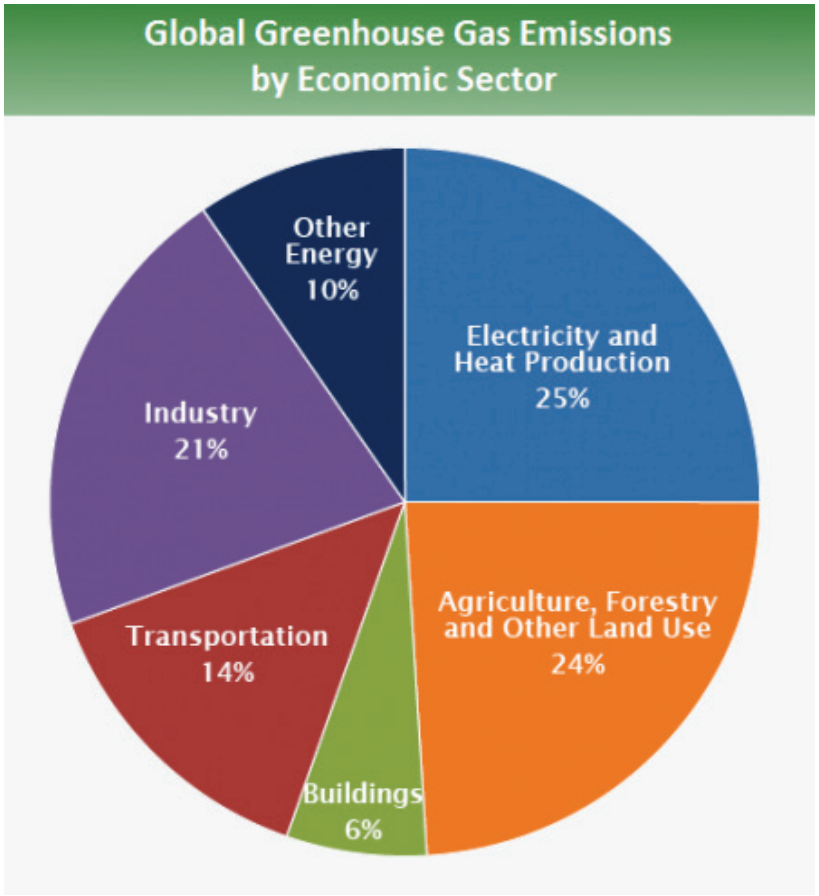
Profitability

- Oversight?

https://i.pinimg.com/originals/ba/cb/b0/bacbb042f62f725af274ad8cba29a690.jpg

https://media.gettyimages.com/photos/brazil-nuts-are-placed-alongside-a-home-on-the-riozinho-do-anfrizio-picture-id113101824

BUSINESS COMMUNITY

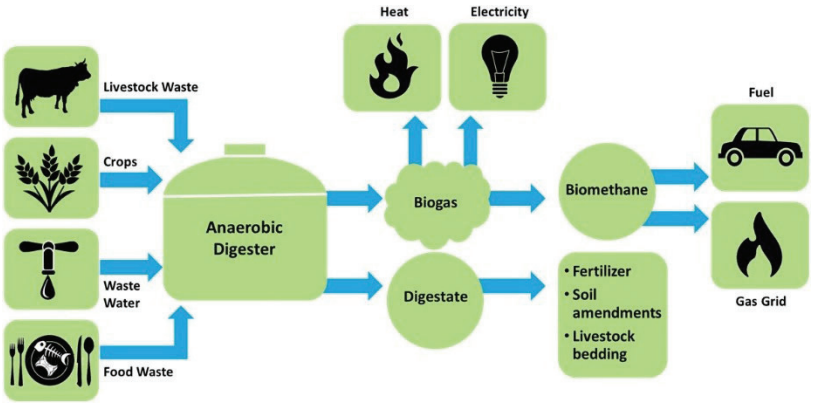


IPCC (2014)

Agriculture

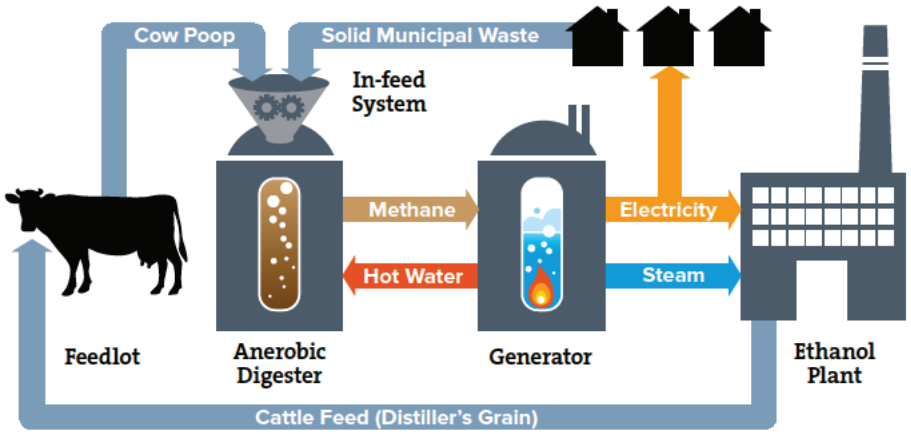
https://cdn.britannica.com/55/174255-050-526314B6/brown-Guernsey-cow.jpg

https://www.cbsnews.com/news/why-cow-dung-patties-are-selling-like-hot-cakes-online-in-india/



https://www.eesi.org/images/content/Figure1-Anaerobic-Digestion-Process.jpg

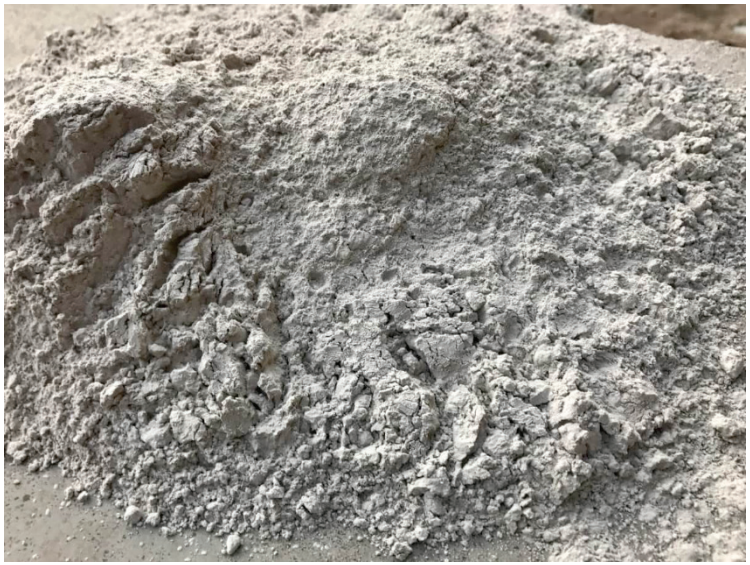
Cogeneration



https://www.alternativesjournal.ca/sites/default/files/article/biogas.png

Buildings

- CalStar Cement vs. Portland Cement Association



https://theconstructor.org/wp-content/uploads/2018/11/Fly-ash.jpg

Energy Efficiency

- ”Negawatts”
- up to 4x cheaper
- Walmart: 20-50%, $25 million, 100,000 tons carbon

https://www.supermarketnews.com/sites/supermarketnews.com/files/styles/article_featured_retina/public/Walmart_Canada_supercenter_exterior_closeup.jpg?itok=_kLuRAr1

Interface Global

Mission Zero:

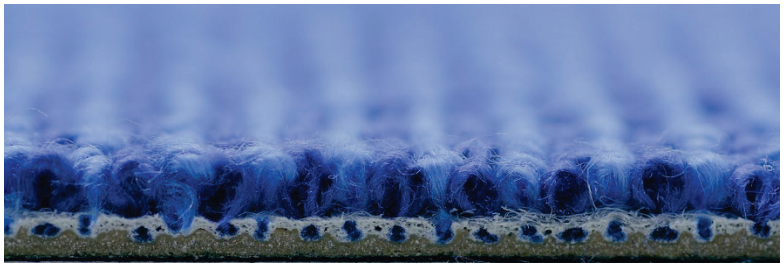
Landfill waste,
FF energy use,
Water waste,
GHG

Interface Global

- GlasBacRE, CoolBlue
- Proof Positive, CircuitBac Green

https://interfaceinc.scene7.com/is/image/InterfaceInc/wc_am-glasbacrecorner-sq?hei=540&fit=fit&wid=840&bgc=245%2C245%2C245

https://interfaceinc.scene7.com/is/image/InterfaceInc/wc_shreddedbacking-gal?hei=540&fit=fit&wid=840&bgc=245%2C245%2C245



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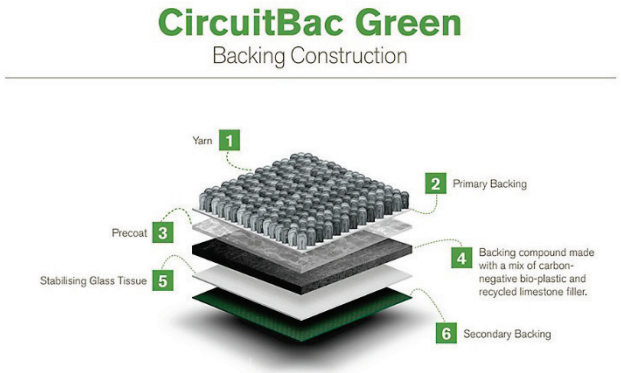


https://interfaceinc.scene7.com/is/image/InterfaceInc/wc_eu-circuitbacgreen2-gal?$960x540$

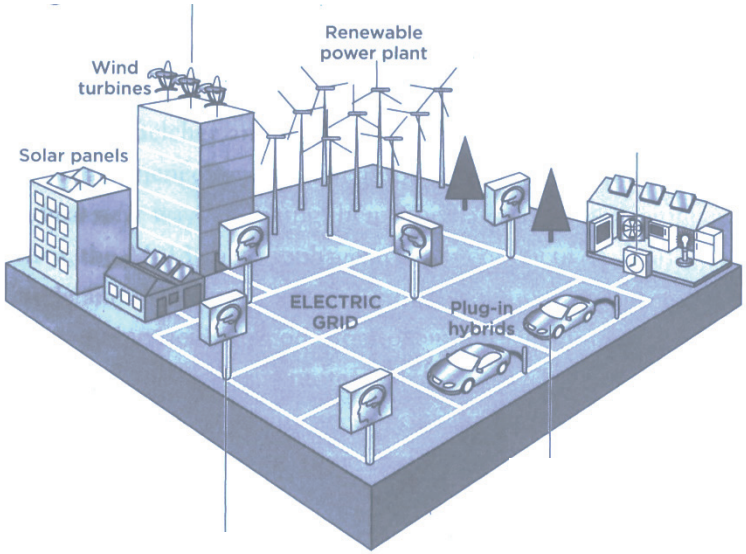
PAX SCIENTIFIC

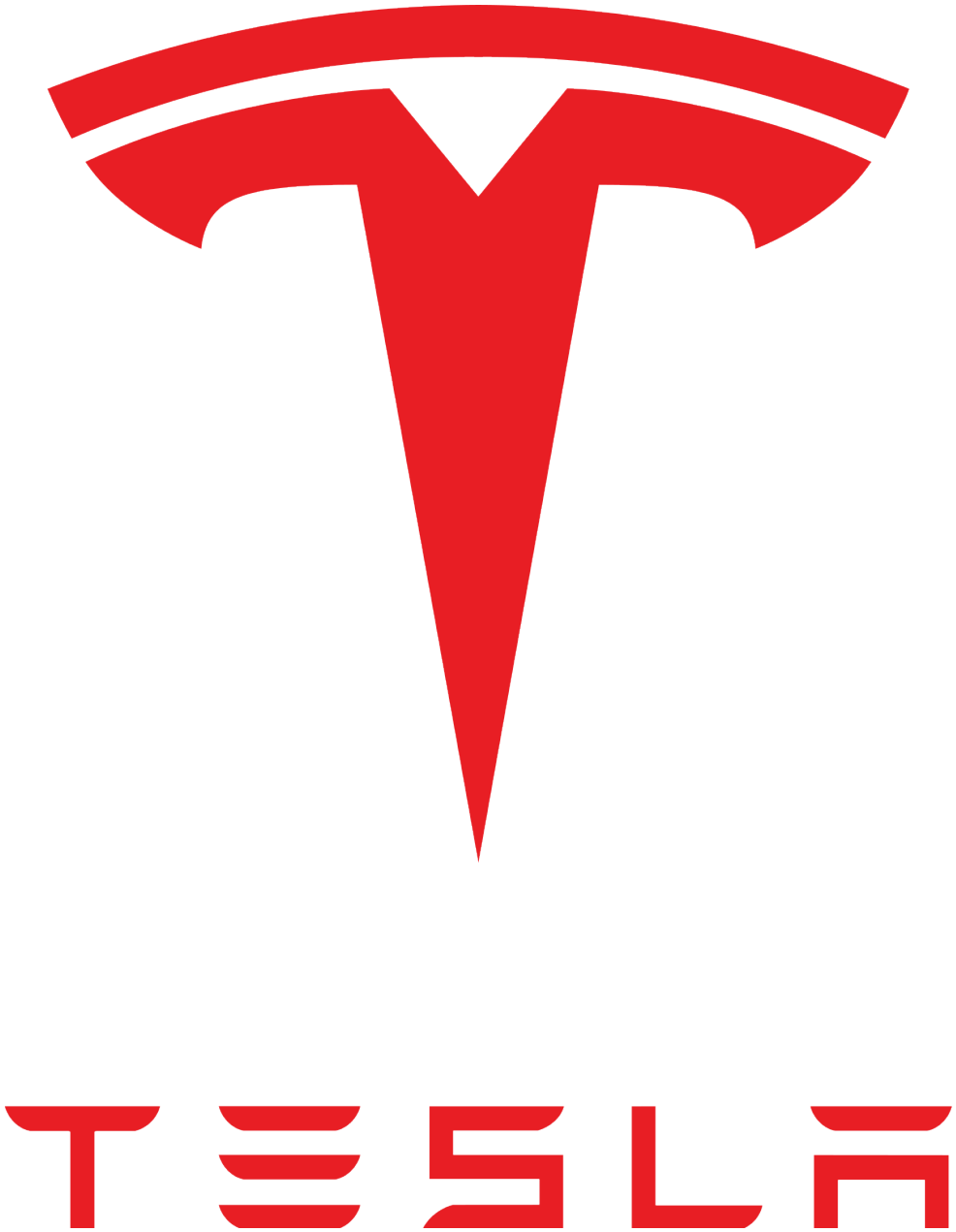
NEXTEK
Power Systems

Energy intelligence

https://www.gridpoint.com/wp-content/uploads/2016/10/GridPoint-Logo-Med.png

V2G





Localized Market Failures

Tragedy of the Commons

https://s26551.pcdn.co/wp-content/uploads/2019/08/Image-from-iOS-105.jpg

"Principal-agent Problems"

https://www.gannett-cdn.com/presto/2019/04/09/USAT/86b5b41c-9b59-4929-9dfa-f6082ed45b12-cpac_flag.JPG?crop=2161,2447,x618,y406&width=540&height=&fit=bounds&auto=webp

Free-market enterprises

- Profitable enterprises that could help reduce FF emissions?

Possible Solutions

Aaron Mendelsohn

5 November 2019

Last Word: Possible Solutions

Ross Salawitch

5 November 2019

Dutch company develops partly solar powered car

By Peter Valdes-Dapena, CNN Business

Updated 5:58 PM ET, Wed June 26, 2019

New York (CNN Business) – The Lightyear One is a car with solar panels stretching across its roof to charge the electric vehicle's batteries. But whether it's really a "solar powered car" depends on how you drive it.

The car, created by Dutch startup Lightyear, has a charging port to plug into a charger. But the solar panels can charge the Lightyear One's batteries at a rate of about 7.5 miles of charge every hour. That's slow compared to plugging it in. Still, if you parked it outside your office on a sunny day, it could soak up enough power to drive 60 miles, which is more than most people drive on a typical day.

"In the summer in the Netherlands, you probably won't have to charge for about two months," said Lightyear CEO Lex Hoefsloot, "and that's with average driving."

The company was founded in 2016 by several members of Eindhoven University of Technology's team that won the Bridgestone World Solar Challenge, a competition for solar-powered cars. If it reaches production, Lightyear One will be the company's first car.

The batteries hold enough energy for 450 miles of driving, the company says. The solar panels will work even when the car is moving, meaning that as you're going down the highway — assuming you're traveling in the daytime — the sun's energy will replenish at least some of the power you're using. On a long drive, help from the sun could add as much as 50 miles to a fully charged battery.

https://www.cnn.com/2019/06/26/business/lightyear-one-solar-powered-car/index.html

New Car Concept Using SuperCapictors may be released

Charlie Turner | 15 Jun 2018

It will need a supercapacitor

To manage the body-panel charge and be able to harness and deploy it to deliver the performance required to meet the brief, the team is pushing the boundaries of supercapacitor technology. The main advantages of supercapacitors compared with standard batteries is their ability to store up to 100 times more energy, their capacity to accept and deliver charge much faster and to tolerate many more charge and discharge cycles. In short, they're lighter, more energy dense and would meet the criteria set out for the Terzo Millennio's three-lap max-attack assault on the 'Ring. But use of the technology at this scale is in its infancy in the automotive world, something Reggiani is keen to solve.

"We have this guy that has a brain ten times bigger than my brain. He's looking into what exists today in the market and has discovered something exceptional. To give you an impression, what we have found with MIT is an element that is able to deliver 4.5V, this means you can have three times more peak energy [than current options] that you can use in every condition," says Reggiani with a glint in his eye. "I'm confident that this will be possible by the end of this project."

https://www.topgear.com/car-news/supercars/closer-look-wild-lamborghini-terzo-millennio

New Car Concept Being Studied

We know there's a hybrid Lamborghini Aventador successor coming sometime between 2020 and 2022. Due to deleted Instagram posts and a fissures in the rumor-verse, we expect a hypercar codenamed LB48H to preview the next electrified V12 Lamborghini. *Autocar* reports the next model in the Italian carmaker's series of low-volume specials will cost about $2.6 million, making it just another walk in the hypercar park as for price.

It's thought that the hypercar will use supercapacitors instead of batteries, providing a lightweight solution that would also showcase future technical potential. The all-electric Terzo Millennio employed nascent supercapacitor tech Lamborghini has been developing with MIT. That solution's upside is lighter size and weight compared to batteries, longer service life, a supercapacitor's fast charge and discharge ability, and the fact that it can discharge and recover energy at the same time. The downside is that supercapacitors have low energy density compared to lithium-ion batteries, so it's possible the LB48H could use a battery and a supercapacitor to work a 49-horsepower motor aiding an 789-hp V12.

The production V12 is expected to get a more mundane solution. Lamborghini's looking ahead to cities mandating a minimum all-electric range up to 31 miles. One idea in play is a split hybrid layout, with an electric motor in charge of the front axle. That eliminates a prop shaft, and sharpens front axle response and torque vectoring. However, without a front transmission, a split system loses efficiency when approaching the triple-digit speeds integral to the brand. The other option would be a more traditional blended hybrid.

Lamborghini's said to have shown the LB48H to prospective buyers in June. We should see the real thing and its possibly glowing carbon fiber soon.

https://www.autoblog.com/2018/12/24/lamborghini-lb48h-supercapacitors-glow-in-the-dark/

GWP – Global Warming Potential

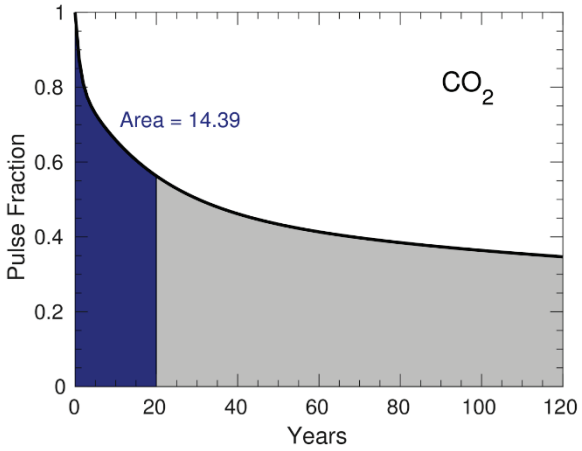
$$GWP\,(CH_4) = \frac{\int_{\text{time initial}}^{\text{time final}} a_{CH4} \times [CH_4(t)]\,dt}{\int_{\text{time initial}}^{\text{time final}} a_{CO2} \times [CO_2(t)\,dt]}$$

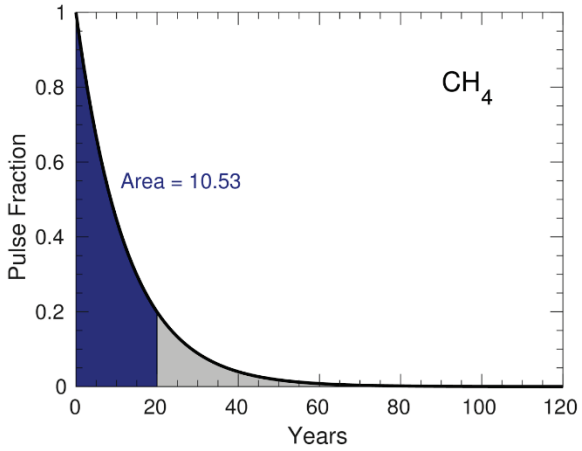
$$GWP\,(N_2O) = \frac{\int_{\text{time initial}}^{\text{time final}} a_{N2O} \times [N_2O(t)]\,dt}{\int_{\text{time initial}}^{\text{time final}} a_{CO2} \times [CO_2(t)\,dt]}$$

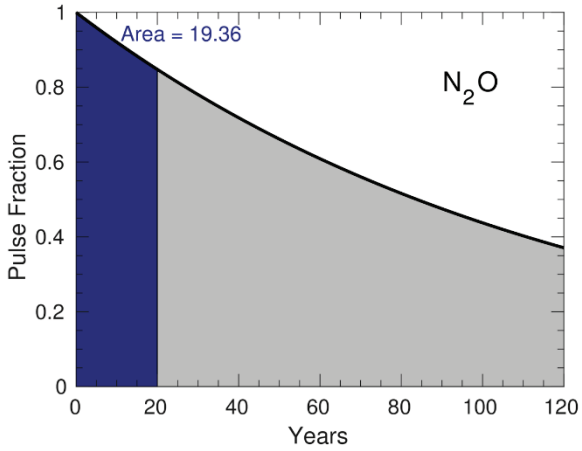
Table 1-1, Paris Beacon of Hope

GHG	IPCC (1995)	IPCC (2001)	IPCC (2007)	IPCC (2013)
100 Year Time Horizon				
CH_4	21	23	25	28, 34*
N_2O	310	296	298	265, 298*
20 Year Time Horizon				
CH_4	56	62	72	84, 86*
N_2O	280	275	289	264, 268*
*Allowing for carbon cycle feedback				

20 year time horizon







$$CO_2(t) = 0.217 + 0.186 \times CO_2(t=0)\, e^{-t/1.286} + 0.338 \times CO_2(t=0)\, e^{-t/18.59} + 0.249 \times CO_2(t=0)\, e^{-t/172.9}$$

$$CH_4(t) = CH_4(t=0)\, e^{-t/12.4}$$

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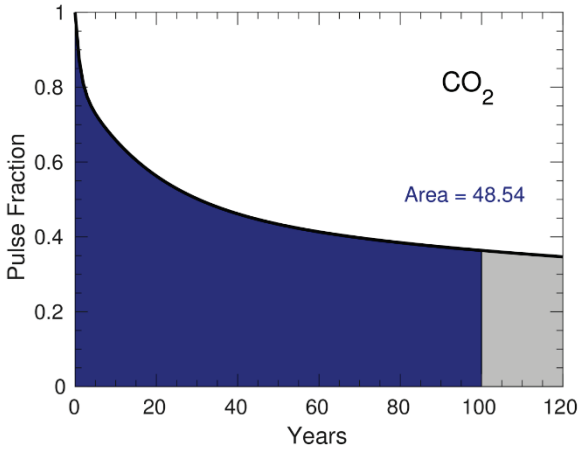

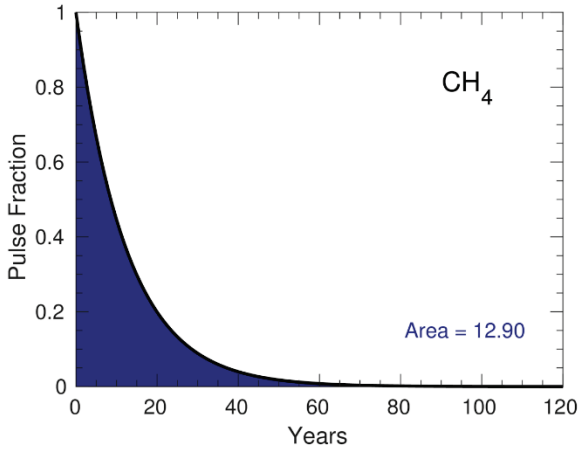

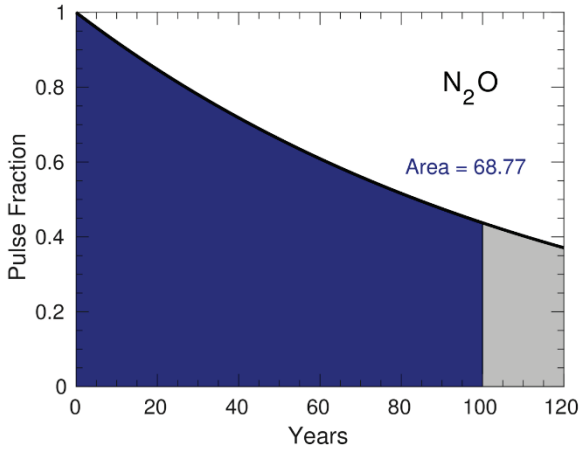

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HONR 229L: Climate Change: Science, Economics, and Governance

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CO_2–equivalent emissions = $CO_2^{\text{Fossil Fuel}}$ emissions + $CO_2^{\text{Land Use Change}}$ emissions +
$28\times(CH_4$ emissions$)+ 265\times(N_2O$ emissions$)$

where 28 & 265 are the global warming potentials
of CH_4 & N_2O on a 100 year time horizon, respectively

and all book-keeping is ***conducted per unit mass***, rather than per unit molecule.

Giga is the scientific word for Billion, or 10^9
Collectively, humans pump **52.5 gigatons** (billion of tons) of CO_2-eq GHGs into the atmosphere every year

Sadly and for reasons I can't quite understand, policy makers use GWPs found on a 100 year time horizon rather than a 20 year time horizon.

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More attention would be given to reducing emissions of CH_4 if a 20 year time horizon was used.

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Some text books give GWPs on a per molecule basis, rather than a per mass basis.

If CH_4 is 28 times more potent than CO_2 on a per mass basis (100 year time horizon), then CH_4 is also
$28\times(16/44) = 10$ times more potent than CO_2 on a per molecule basis (100 year time horizon)

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If CH_4 is 84 times more potent than CO_2 on a per mass basis (20 year time horizon), then CH_4 is also
84×(16/44) = 30 times more potent than CO_2 on a per molecule basis (20 year time horizon)