

CA115 Digital Innovation Management Enterprise

Seminar, Week 6. Innovation #2: Climate and Energy

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These notes will be posted to Loop.

Climate Change Story

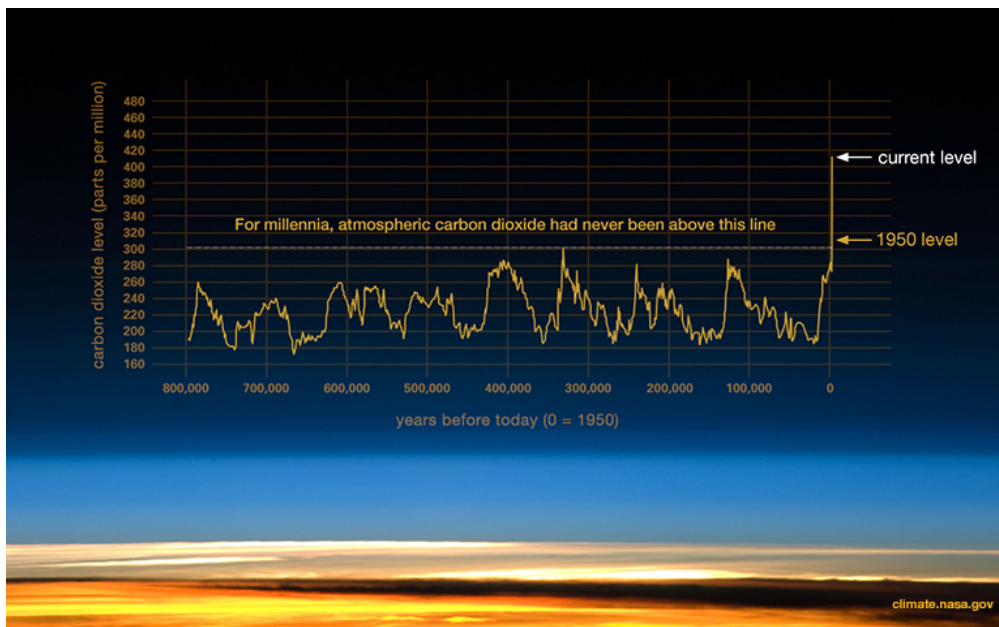
Act I: Once Upon a Time Carbon was Stored, Slowly

See [The Carbon Cycle](#) at NASA's Earth Observatory website.

- Carbon is the fourth most abundant element in the universe.
- Carbon circulates on the surface and atmosphere relatively quickly; it is absorbed and emitted by plants and animals.
- There is also a slow sequestration of carbon as plants and animals die and are slowly buried in the earth.
- This has been happening for hundreds of millions of years.

Act II: Suddenly, the Stored Carbon was Released

- This process has been disrupted.
- We are releasing billions of tonnes of extra carbon into the system all of a sudden.



Graphic from [NASA](#).

This Has an Effect

- Carbon dioxide (CO₂) levels in the atmosphere are closely correlated to temperature.
- This happens because of the *greenhouse effect* (see [here](#) and [here](#)); adding carbon dioxide to the atmosphere prevents heat from escaping.
- Other greenhouse gasses include methane, nitrous oxide and chlorofluorocarbons (CFCs).
- We are in this period.

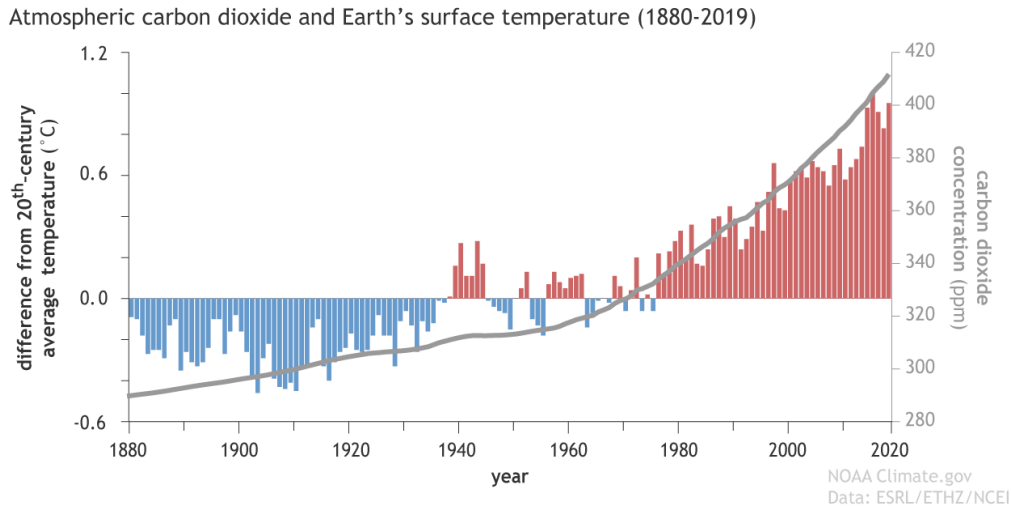
Act III: Solving the Problem

- This part of the climate change story is yet to be written.

Understanding Climate Change

Global Temperatures

See [Randall Munroe's XKCD #1732](#), [global temperature timeline](#).



Graphic from [Climate.gov](#), the US National Oceanic and Atmospheric Administration.

- Small changes to the average world temperature have large effects.
- At five degrees Celsius below the current temperature, there was an ice age. At five degrees above recent temperatures, many of cities will be under water.
- Using the absolute temperature scale, i.e. Kelvin, the change required to go from the ice age to an uninhabitable planet is small, of the order of a few percent.
- In 2013, [the world was close to an 11,000 year peak](#); it's continued to get warmer at a much steeper rate.

Feedback Loop

- As the world warms, ice at the poles (and elsewhere) melts.
- Ice at the poles reflects solar radiation back into space; the extent of ice coverage is known as the *albedo* of the planet.
- The melting ice leads to *ice-albedo* feedback, where melting ice reduces the reflective surface area, meaning that the world absorbs more heat and warms even faster.

Relationship to Environmental Damage

- Climate change leads to damaging environmental changes, e.g. desertification and melting ice.
- Environmental damage accelerates climate change through feedback loops; the ice-albedo feedback is one example.
- Climate change mitigation and looking after our environment go hand in hand, generally.

The Climate in the Present Day

See [US National Oceanic and Atmospheric Administration's summary of last year's climate anomalies, i.e. things that happened that have been linked to climate change.](#)

- [2021 was one of the warmest years on record](#); the past decade was the warmest ever.
- [40 billion tonnes of CO₂ are discharged into the atmosphere annually.](#)
- The carbon dioxide content of the atmosphere has been rising quickly since the 1800s; see [the Keeling Curve](#).

The Climate in the Future

It's difficult to predict the future exactly. The [UN's Intergovernmental Panel on Climate Change published its Sixth Assessment report last year](#) that contained some predictions. You can read [a \(rather dense\) summary for policy makers](#). If average temperature rises by 0.5 C, the world may experience close to twice the number of extreme temperature events experienced these days, i.e. the kind that are expected once every 50 years with no human effects. If it rises by 1 C, this will increase to three times. And by 3 C, the number of such events will jump almost ten-fold.

If we continue as we are, it seems likely that hot and dry places will become hotter and drier. The ice-caps are likely to continue melting and sea levels will rise. Weather events will become more extreme.

Solutions

Mitigation and Adaptation

1. Reducing emissions of and stabilizing the levels of heat-trapping greenhouse gases in the atmosphere ("mitigation");
2. Adapting to the climate change already in the pipeline ("adaptation").
3. [Mitigation and adaptation at NASA Climate](#).

Mitigating and adapting to climate change can happen by *changing our behaviours and through innovation*.

- It must happen now; it's up to the people now alive to fix this problem.
- The world will adapt, either way.
- However, it'd great to imagine that humanity will be part of the future!

Reduce or Eliminate

One approach is to reduce or eliminate things that contribute to climate change.

- Eliminate fossil fuel use.
- Stop deforestation, in particular the destruction of the rain forests.
- Reduce palm oil usage.
- Reduce meat consumption and herd sizes.
- Reduce air travel.
- Reduce car usage.
- Reduce shipping.
- Reduce consumption generally.

Or, encourage the opposite behaviours, i.e. promote rail, modest lifestyles, repair and reuse and so on.

This approach is associated with people [Greta Thunberg](#), [Arundhati Roy](#) and [David Attenborough](#), although their position - and that of many other people and organisations, often considered "environmentalist" - is much more nuanced and progressive.

Innovate

Another approach is to innovate: to create new solutions. Although the list here is technical, really innovation in this sense can expanse to include the social changes already discussed.

- Remake our energy systems.
- Create alternatives to meat consumption, i.e. plant based "meats" or artifical meat.
- Electric airplanes, better rail connections.
- Electric cars, better mass transit systems. Remote working, jobs in towns where people live.
- Advanced manufacturing with greater automation, built locally.
- Repairable technology.
- Progressive laws and supports for low carbon technology.
- Carbon capture and storage technology.

Aspects of this approach are associated with people like [Elon Musk](#). Elon Musk has consistently drawn attention to climate change and his presentations contain good information.

In a different way, perhaps, aspects of this approach are often endorsed by corporations. In general, it seems that companies favour solutions that minimise change to current lifestyles and consumption and which push hard decisions into the future.

Still, history has shown that humans are good at finding innovative solutions to crises.

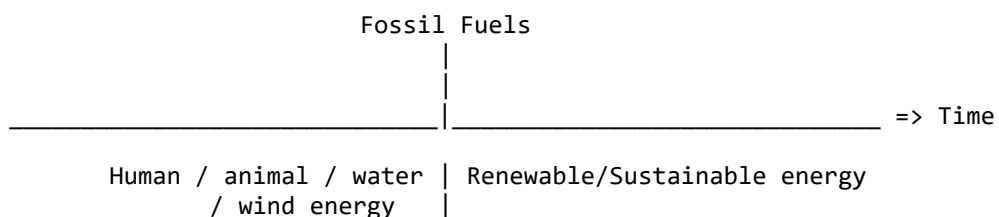
Summary

As with most things, the solution will be a combination of both adapting and mitigating, eliminating (and reducing) and innovating. Some things, e.g. fossil fuel use for transport and electricity generation, ought to be ended almost immediately.

Energy

However, there's another problem!

Fossil Fuels Are Running Out



The Earth is about 4.5 billion years old. Humans have been on Earth for about 300,000 years. Fossil fuels have been burned at industrial scale for only about 200 years. The vertical line above represents, crudely the fossil fuel era. In reality, the line will be almost impossibly thin on the time scale of humanity's existence.

The Climate *and* Energy Problem

1. We have to do something about climate change, [now](#).
2. Fossil fuels are the exception in humanity's history of energy, [a short interlude on the way to something else](#). Even without the problem of climate change forcing something new, we are coming to the end of this interlude.

The Role of the Individual

Individual Actions

Some of the things that will help include:

- Work to transform our culture of consumption into something sustainable.
 - Avoid fast fashion
 - Keep old cars running longer - this is better than switching frequently to new ones
- Reduce meat consumption and cook well
 - More vegetables
 - Local ingredients
- Reduce our energy consumption
 - Build high-quality, well insulated homes
 - Use LED lighting
 - Use green options for electricity, i.e. sign up for wind energy electricity suppliers
- Talk to politicians and leaders whenever possible about climate change
 - What concrete actions are you taking?
 - Learn to look past "green-washing" and marketing. See many fossil fuel company advertisements.
- Look after our local environment as a start to looking after the planet - Ireland is poor at this.

The Limits of Individual Action

- Individual action is a good habit but cannot achieve scale without wider societal change.
- This can be effected by government and large organisations.
- There have been real, concerted efforts to push responsibility down to individuals and to create the illusion that "we are all *equally* responsible" for climate change and environmental degradation.

The Limits of Individual Action



See also the episode of [NPR's Planet Money called Waste Land](#) for the story of the recycling symbol for plastics.

The Role of Society

Government

- Back in the 2000s, [the Intergovernmental Panel on Climate Change](#), a United Nations body, began assessing the science related to climate change. The IPCC is an advisory panel.
- In 2015, at [the United Nations Climate Change Conference \(COP 21 / CMP 11\)](#) in Paris, 196 countries signed up to an agreement to, "to limit global warming to well below 2, preferably to 1.5 degrees Celsius, compared to pre-industrial levels."
- Ongoing UN meetings of government leaders (Climate Change Conferences, also COP meetings) seek to address climate change.
- Not enough is being done. The world needs better leadership in this area.

Actions for Society

These actions might include:

- Rapid de-carbonisation of energy, not only the grid. Solve the "base load" problem. Natural gas is not a "transition fuel", whatever you read!
- Investment in public transport, i.e. electric trains.
- Rapid de-carbonisation of industry and construction.
- Laws or tools that force companies to factor in climate (and environmental) damage into their profits, including shipping and aviation.
- Fewer meetings and commitments and more action.

Challenges

Greta Thunberg is demonstrably right in most of what she says. Her serious-minded and direct activism is effective.



- Changing the status quo; resistance because of changes to power structures, lifestyles and money.
- Time. It's clear that climate change is happening fast; change to mitigate and adapt is needed as soon as possible.

Reasons for Optimism

- Humans are resourceful and have overcome many challenges in the past through a mix of social and technical innovation.

And, as reported in Time Magazine this month:

These numbers echo the assessment of the Intergovernmental Panel on Climate Change, which in its landmark 2018 report stated that in order to limit climate change to 1.5°C, annual investments in clean energy needed to increase to around 3% of global GDP. Since humankind already spends about 1% of annual global GDP on clean energy, we just need an extra 2% slice of the pie!

See [The Surprisingly Low Price Tag on Preventing Climate Disaster](#).

Energy Solutions

Technology and Breakthroughs

- Wind: nowadays, a mature technology that works very well. Wind is intermittent, like solar energy, but not unpredictable. Some more information about wind technology in the notes about wind turbine control.
- Hydro, mostly from river dams. Dams are often destructive; see [Arundhati Roy](#).
- Wave, attractive but there are no successful long-term deployments. The sea is an unforgiving environment.
- Solar. The fundamental energy source for Earth. Eventually, perhaps, this will be the winning technology. You will see a lot more solar plants in the near future in Ireland.
- Geothermal. Good but depends on geography.
- Nuclear. This works well but it is very expensive, before and after operation, both financially and environmentally. Accidents can threaten entire countries. See Chernobyl.
- Storage. We need an awful lot more of this. Batteries, pumped hydro, molten salts.
- Transport. Electrifying transport will be a major step forward.

[Solar is the cheapest form of energy since late 2020](#). Wind is next cheapest. If the [base load problem](#) is solved, this is the solution.

Game-Changers

- Nuclear fusion.
- Geo-engineering, e.g. [artificial albedo effect](#).
- Artificial meat.

Digital Innovation

These days, it's hard to imagine any high technology without a digital aspect. Wherever you find innovative solutions for climate or energy, you will find a digital aspect.

References

These will be posted to the Books, Articles and Media page on Loop.

Niall McMahon, 2022.