our January science page

We're excited to announce the relaunch of our monthly science page! (Please bear with us as we renovate...) This month's page features commentary by Spencer Shorkey, our new science editor. If you are interested in writing about science and technology or have topics you'd like to see covered in this space, write to to him at *science@montaguereporter.org*. – Eds.

COMMENTARY

Time to Look Up

By SPENCER SHORKEY

MILLERS FALLS – I recently watched the movie *Don't Look Up* on Netflix. This movie included many renowned actors and was pretty entertaining overall, but its purpose was obviously more than entertainment – a thinly veiled introspection on how politics often fails to deliver what is in society's best interest.

Without revealing too many details, the gist is that a network of wealthy influencers and politicians use a pending worldwide catastrophe as a tool to maintain power for slightly longer. The system of corruption, media control, and zealot-like belief in technology enables them to gamble civilization's future against the potential for greater power and profit.

Obvious parallels can be drawn between *Don't Look Up* and real life, where media and politics are often biased toward business agendas at the expense of scientifically supported policy, and governments fail to commit the resources necessary to prevent catastrophe. Most viewers see the movie as an indictment of the US federal government's inadequate response to climate change.

An Inhibited Truth

Climate science has a long history, involving many pioneering scientists and institutions. In the early 1800s Joseph Fourier proposed a role for atmospheric gases in trapping heat, comparing the warming effect to a greenhouse. In the mid-1800s coal gas (CO_2 and methane) was shown to be a strong absorber of light compared to other atmospheric gases, and by 1895 Svante Arrhenius calculated that doubling atmospheric CO_2 would lead to a 5° C global warming effect – which remains a good estimate to this day.

By the 1950s, Scripps Institution of Oceanography was continuously monitoring the increasing atmospheric CO_2 levels. In a 1988 testimony before the US Congress, NASA scientist James Hansen reported he was "99 percent sure" that global warming was already upon us.

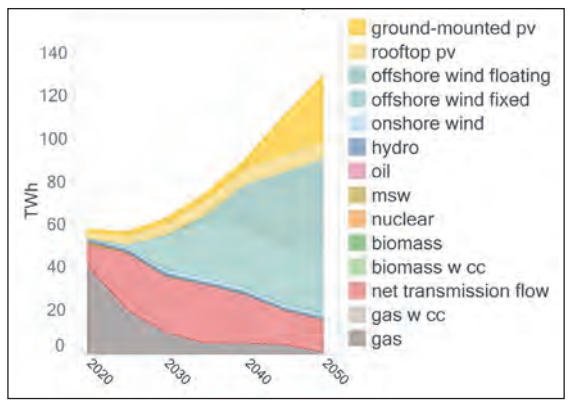
The largest international effort to combat climate change to date is the 2016 Paris Agreement, which was ratified by nearly all countries worldwide, and aims to limit global warming to 2° C (or 3.6° F). The choice of a 2° C target, rather than a more conservative 1.5° C, was reportedly more influenced by pressure from high-emission countries than scientific reality.

UMass Amherst researchers modeling Antarctic melting have shown 1.5°, 2°, and 3° C scenarios predict sea level rises of approximately 0.3 m, 0.4 m, and 1 m respectively by the year 2100. Even in the best-case scenario of 1.5° C warming, long-term Antarctic melts will raise the sea by up to one meter by 2300. Hundreds of millions of people will be displaced by this factor alone.

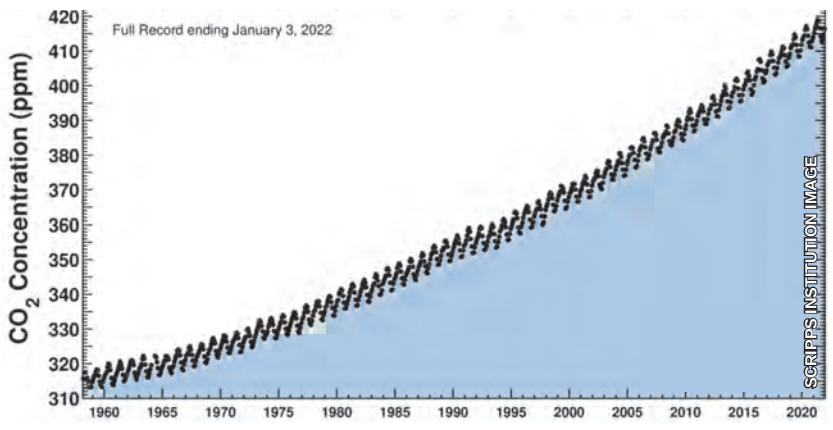
In a worst-case scenario, where unabated CO_2 emissions result in up to 5° C of warming, 10 meters of sea level rise from Antarctic ice is predicted by 2300, which would put many US states largely underwater. Compared to pre-1900 measures, mankind has so far increased CO_2 levels by 50% (from 280 to 420 ppm), resulting in 1.2° C of warming, 0.2 m sea level rise, and increasingly dangerous weather patterns.

So we have established a pending worldwide catastrophe, which we have a meaningful ability to mitigate, at least theoretically. So what are governments doing to prevent catastrophe?

According to Climate Action Tracker's 2021 analysis of worldwide policy, governments have not enacted enough climate action policy to meet the 2° C target, on track instead for 2.7° C of warming. A December 2020 report from Princeton, *Net-Zero America*, calls for at least $2.5 trillion of investments in "energy supply, industry, buildings, and vehicles" in the United States by 2030 in order to reach the Paris decarbonization targets. A similar report by the National Academies recommended investing $300 billion per year, amounting to $3 trillion over the decade.



Left: The "100% Renewable Primary" energy mix envisioned in the state's 2050 Decarbonization Roadmap leans heavily on solar (yellow) and offshore wind (green) generation. Right: Offshore wind leases, in a map included in the report.



Carbon dioxide measured in Hawaii by the Scripps Institution, the "Keeling Curve."

The largest federal clean energy expenditure to date is the $90 billion included in the American Recovery and Reinvestment Act of 2009. At present, the Biden administration's plans for $555 billion in clean energy and climate spending, most recently incarnated as part of the $2.2 trillion Build Back Better Act, is awaiting a vote in the US Senate, but seems unlikely to pass.

The science has long informed us that the consequences of continuing to burn fossil fuels are severe, and according to a recent Third Way poll, the majority of Americans in every state support government involvement in developing clean energy. So how does such scientifically and popularly supported policy fail to gain political traction? In short, climate change denialism concocted by the fossil fuel industry has led to a political economy of delaying action.

I probably cannot give adequate description to the maddening prevalence of anti-science propaganda used for political gain, or the corrupting influences of corporate money in politics that have led to our current situation. However, *Don't Look Up* does an entertaining job of tracing these nefarious forces with dark humor throughout.

State Leadership

While the federal government remains deadlocked by denialism, many states are taking the necessary steps to invest in our future. Massachusetts, notably, will soon be home to the USA's largest wind farm, sited offshore at the "Vineyard 1" site, and is one of 23 states with 2050 Net-Zero policies. Governor Baker's administration recently released the *2030 Clean Energy and Climate Plan* (CECP) and the *Massachusetts 2050 Decarbonization Roadmap*, setting targets of 40 to 70 GW of renewable power capacity by mid-century, which would generate over 100 TWh of renewable energy annually.

The 0.8 GW Vineyard 1 plans to produce power by 2023, and will be joined by at least three more projects at the same offshore hub, together yielding up to 3 GW of wind capacity by the end of this decade – enough to power 1.5 million households. Energy storage systems will be critical to balance intermittent wind supplies with fluctuating power demand. The *2050 Roadmap* stipulates "1.8 GW of pumped hydro storage that is maintained in all pathways," likely expected to include the largest energy storage facility in the Northeast, the massive hydroelectric battery located atop nearby Northfield Mountain.

A side note on the Northfield battery in our backyard is that, though many are concerned that the effects of its pumping water into and out of the Connecticut River are problematic, this battery – which can store up to 8.7 GWh of energy, and runs at up to 1.2 GW – is an energy storage asset worth $2 to $3 billion when measured in conventional lithium battery prices. The Vineyard 1 project itself, meanwhile, is expected to cost $2 to $3 billion.

Between 2016 and 2020, the state's Clean Energy Commission (MassCEC) spent $30 to $45 million on clean energy development and deployment annually, attracting on average $410 million of private solar investments, according to a production tracking database.

Massachusetts utility companies also sponsor the MassSave initiative, which spends $700 to $800 million on energy efficiency efforts each year, expecting future savings of between $3 to $4 for every dollar spent. MassCEC and MassSave spending has been roughly evenly split between commercial and residential projects, annually supporting the installation of about 10,000 residential solar arrays and 5,000 residential heat pumps, and the weatherization of about 30,000 homes.

However, of the over 1 million single-family homes in the state, to date fewer than a quarter use non-fossil fuel heating, and fewer than one-tenth have had solar installed. There is a long way to go to meet the interim goals in the 2030 CECP, which calls for us to "pivot the market" in this decade in order to see heat pumps in the "vast majority of the Commonwealth's three million residential households" by 2050.

"Heat pumps and deep building envelope efficiency retrofits are likely to be the least-cost decarbonization solution," the report points out. "About one million residential gas, oil, and propane furnaces and boilers will likely reach their end-of-life between 2021 and 2030…. [W]idespread deployment of heat pump systems will translate to overall societal cost savings in the coming decades."

Close to Home

If you are looking to invest in clean energy technology for your house in Massachusetts, incentives are available for heat pumps, solar power, battery storage, and electric vehicles.

Though MassCEC has managed a number of clean energy incentive pilot programs, MassSave is the go-to resource for homeowners seeking rebates and loans to support clean energy projects (see *www.masssave.com/en/saving/residential-rebates*). Homeowners can receive a free energy assessment qualifying their home for insulation upgrades, renewable heating system rebates, and zero-interest loans.

Replacing fossil fuel systems with renewable air-source or ground-source heat pumps is the most impactful action homeowners can take to lower their buildings' carbon footprints. MassSave rebates of $10,000 to $15,000, as well as a federal renewable tax credit, are available for such projects.

Though air-source heat pumps have lower up-front installation costs, ground-source pumps are more efficient, and thus have a lower cost of operation. The installation costs for ground-source pumps are also dropping quickly thanks to innovative new installers such as Dandelion Geothermal, making a ground-source the most economical option for replacing residential fossil fuel systems.

MassSave's 0% interest HEAT loan can also provide up to $25,000 for home insulation, heat pumps, or solar-battery systems, and the state's MOR-EV program provides up to $2,500 for new battery-electric vehicle purchases.

To reach "net zero" by 2050, it will be critical that more Massachusetts homeowners and landlords participate in these clean energy programs. Buildings with clean energy upgrades have significantly lower utility bills, and increased property value. (My own ground-source heat pump and rooftop solar array save me about $1,500 and $3,000, respectively, in annual utility costs.)

Thanks to the state's excellent policies supporting clean energy, it's possible for most homeowners here to afford clean energy upgrades, and it makes sense to act now to maximize utility savings and minimize carbon emissions. While there was not much that everyday people could do to prevent catastrophe in *Don't Look Up*, thanks to strong leadership at the state level, Massachusetts residents don't have to wait for our federal government to change its course in order to take meaningful action on carbon reduction.