A Net-Zero Carbon House

Redefining the Oil Industry: Preserving Brand Value During the Climate Emergency

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By
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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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General Research Problem

How can carbon emissions be reduced to combat the climate emergency?

For years, scientists have warned against climate change and the long-term effects it will have on our world. Recent research shows trends of rising methane and carbon dioxide levels, sea levels, temperatures, and loss of Arctic ice. Three important greenhouse gases, methane, carbon dioxide, and nitrous oxide, set new year-to-date records for atmospheric concentrations in both 2020 and 2021 (Ripple et al., 2021). Emissions have caused the average global temperature to rise 1.5 ºF since 1900. It is projected to rise another 2-11.5 ºF by 2100 (U.S. Global Change Research Program, 2009). Emissions must be cut drastically to prevent this heating from occurring.

Greenhouse gas (GHG) emissions present risks for human health and ecosystems. Water shortages from droughts is an urgent problem in the Western U.S., causing higher risk of forest fires. Frequency of extreme weather events, including hurricanes and flooding, is projected to increase. Disease caused by food, animals and water will be a greater risk (U.S. Global Change Research Program, 2009). These events will result in loss of human life and extinction of other species if GHGs are not reduced. Innovations utilizing green energy can be used to reduce emissions in energy production, transportation, and industry. A shift towards carbon reduction in the atmosphere will have social impacts, such as changes to business models or policy.

A Net-Zero Carbon House

How can we design a functional zero-carbon-footprint house that is cost-effective and offers insight on how to retrofit current homes?

The technical project advisor is Dr. Harsha Chelliah, a professor in the Department of Mechanical and Aerospace Engineering. This project is a capstone, and a team project in collaboration with Cathryn Palmer, Max Gerber, and Jack Pazin. We will design a net-zero carbon home for the technical research project, focusing on insulation. Retrofitting homes to have a zero-carbon footprint is vital for reducing GHG emissions and meeting the Biden White House goal of net-zero carbons emissions by 2050 (Biden Administration, 2021). A homeowner can save on their energy bills by converting their home to net-zero, with a return on investment of up to 15%. This can be achieved by adding the "Fab Four" to a home, which include heat pumps, insulation, triple glazed, windows, and solar panels (Green, 2021).

Correctly insulating a home prevents unwanted heat transfer in or out. It can reduce heating and cooling costs by 15-20% (U.S. Department of Energy, 2021). Insulation is classified by its R-value, a metric that quantifies the material's thermal resistivity per unit thickness. Materials with a lower R-value require thicker layers to prevent heat loss. Fiberglass and mineral wool are often used for home insulation and have R-values of 2.5-3.9 per inch (U.S. Department of Energy, 2021). State-of-the-art materials, such as vacuum-insulated panels (VIPs), have an R-value of 60 per inch. VIPs are not feasible for home construction due to the risk of puncturing the vacuum. Instead, they are used for high-level applications like cryogenic refrigerators (Thermal Visions, 2021). More porous insulations perform better than dense materials because of the high air content, which has a low thermal conductivity (Gangassaeter, 2017). Different parts of the country recommend different R-values of insulation, but there are no standards for meeting net-zero carbon in a home (U.S. Department of Energy, 2021).

The project design is split into three systems: energy generation, heating and cooling, and insulation. The goal is to design and install the three systems at the reCOVER TDRH3 house

located at Milton Airfield such that the house has no carbon footprint. Our group will focus on researching and testing insulation for the home. Other groups in the Capstone class will develop systems for solar panels and a ground-source heat pump. Layering insulation types to prevent heat transfer is state-of-the-art in existing systems. Documentation recommends locations for insulating to maximize energy savings, for example under the floors and in attics (U.S. Department of Energy, 2021). There are no specific metrics on which insulation combinations result in the highest R-value.

The home in consideration for the design is in Charlottesville, constraining the test climate to this region of Virginia. There is no wiring in the house, so powering appliances off the energy system will not be considered. We will use Solidworks to run simulations comparing the effectiveness of different insulation materials. We will determine the most cost effective and sustainably sourced insulation materials from the simulations. Then we will run experiments in a lab simulating one-dimensional heat transfer through a wall to quantify the energy loss for each material. We will install the three systems at the Milton Airfield house and run tests to ensure that the house can be heated and cooled with solar energy. After testing and installation, we will quantify what R-value insulation must have in Virginia to achieve a net-zero carbon footprint. We will also write a report detailing the research done for the final design and the cost effectiveness of this project so others can retrofit their own homes to be net-zero carbon. In the future, other UVA Engineering students will be able to contribute to this project by adding electricity and appliances to the reCOVER house.

Redefining the Oil Industry: Preserving Brand Value During the Climate Emergency

How is ExxonMobil striving to protect its brand value and its corporate reputation amid the climate emergency?

How can oil industries maintain their reputations amid the climate emergency? Climate change is resulting in rising temperatures and sea level, extreme weather events, and increased ice melt, all of which are predicted to grow. These effects are caused by burning fossil fuels (coal, oil, natural gas) which emit GHGs (U.S. Global Change Research Program, 2009). The Biden White House has promised that the U.S. will achieve "100% clean energy economy and reach net-zero emissions no later than 2050."; it seeks expenditures of $1.7 trillion in clean energy and environmental justice over the next ten years (Biden Administration, 2021). This will influence existing companies to adopt net-zero emission business models, which may boost their integrity in the eyes of consumers. It will incentivize start-up companies to market new technologies promoting net-zero emissions. However, oil companies like ExxonMobil profit off fossil fuels. ExxonMobil is changing their business model to fit with the call to reduce fossil fuel usage while maintain brand value.

Brand value and corporate reputation are largely dependent on trust that the consumer has in the company. Mayer et al. defines trust as "the willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustor" (Mayer et al., 1995). Vulnerability is important in trust because it is viewed as taking a risk, and trust is vital for successful business relationships. Dorison, et al. (2021) found that "escalation of commitment," or the tendency to "maintain commitment to a course of action often despite negative impacts," is common in business models. They contend that escalation in a business signals "integrity and benevolence-based trust" (Dorison et al.,

2021). A party's perceived integrity depends on the consistency of its actions, its apparent "sense of justice," and credible information from other sources (Mayer et al., 1995).

Participants include oil companies striving to protect their brands while managing demands to reduce and ultimately eliminate fossil fuels. ExxonMobil released statements in 2016 supporting the Paris Agreement and acknowledging the risks related to climate change (ExxonMobil, 2016). In 2021, ExxonMobil has continued to claim that it is committed to developing "new ways to decarbonize the largest emitting sectors – manufacturing, power generation and transportation systems" (ExxonMobil, 2021). Repeatedly showing support for decarbonization improves ExxonMobil's perceived integrity, building stronger trust between the company and consumers. Since 2000, ExxonMobil has invested $10 billion in the research and development of less carbon-intensive energy sources. Though carbon capture and storage techniques have so far shown little promise of making any significant difference, ExxonMobil argues that CCS could capture "90 percent of CO_2 and prove up to six times more effective than conventional technology." ExxonMobil claims that by 2025, it will cut "absolute upstream emissions" by 30 percent relative to 2016 levels. They say this plan represents "some of the most aggressive reductions in the industry" (ExxonMobil, 2021).

Participants include environmental advocacies that promote an effective public policy response to the climate emergency. After the recent budget resolution, the Sierra Club backed a bill in Congress (Sierra Club, 2021). The Biden White House recently released a plan to reach net-zero emissions by 2050 and is encouraging Congress to pass an infrastructure bill that will invest $1.7 trillion in clean energy over the next ten years (Biden Administration, 2021). Participants also include trade associations that defend fossil fuels. When California's governor issued an executive order banning the sale of new combustion-engine vehicles in the state by

2035, the American Petroleum Institute attacked it as a "'profoundly counterproductive plan'" that would "'increase the cost of living in California'" (American Petroleum Institute, 2020).

Some advocacies expose oil companies' expenditures for lobbying and political campaigns. Open Secrets revealed that oil and gas companies spent "over $81.9 million on lobbying in the first three quarters of 2021." ExxonMobil spent $4.4 million on lobbying during this period. Senator Joe Manchin (D-W.Va) reportedly receives more donations from the oil and gas industry than any other Congressperson, taking in $577,000 in the first three quarters of 2021. The $150 billion Clean Energy Performance bill was dropped when Manchin opposed it (Gans, 2021). Participants also include companies that produce renewable energy systems. According to General Electric, its Haliade-X wind turbine operates at 14 MW (General Electric, 2021).

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