Bren School Climate-Related Risks and Opportunities

Final Report

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Introduction

A topic of growing interest in the climate field is risk assessment and mitigation. Business sustainability depends on anticipating future conditions and preparing for them. As climate change increasingly plays a role in projections of the physical and socioeconomic landscape of the future, businesses must incorporate climate-related risks (and opportunities) into their strategic planning process. This report summarizes the methods and results of our analysis of climate risks and opportunities most relevant and urgent for Bren Hall, which houses the environmental science and management graduate program at the University of California, Santa Barbara.

Background

Business leaders do not currently have formal standards to follow for climate risk assessment. However, the Task Force on Climate-Related Financial Disclosures (TCFD)[1] has published recommendations that can be considered best practices in terms of business disclosures. Our team found the general principle of relating climate risks to financial consequences very helpful, as this translation makes the results of risk assessment more actionable for decision makers. TCFD also provides valuable guidance on how to manage uncertainty with sensitivity/scenario analysis.

Bren Hall is already recognized as the "greenest" laboratory building in the country,[2] having earned 3 separate LEED Platinum[3] certifications. However, the school is vulnerable to physical threats in the Santa Barbara area, as well as to market and societal shifts in response to climate change.

Objectives

The main objective of this project was to identify and quantify key risks and opportunities that climate change poses to the Bren School. The breadth and uncertainty of climate impacts make it impossible to include all possible risks, so our team has selected 6 areas of focus to analyze for this project. We believe these issues to be the greatest magnitude and most readily quantified, and therefore of the greatest use to the school's administrators in strategic planning for the future.

This project also serves as an example for other organizations who are interested in evaluating their own climate-related vulnerabilities. We hope that our work can provide a framework or starting point for similar analyses, and promote greater adoption of climate risk assessments so that we collectively move towards a more adaptable and resilient economy in the face of climate change.

General Methods

System Boundary

Bren Hall is situated on the eastern edge of the UCSB campus, overlooking the ocean from a cliff. The UCSB campus is located in Goleta, southern California, and is supported by utilities and supply chains running through the cities o f Goleta and Santa Barbara. Since the Bren School is integrated with the rest

[1] Task Force on Climate-Related Financial Disclosures https://www.fsb-tcfd.org/recommendations/

[2] Bren School of Environmental Science & Management https://bren.ucsb.edu/about/bren-hall

[3] U.S. Green Building Council - LEED Rating System https://www.usgbc.org/leed

of campus in terms of supply and payment for utilities, etc, we expanded the boundary of the system considered from the physical building itself. Depending on the risk being analyzed, we considered effects to Bren as a component of the greater university or town.

Similarly, the time frame under consideration varied depending on the risk under consideration. Climate change effects are predicted to manifest over long time scales, but uncertainty and the limits of downscaled modeling make it difficult to make local predictions further out than 5-10 years. Important milestones that can be used as brackets on the system boundary include 2025, the deadline for the University of California system to reach carbon neutrality, and 2050, a common endpoint used by climate models.

Calculation Procedure

To start, our team compiled an extensive and comprehensive list of possible risks and opportunities to the Bren School. This list included issues that can be divided into two main categories, as defined by TCFD.[4] Physical risks are those relating to the physical impacts of climate change, and can be event-driven (acute), such as the increased occurrence of extreme weather events, or longer-term shifts in climate patterns (chronic), which can cause sea level rise or prolonged heat waves.

This list of risks and opportunities was then narrowed down to a manageable scope for this project. Issues were prioritized by evaluating the Bren School's level of exposure or vulnerability, which was determined by the probability of an event occurring, and the magnitude of the impact or cost should the event occur. This risk rating process is adapted from an approach commonly used for risk assessment under ISO 14000 standards. The risks were also prioritized if the time frame of expected impact fell within our system boundary. Lastly, we had to practically consider whether the risk itself could be readily quantified, and if we then had a mechanism to translate that risk into financial terms.

Once we narrowed the risk list down to 6 issues of concern, each risk topic used a quantification and calculation process appropriate to the context and data available.

Highlighted Risks

Drought and Water Supply

Background

Due to climate change, the frequency and duration of drought in certain regions should be more severe in the future. The last severe drought Santa Barbara County experienced was from 2014-2017 (See Appendix A: Figure A-1). Droughts affect water supply by limiting the amount of supply available to its different users-- residential, agricultural, industrial, and environmental.

UCSB, and therefore Bren Hall, receives water from Goleta Water District[5]. The current water portfolio of the district is made up of local and imported sources. Lake Cachuma and groundwater are the local

[4] https://assets.bbhub.io/company/sites/60/2020/10/FINAL-2017-TCFD-Report-11052018.pdf

[5] Chancellor's Campus Sustainability Committee Subcommittee on Water. 2017. "UCSB Water Action Plan: Draft Version." University of California, Santa Barbara.

sources and make up 70% and 17% of the district water portfolio during an average year, respectively. The State Water Project is an imported source and the most expensive. It makes up 15% of the district's water portfolio. The district also uses recycled water, but for non potable uses[6]. Currently, existing policies in California do not allow for recycled water to be used as direct potable reuse.

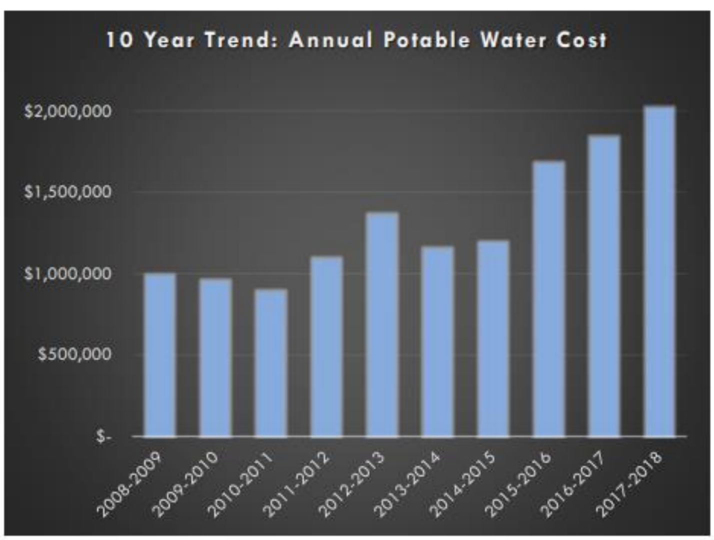
Based on expected future drought conditions, Goleta Water District has forecasted how their water portfolio will change in present time and in 2035. For both years and when the district faces multiple dry years, the district plans to significantly lower their supply from Lake Cachuma and increase their supply from groundwater. Typically groundwater is considered to be more expensive to extract than surface water. The district's supply during multiple dry years is based on previous allocations from Lake Cachuma during dry years. Additionally, because of environmental concerns, the district's allocation of water has decreased in the past years and is expected to continue to decrease. The district plans to slightly increase their supply from the State Water Project for present time and future years, but not significantly.

Methods

UCSB's annual potable water use for the past 10 years has relatively stayed the same despite the campus population increase (See Appendix A: Figure A-2). This is due to conservation efforts, policies, and sustainability goals. To determine Bren Hall's usage, data was obtained from UCSB to determine daily and annual average usage from July 2017 through July 2019. Bren Hall's water usage makes up a relatively small portion of the overall's campus annual potable water use (200,000 ccf per year). On average, Bren Hall uses 1,095 ccf per year or 3 ccf per day (See Appendix A: Figure A-3).

Although the overall campus's potable water use has not increased in the past ten years, costs have increased. Goleta Water District's water prices prior to 2015 and 2016, did not consider drought effects[7]. To determine projected costs for Bren Hall, projected water rates from Goleta Water District were used.

Figure 1. UCSB annual potable water costs for 10 years.



Results

UCSB is considered an urban customer and based on forecasted rates from the district, the university should see an annual increase of 9-11%. The annual increases are not only due to expected increases of drought, but due to various factors such as aging infrastructure, change in water portfolio, and water being underpriced in previous years. Bren's current annual water bill is $8,146 and should increase to $11,726 by 2025[8].

An annual increase of 9-11% is a best scenario for Bren Hall. This is because it may be the lowest increase in costs for Bren

6 Bachman, Steven and Bondy Groundwater Consulting, Inc. 2017. Water Management Plan. Goleta Water District.
7 New Water Rate Information. 2020. Goleta Water District.
8 Ordinance No. 2020-01.

Hall. Due to the severity of the 2015 drought, new surcharges have been implemented by Goleta Water District.

Currently, surcharges correspond to a stage level and are only in effect if the district is in a stage two, three, four, or five water shortage emergency. For urban customers, declaration of a stage five implements a $5.73[9] surcharge. This could result in a $15 increase per day for Bren Hall, in addition to a water price increase. Due to Proposition 218, surcharges are limited by the district and can only be as high as the amount it costs to cover the effects from a drought for the district[10].

Penalties have also been implemented by Goleta Water District because of past droughts. Penalties are structured a little differently than surcharges. If the district implements a water shortage emergency greater than one, penalties can only be given if a violation occurs. Violations include watering your lawn more than twice a week and having hotels limit washing linens. Unlike surcharges, penalties are not subjected to Proposition 218. The highest penalty the district currently has is a one time fee of $500.

Discussion

UCSB as a campus does have opportunities to continue to decrease their potable usage. In 2009, Senate Bill X7-7 was passed and required urban water districts reduce consumption by 20% by 2020. Because of this bill, the University of California implemented sustainability goals, which included reducing all campuses water usage by 20% by 2020 and 35% by 2025-- using 2008-2009 as a baseline. Currently, UCSB still needs 3% to reach 2020 goals[11]. For Bren Hall, it is uncertain how much more water usage can be reduced as the building has already installed water efficient toilets and changed its landscape to be more drought tolerant. However, certain annual maintenance checks, such as faucet leaks, could help Bren Hall avoid unintentional water usages and high costs. Additionally, if policy changes for recycled water happen in the future and direct potable reuse becomes legal, then Bren Hall could purchase more recycled water and see a decrease in water costs as recycled water is typically cheaper. However, the amount of recycled water available would be limited to the district's capacity to treat and store water.

Utility Prices - Natural Gas

Background

As energy usage and production continue to contribute to climate change and be scrutinized as a result, how the Bren School uses energy is important. Particularly, the Bren School's usage of natural gas needs to be evaluated as it contributes to climate change but also is important for operations. Reliance on natural gas is a risk to the Bren School's reputation as an environmental school but also to its finances, as policy to reduce greenhouse gas emissions could impact natural gas prices.

Methods

In order to determine the Bren School's exposure to risk from natural gas, the amount of natural gas, the current cost of natural gas, and projected natural gas prices had to be understood. This was determined by looking at natural gas usage per day and cost per therm from January 2017 through February 2020. Data

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[9] Surcharges appeared to not be up to date on the district's website, so the cost could potentially be higher in 2020.

[10] Kennedy and Jenks Consultants. 2014. Drought Preparedness and Water Shortage Contingency Plan. Goleta Water District.

[11] Chancellor's Campus Sustainability Committee Subcommittee on Water. 2017. "UCSB Water Action Plan: Draft Version." University of California, Santa Barbara.

was only used up until February 2020 to understand regular use of Bren Hall prior to the COVID-19 pandemic. To project natural gas prices, the U.S. Energy Information Administration's Annual Energy Outlook 2020 was used. Commercial natural gas price projections from 2019 through 2050 from the Annual Energy Outlook 2020 were used to estimate price increases for natural gas use at the Bren School.

Results

Based on three years of past natural gas data, prior to the COVID-19 pandemic, the Bren School used an average of 101.3 therms of natural gas per day at an average cost of $0.50 per therm. This results in an average annual cost of $18,501.69 for natural gas usage. Using baseline data from the past three years, natural gas prices were projected through 2050, while keeping natural gas usage constant as it has been over the past three years. See Table B-1 in Appendix B.

Using expected price increases of natural gas through 2050, as shown in Table B-1 in Appendix B, the expected annual costs of natural gas can be projected. Using natural gas usage average from January 2017 through February 2020, the total projected annual cost increase is shown in Table 1 below.

Table 1: Natural Gas Projected Annual Cost Increase

	Current	**2025**	**2030**	**2040**	**2050**
Projected Rate ($/therm)	0.50	0.51	0.55	0.57	0.59
Projected Annual Cost ($)	18,501.69	18,993.75	20,297.73	20,962.02	21,872.34
Projected Increase from 2020 ($)	---	492.06	1,796.04	2,460.33	3,370.65

Table 1 shows that the Bren School at minimum is exposed to an $18,501.69 risk from natural gas and can expect a minimum exposure of $21,872.34 in 2050.

Discussion

Reducing reliance on natural gas provides opportunities for the Bren School to find innovative ways to reduce its greenhouse gas emissions, potentially save money, increase reputation, and meet the University of California Carbon Neutrality Initiative. The University of California Carbon Neutrality Initiative has plans to eliminate natural gas from its operations by 2025, a policy which will impact energy operations to Bren Hall.[12] Meeting the University of California Carbon Neutrality Initiative provides the opportunity of increasing the Bren School's reputation while also reducing risk from exposure to potential price changes in natural gas.

[12] Meier, A., S.J. Davis, D.G. Victor, K. Brown, L. McNeilly, M. Modera, R.Z. Pass, J. Sager, D. Weil, D. Auston, A. Abdulla, F. Bockmiller, W. Brase, J. Brouwer, C. Diamond, E. Dowey, J. Elliott, R. Eng, S. Kaffka, C.V. Kappel, M. Kloss, I Mezić, J. Morejohn, D. Phillips, E. Ritzinger, S. Weissman, J. Williams. 2018. University of California Strategies for Decarbonization: Replacing Natural Gas. UC TomKat Carbon Neutrality Project. http://doi.org/10.17605/OSF.IO/HNPUJ

Utility Prices - Electricity

Background

Similar to natural gas, the Bren School's exposure to electricity also needs to be considered when looking at climate risks and opportunities. Electricity is less straightforward than natural gas because greenhouse gas emissions are dependent on the grid mix at that time. Currently the Bren School is part of the greater UC Santa Barbara campus, which is served by Southern California Edison and is subject to the grid mix and prices charged by Southern California Edison. UC Santa Barbara has on-site solar that meets some of the campus demand and the Bren School itself also has solar on the top of Bren Hall. The energy generated from solar installations on campus gets used on campus and does not get exported back to the electricity grid as generation of energy from solar on campus is never greater than demand on campus. Similarly, electricity generation from solar at Bren Hall gets used up at Bren Hall as the electricity demand at Bren Hall is always greater than the electricity generated from the solar panels at Bren Hall.

Methods

In order to determine the Bren School's exposure to electricity risks and opportunities the electricity usage, electricity prices, and electricity price projections at Bren Hall were examined. Specifically, monthly electricity usage and prices at Bren Hall from January 2017 through December 2019 was analyzed and averaged to get a current baseline of energy use. To project electricity prices, the U.S. Energy Information Administration's Annual Energy Outlook 2020 was used. Commercial electricity price projections from 2019 through 2050 from the Annual Energy Outlook 2020 were used to estimate price increases for electricity use at the Bren School.

Results

Based on three years of past electricity data, prior to the COVID-19 pandemic, the Bren School used an average of 127,328.77 kWh of electricity per month at an average cost of $0.084 per kWh. This results in an average annual cost of $129,026.48 for electricity usage. Using baseline data from the past three years, electricity prices were projected through 2050, while keeping electricity usage constant as it has been over the past three years. See Table B-2 in Appendix B below.

Using expected price changes of electricity through 2050, as shown in Table B-2, the expected annual costs of electricity can be projected. Using electricity usage average from January 2017 through December 2019, the total projected annual cost increase is shown in Table 2 below.

Table 2: Projected Annual Electricity Costs

	Current	2025	2030	2040	2050
Projected Rate ($/kWh)	0.084	0.084	0.084	0.080	0.077
Projected Annual Cost ($)	129,026.48	127,797.66	127,797.66	122,882.37	117,967.07
Projected Change from 2020 ($)	---	-1,228.82	-1,228.82	-6,144.11	-11,059.41

Table 2 shows that the Bren School is currently exposed to $129,026.48 risk from electricity and can project a risk of $117,967.07 in 2050.

Discussion

Projecting electricity risk and opportunities is slightly different than natural gas because electricity is generally seen as a replacement for more greenhouse gas intensive energy sources and thus in the future electricity use may be expected to increase. At the same time, with the increasing prevalence of renewable energy sources, greenhouse gas emissions from electricity are expected to decrease along with decreasing costs. This creates both a risk and opportunity for the transition to electricity to increase electricity use overall creating more financial exposure to electricity price changes but also a decrease in greenhouse gas emissions from switching to electricity.

The University of California is moving in this direction with the University of California Carbon Neutrality Initiative which encourages the movement towards electrification and local energy solutions to reduce greenhouse gas emissions.[13] This creates opportunities for local energy solutions such as increased energy efficiency and reliance on on-site electricity solutions including solar or battery storage.

Wildfire Energy Disruption

Summary

Climate change exacerbates wildfire risk, which creates a disruption threat to energy service at UCSB. We quantify the value of lost energy for weather related outage durations experienced during a 4 year period which involved a major local wildfire event. Future wildfire predictions are uncertain but our analysis suggests over $20,000 of exposure from a single wildfire event.

Background

Anthropogenic climate change has enhanced the risk of wildfire due to a combination of: dry fuels from increased warming, reduced warm season precipitation, and delayed winter precipitation which increases the chance that fuels will be dry during the strong wind events in the fall[14]. Consequently, the California wildfire season is expanding, and climate change projections indicate that the potential fire severity will continue to increase[15]. Furthermore, the number of autumn days with extreme fire weather has more than doubled since the 1980s[16].

During times of high fire threat, utilities can initiate Public Safety Power Shutoffs (PSPS), a preemptive measure utilized to prevent the risk of wildfires that are caused by the energy infrastructure that the utility owns and manages. Extended periods of wildfire threat makes communities more vulnerable to uncertain PSPS events. Although PSPS events are less common in Southern California Edison's (SCE) service

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[13] Meier, A., S.J. Davis, D.G. Victor, K. Brown, L. McNeilly, M. Modera, R.Z. Pass, J. Sager, D. Weil, D. Auston, A. Abdulla, F. Bockmiller, W. Brase, J. Brouwer, C. Diamond, E. Dowey, J. Elliott, R. Eng, S. Kaffka, C.V. Kappel, M. Kloss, I Mezić, J. Morejohn, D. Phillips, E. Ritzinger, S. Weissman, J. Williams. 2018. University of California Strategies for Decarbonization: Replacing Natural Gas. UC TomKat Carbon Neutrality Project. http://doi.org/10.17605/OSF.IO/HNPUJ

[14] Williams, A. P., Abatzoglou, J. T., Gershunov, A., Guzman-Morales, J., Bishop, D. A., Balch, J. K., & Lettenmaier, D. P. (2019). Observed Impacts of Anthropogenic Climate Change on Wildfire in California. Earth's Future, 7(8), 892–910. https://doi.org/10.1029/2019EF001210

[15] Barbero, R., Abatzoglou, J. T., Larkin, S., Kolden, C. A., & Stocks, B. (2015). Climate change presents increased potential for very large fires in the contiguous United States. International Journal of Wildland Fire, 24(7), 892–899. https://doi.org/10.1071/WF15083

[16] Goss, M., Swain, D. L., Abatzoglou, J. T., Sarhadi, A., Kolden, C. A., Williams, A. P., & Diffenbaugh, N. S. (2020). Climate change is increasing the likelihood of extreme autumn wildfire conditions across California. Environmental Research Letters, 15(9), 094016. https://doi.org/10.1088/1748-9326/ab83a7

territory, large swaths of PG&E's service territory have experienced 2 or more shut-offs since PSPS started in 2019. In October of 2019 some customer accounts in Northern California were without power for several days.

The California Public Utilities Commission (CPUC) maintains a High Fire Threat District map[17] which designates a majority of Santa Barbara, and neighboring Ventura county, under high risk of utility associated fire threat. While the UCSB campus is not under direct fire threat, the Los Padres mountains just north of the suburban coastal areas of Goleta and Santa Barbara are classified as Tier 3 extreme fire threat (Appendix C). SCE transmission lines and substations, which serve the UCSB campus, cross through the Tier 3 zones rendering the UCSB campus energy service vulnerable to disruption from PSPS and wildfire events.

Among the many large CA wildfires in recent history, the Thomas Fire (December 2017-January 2018) burned locally in Santa Barbara and Ventura counties. The fire reached a western extent at Gibraltar Rd. above Montecito. This fire and subsequent mudslides caused energy interruptions to the Santa Barbara area[18]. These energy disruptions come at a cost to utility customers, particularly non-residential customers that cannot maintain operations.

Methods

To determine the cost of energy disruptions during wildfires and public safety shut-offs we calculated the dollar value benefit of maintaining energy to Bren Hall's critical demand during weather related outage durations experienced in Goleta during a 4 year period (2016-2019), which included the Thomas Fire. We based our calculation on the following information: (1) annual duration of wildfire and weather related energy disruption in minutes, (2) average critical load energy demand at Bren hall per minute during wildfire season, (3) willingness to pay for maintaining critical load during an outage.

To find the annual duration of wildfire and weather related energy disruptions in Goleta we used the System Average Interruption Duration Index (SAIDI) values from SCE Service Reliability Report for the 13 circuits serving Goleta, CA[19]. The SAIDI value is the total number of minutes that the average customer was without power due to sustained outages (greater than 5 minutes). SAIDI values are categorized by outage cause, and for the purpose of our analysis we adjusted the SAIDI value to only include outages caused by "weather/fire/earthquake."

Energy demand at Bren Hall was calculated by taking an average energy use per minute (kWh/minute) from 2019 energy use data. The energy demand at Bren Hall is not consistent throughout the year because demand is higher when school is in session. So we adjusted the energy demand to only the months when wildfires occur (May-December). We then adjusted this demand to the critical load, which is the portion of the demand that sustains critical infrastructure. We assumed a critical load demand of 25%. We then took the adjusted SAIDI value of annual weather related outage durations in minutes and multiplied it by the wildfire season critical energy demand in kWh/minute.

Once we had the critical energy demand that was disrupted during wildfire and weather related outages we multiplied it by an annualized average willingness to pay to avoid energy disruption prepared for

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[17] Fire-Threat Maps and Fire-Safety Regulations Proceedings. from https://www.cpuc.ca.gov/firethreatmaps/

[18] Edison International. (2017). Thomas Fire Leads to Santa Barbara Area Outage. Edison International., from https://newsroom.edison.com/releases/releases-20171210

[19] Circuit Reliability Review, Goleta. (2020). SCE.Com. from https://library.sce.com/content/dam/sce-doclib/public/reliability/Goleta.pdf

resilience analysis in Santa Barbara by the Clean Coalition[20]. This value was derived for medium and large commercial and industrial facilities from a study by the Department of Energy at $117/kWh.

Results

The average energy use at Bren Hall during wildfire season in 2019 was 2.204 kWh/min, and average critical load demand was 0.551 kWh/min.

Table 3: Weather related SAIDI value and $ value of interrupted energy for Goleta, CA for 2016-2019. High SAIDI values in 2017 & 2018 include outages from the Thomas Fire

Year	Adjusted SAIDI (minutes)	Value of Interrupted Energy ($USD)
2016	43.92	$ 2,831.33
2017	268.54	$ 17,311.59
2018	100.08	$ 6,451.72
2019	14.85	$ 957.31

Discussion

Without backup power, wildfires and weather related outages may have cost Bren more than $20,000 during the Thomas Fire. While it is impossible to predict an accurate fire return interval, the frequency and severity of wildfires is increasing and energy loss from wildfire threat is concerning. Threat from wildfires can also cause outages via PSPS events. PSPS events have just begun in 2019 and a lack of data also makes it hard to predict an annual outage duration. However, the data from the Thomas Fire is a good indication of how costly a wildfire can be from the perspective of energy loss.

Our results are influenced by three areas of uncertainty. We were unable to determine the exact circuit that supplies UCSB so we had to use the average for all 13 circuits in Goleta, though some circuits had much longer outage durations than others. We based our value of lost energy from a review of customer surveys by the DOE, though a direct conversation with UCSB representatives may have yielded a more accurate number. Finally our conservative assumption for critical load (25%) may be too low. As the university continues to pursue more energy efficient systems, the share of critical energy demand will probably increase.

Bren does not have batteries or a diesel generator to use for energy backup, though UCSB has diesel generators. If Bren decides to invest in a backup technology to avoid the potential cost of energy disruption it is important to note that diesel generators have emissions that are bad for air quality and will increase our Scope 1 emissions total. There is an opportunity for Bren to obtain backup without additional emissions via batteries or a microgrid system.

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[20] Lewis, C.Value-of-resilience from Solar Microgrids VOR123 Methodology.

Flood Insurance Costs

Summary

When examining the financial implications of climate change on Bren Hall related to transition risks, one of the ways in which Bren may be affected is through insurance related costs and opportunities. While Bren Hall is relatively insulated from increased risks and costs associated with rising insurance costs related to climate change, there will likely be increased costs for the surrounding communities, which may impact the people who work at Bren and attend school at Bren. Bren school does not pay insurance as an entity, but is covered by UCSB wide policies.

Background

According to the reports, presently, there are 2,185 insurance policies through the National Flood Insurance Program (NFIP) between the cities of Santa Barbara and Goleta[21]. The current properties covered by the NFIP are ones that exist in a designated high risk floodplain area, as severity of flooding increases and as wildfires grow larger this will increase the area of a high risk flood area. It is no longer just low-lying areas that need to worry about flooding, as the NFIP covers damage from mudslides related to post-fire burns. The average annual increase of homes being listed in this area was ~3% annually either due to new construction, redrawing of maps, or wildfire risks[21].

These contracts represent a property value of ~$626M. The current cost of paying into the NFIP is $40 annually, covering up to $250,000.00 in damages, and additional coverage may be purchased through private insurers[21]. The NFIP will no longer be issuing new contracts as of September 2020 under the old rating measurements, which means that new construction and existing residential buildings looking to adopt flood insurance will have to go through private insurers for coverage or wait for the new NFIP program to rollout[22]. The NFIP currently provides 96% of all flood insurance domestically, and will be rolling out a new risk assessment tool entitled Risk Rating 2.0[23]. This tool aims to have premiums more reflective of property values and risk of needing flood insurance, while also covering the current budget shortfall facing the NFIP. With respect to Santa Barbara County this could dramatically increase the rates that current residents pay as several new factors will be factored into the calculation, including distance to the coast, replacement cost value (value of the home), and pluvial flooding (mudslides).

Methods

By 2050, the number of properties was estimated to be ~5,300 which also matches up with data obtained from flood maps that project flood risk in 2050[24]. While there have been no definitive estimates on what the new rates will look like, to project out rates numbers from private insurance estimates were taken. The average rate for 12 different companies was $1007.29, with a standard deviation of $556.89 for an equivalent coverage of $250,000.00. This rate was calculated by drawing the rate from multiple private flood insurance websites for a median home value in Santa Barbara ($800,000) with a coverage of

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[21] *FEMA Flood Map Service Center | Search All Products*. (n.d.). Retrieved from https://msc.fema.gov/portal/advanceSearch#searchresultanchor

[22] Horn, D. P., & Webel, B. (n.d.). *Introduction to the National Flood Insurance Program (NFIP)*. 31.

[23] *National Flood Insurance Program (NFIP) and Risk Rating 2.0*. (2020, July 20). http://www.larealtors.org/risk-rating-2-0

[24] *Climate Central | Land projected to be below annual flood level in 2050*. (n.d.). Retrieved from https://coastal.climatecentral.org/map/12/-73.9605/40.7101/?theme=sea_level_rise&map_type=year&basemap=roadmap&contiguous=true&elevation_model=best_available&forecast_year=2050&pathway=rcp45&percentile=p50&return_level=return_level_1&slr_model=kopp_2014

$250,000.00, and a $5000 deductible. Each of the projection levels were then multiplied by the number of properties in the flood risk areas to arrive at the annual total. Annual totals were then summed to find the total cost to the community by the year 2050.

To see what proportion of this would be taken by the Bren community, the total population of the Bren and Bren adjacent community was taken and estimated to be 440 people, and was divided by the overall population of the Santa Barbara/Goleta areas which is ~122,000 people. This proportion was then multiplied by the total costs for the low, medium, and high projections to arrive at different estimate levels for the Bren community.

Results

The total costs projected to the Santa Barbara and Goleta communities by 2050 under the low projection are $68M, $110M for the medium projection, and $171M for the high projection. As it relates to the Bren community costs, and under the low projection the Bren community by 2050 may need to pay an additional $218k in flood insurance costs, $394k in the medium projection, and $612k in the high projection. Annually for Bren, this could range from ~$7,000 to ~$20,000 in costs; which would only be borne by a handful of individuals within the community as not all community members would live in a flood zone.

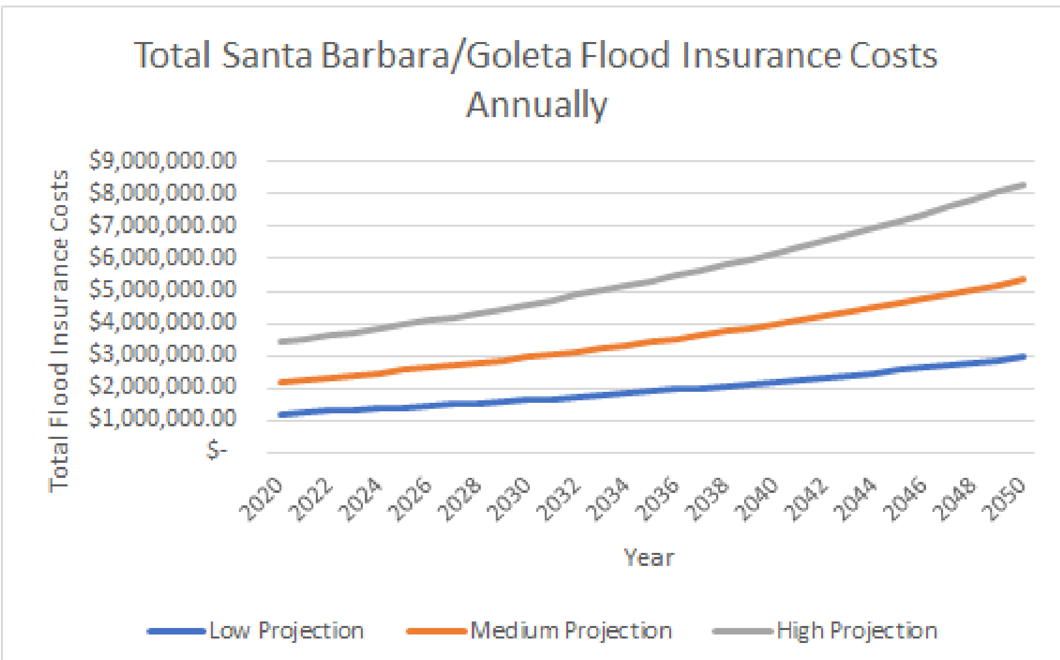

Figure 2: Shows the estimated annual insurance costs by the Santa Barbara / Goleta communities until 2050 under a low ($556.89), medium ($1,007.29), and high ($1,564.18) projections. The value is multiplied by the number or properties at risk of flooding starting at 2,185 in 2020 and growing by 3% annually inline with FEMA data.

Discussion

With these increased insurance rates facing the community, the cost of living in Santa Barbara will almost certainly increase to accommodate the increased insurance costs facing residents. This means that to attract students and faculty Bren may need to pay more in salaries to faculty, or increase the amount it pays to teaching assistants. The University, and UC system as a whole was grappling with protests amongst graduate students who are already feeling pinched by a high cost of living in 2020. This could result in monthly increases of salaries for staff, faculty, and students, that could cost millions of dollars to the Bren school over the course of coming decades.

Additionally, this is only projecting out individual flood insurance costs and is not including the current insurance paid by the University that covers Bren Hall. Nor does it include other types of insurance policies that may change as a result of climate change such as wildfire insurance. Wildfire insurance is very difficult to project out as rates can fluctuate based on wildfire activity and proximity to the WUI; recently a house went on the market in Montecito worth $1.5M in value, but projected wildfire insurance was $40,000 annually. That said further research into costs related to wildfire insurance costs would likely be warranted. [25]

Carbon Pricing and Carbon Taxes

Changes to carbon policy, particularly carbon pricing mechanisms, are likely to be a major component of government actions to address climate change. The Bren School is already familiar with carbon emission trading schemes (ETS) through California's Cap-and-Trade Program and through voluntary carbon offsets that the University has purchased in order to meet the goals of the UC's Carbon Neutrality Initiative.[26] ETS carbon prices fluctuate due to changes in carbon offset supplies, demand, offset quality and "leakages" where emissions reductions in one area result in emissions increases elsewhere.[27] The Biden administration has announced that the U.S. will achieve net-zero GHG emissions by 2050 but has not yet committed to a carbon pricing mechanism to achieve the goal.[28] Because of these uncertainties, this report evaluates the financial risk to the Bren School of implementation of a federal carbon tax.

The 116th US Congress (2019-2020) proposed ten different carbon tax plans serving as the basis of this analysis. The annual financial cost to the Bren School and Community was determined for the years 2020-2030 based on the highest and the lowest proposed carbon taxes. The "low" tax scenario (Stemming Warming and Augmenting Pay Act of 2019 introduced by Congressman Francis Rooney, R-FL) starts at $30 per metric tonne CO2e in 2021 and rises at 5% plus inflation per year, reaching $44 by 2030, while the "high" carbon tax (Climate Action and Rebate Act introduced by Senator Chris Coons, D-DE) starts at $15 per tonne and rises $15 per year, reaching $150 by 2030.[29] Figure E-1 in Appendix E shows the proposed taxes alongside the carbon prices needed to meet the goals of the Paris Agreement according to the Sustainable Development Scenario (SDS) developed by the International Energy Agency. The SDS determines that advanced economies will need CO2 emissions priced at an average $63/tonne in 2025 and

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[25] Schubach, A. (n.d.). *California Wildfires Are Driving up Fire Insurance Premiums—And Home Prices*. Retrieved December 11, 2020, from https://www.mansionglobal.com/articles/california-wildfires-are-driving-up-fire-insurance-premiums-and-home-prices-220244

[26] R. Bales, S. Rebich-Hespanha, L. Leombruni, H. Hodges, A. Heeren, H. Gelbach, N. Van Leuvan, J. Christensen. (2018) Strategic Communication to Achieve Carbon Neutrality within the University of California, Report of the UC TomKat Carbon Neutrality Project. DOI:10.6071/H87D2S8W. URL: https://doi.org/10.6071/H87D2S8W.

[27] Suh, Sangwon. ESM 271: Carbon Accounting. (17 Nov. 2020) Bren School of Environmental Science & Management, UC-Santa Barbara. Class lecture.

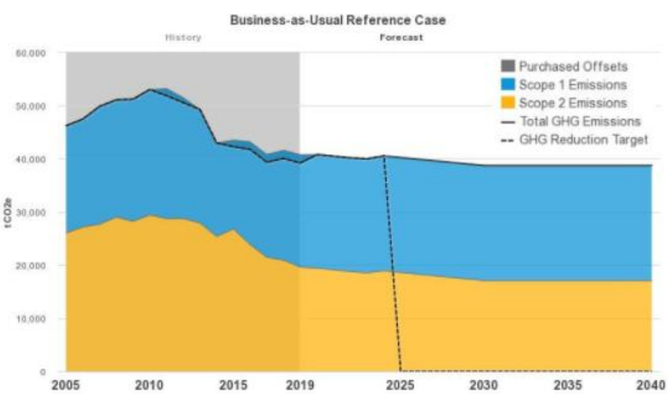
[28] Goldstein, Lorrie. "Biden's Climate Plan Omits National Carbon Tax -- for Now." *Toronto Sun*. (November 8, 2020) https://torontosun.com/opinion/columnists/goldstein-bidens-climate-plan-omits-national-carbon-tax-for-now.

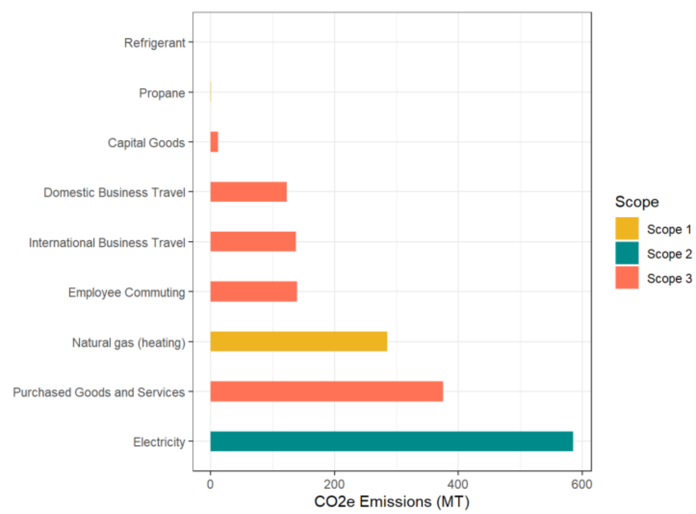
[29] Larsen, John, Noah Kaufman, Peter Marsters, Whitney Herndon, Hannah Kolus, and Ben King. "Expanding the Reach of a Carbon Tax." Columbia University Center on Global Energy Policy and Rhodium Group (October 2020) https://rhg.com/wp-content/uploads/2020/10/Expanding-the-Reach-of-a-Carbon-Tax-Emissions-Impacts-of-Pricing-Combined-with-Additional-Climate-Actions.pdf.

converging on $140/tonne by 2040.[30] Using a linear regression model, the price in 2030 was interpolated as $89/tonne.

Methods

This analysis estimates risk to the Bren School in a business-as-usual scenario as a worst-case. The Fovea Climate Action Plan (CAP) projects Scope 1 and 2 GHG emissions at UC-Santa Barbara from 2020-2030 in a business-as-usual scenario, see Figure 3.[31] Bren School Scope 1, 2 and 3 emissions were provided by Dr. Sangwon Suh as determined by ESM 271 students in Fall 2018. Scope 1 and 2 emissions covered the 2017 fiscal year, from Jun. 30, 2017-May 31, 2018. Scope 3 emissions covered the UCSB academic calendar: Sept. 24, 2017-Jun. 15, 2018. Figure 4 shows all emissions sources evaluated and identified. It is assumed that the emissions are a representative year for Bren and that Scope 3 emissions during the summer academic term would not drastically change Scope 3 emissions though it should be noted that future analyses should evaluate the contribution of these emissions.





<u>Figure 3 (left): Historic and projected GHG emissions at UCSB under business-as-usual scenario, 2005-2040 (Fovea, 2019)</u>
<u>Figure 4 (right): Bren School Scope 1, 2 and 3 GHG emissions, 2017/2018 academic and fiscal year (ESM 271 class, 2018)</u>

An average of the total Scope 1 and Scope 2 emissions across UCSB for the years 2017 and 2018 were determined from the CAP and compared to the 2017/2018 emissions from Bren. Scope 1 emissions were 20,015 tonnes CO_2e, with 1.42% of emissions attributable to Bren. Scope 2 emissions were 21,181 tonnes with 2.76% of emissions attributable to Bren. These percentages were used to estimate the business-as-usual Scope 1 and 2 emissions from the Bren School for the years 2020-2030 using the projections for UCSB from the Fovea CAP. Further, it was determined from the 2017/2018 Bren emissions, that when considering Scopes 1, 2, and 3, 48% of the Bren School's carbon footprint can be attributed to Scope 3 emissions. Assuming the projected Scope 1 and 2 emissions represented only 52%

[30] IEA (2020), World Energy Model, IEA, Paris https://www.iea.org/reports/world-energy-model

[31] "UCSB: CAP2 10.7.2." Fovea, LLC. Accessed December 9, 2020. https://cap.foveaservices.com/cap/ucsb.

of total emissions attributable to Bren, Scope 3 emissions were also projected from 2020-2030. Results are shown in Figure E-2 and Table E-1 in Appendix E.

Results

The high and low carbon tax proposed by Congress was applied to Bren's total annual emissions for each year between 2020 and 2030 to determine a high and low estimate of Bren's annual financial risk from a carbon tax in a business-as-usual scenario. Inflation was not considered for tax rates although the low carbon tax rate is tied to inflation. Results are shown in Figure 5. In 2025, annual risk is $57,066-$117,371. In 2030, risk increases to $69,128- $222,802. This assumes that, even though the carbon tax would likely be levied "upstream," i.e. to fossil fuel suppliers, 100% of the costs of the carbon tax would be passed on to Bren. This analysis includes Scope 3 emissions from faculty, staff and student commuting although the risk would be to each individual member of the Bren community, and not to the Bren School at large. Emissions from Bren community commuting account for 8% of Bren's total emissions.

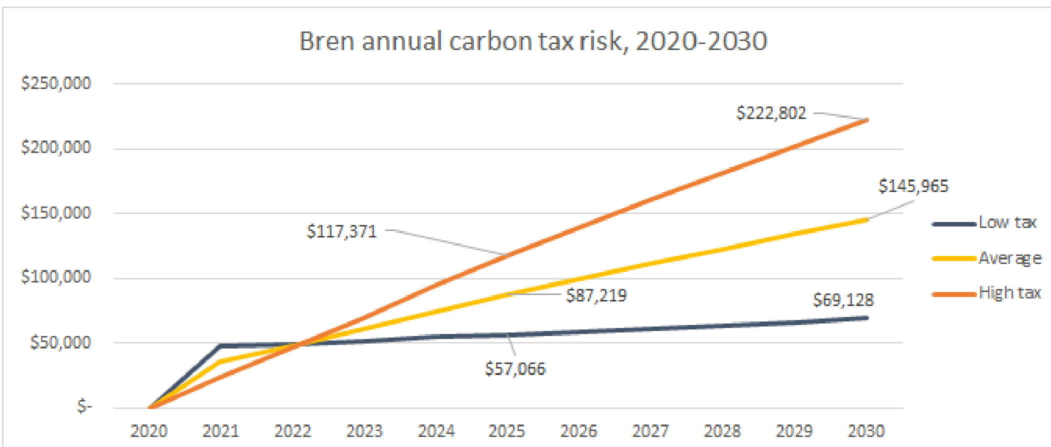


Figure 5: Annual Bren School carbon tax financial risk, 2020-2030

Discussion

This analysis assumes a business-as-usual scenario. However, the implementation of a carbon tax will impact GHG emissions economy-wide. Future analysis should estimate industry-specific and geographic-specific reductions in carbon emissions in response to a carbon tax and adjust financial implications of the tax accordingly. Future analyses should also incorporate UCSB's plans for achieving carbon neutrality which is an opportunity for Bren to reduce GHGs before a carbon tax is implemented. Further research should be done on the implications of a federal carbon tax on California's existing Cap-and-Trade Program and the voluntary carbon offset market.

Highlighted Opportunities

Technological Upgrades

Bren Hall has already undertaken significant energy efficiency improvements that generate savings in both dollars and CO_2e emissions. The building is designed to take advantage of natural light, heating, and cooling; the remaining energy demand is managed to be as minimal as possible, utilizing reflective roof coatings, photovoltaic solar panels, a multi-building water chiller, and a modernized boiler. Scope 1 and 2 emissions for the building are therefore quite low.

Instead, voluntary technological improvements that seem most promising are those that fall on the left side of the McKinsey abatement cost curve[32] - where emissions can be abated with projects that actually provide financial savings. An example of such a project would be upgrading the facility's lighting to light-emitting diode (LED) technology. LED bulbs are more efficient than fluorescent or incandescent lighting, reducing energy demand and therefore generating savings on the electricity bill. UCSB joined the UC Million LED challenge in 2019, which provides funding for bulb replacements for their contribution to meeting the UC's 2025 carbon neutrality goal. UCSB also founded The Green Initiative Fund (TGIF) in 2006 to fund projects that reduce the University's environmental impact.

A retrofit of 163 incandescent fixtures in the lab wing of Bren Hall has recently been proposed. The existing 20W incandescents will be replaced with 3.5W LEDs. Assuming a run time of 8 hours per day, 5 days per week, and 50 weeks per year, the replacement saves 5,379 kWh each year. Using the TGIF CO_2 savings calculator, which references the conversions from the 2009 California Climate Action Registry (CCAR) Protocol[33] shown below, the upgrade also saves 1.76 tonnes of CO_2 equivalents each year.

Table 4: Emission Conversion Factors from CCAR Protocol 2009

lbs CO_2/kWh	lbs N_2O/kWh	lbs CH_4/kWh	N_2O GWP	CH_4 GWP	lb/MT
0.0724	8.1×10^{-6}	3.02×10^{-6}	23	296	2205

We can monetize these emissions savings in several different ways. Using the current electricity rate of \$0.084/kWh, this equates to a little over \$450 saved each year. The cost of the upgrade, including installation labor, totals around \$4,400, suggesting a 10-year ROI. Over those ten years, the LED bulbs will have saved nearly 20 MT CO_2e. The marginal cost of reduction based on the initial expenditure and 10-year payback period is about 200 \$/MT. Alternatively, we can use the projected average carbon price of \$63/tonne (2025) and estimate \$111 saved each year. However, a note for future lighting upgrades is that fluorescent bulbs in other parts of the building use specialized ballast that will be more costly to remove or retrofit.

Another upgrade for the Bren School to consider is a refrigerant replacement. There are 4 refrigerant units in the building that use R-22, also known as chlorodifluoromethane or freon. This is a hydrochlorofluorocarbon (HCFC) known for contributing to depletion of the ozone layer, and has therefore been phased out under the Montreal Protocol. The final ban on manufacturing and import of this substance in the U.S. went into effect in January 2020, which means the domestic supply is shrinking and becoming more difficult to secure. If there is ever any need to refill the refrigerant in the existing units, it may be extremely expensive or even impossible to do so, which could result in costly downtime. The Bren School would also need to account and possibly pay for the emissions attributable to the leaked refrigerant. There are 6 units using R-22 and R-404A, another HFC, with a total of 82.5 pounds of

[32] Enkvist, Nauclér, and Rosander. (2007) A cost curve for greenhouse gas reduction, McKinsey Quarterly. https://www.mckinsey.com/business-functions/sustainability/our-insights/a-cost-curve-for-greenhouse-gas-reduction

[33] California Climate Action Registry General Reporting Protocol (2009) http://www.caclimateregistry.org/tools/protocols/general-reporting-protocol.html

refrigerant. Using a global warming potential 1,810[34] times greater than that of CO_2, the full refrigerant volume equates to nearly 68 tonnes of CO_2e.

At the average carbon price of $63/tonne, leakages could cost the Bren School up to $4,267. The cost of replacing the refrigerant or unit on demand is uncertain, but likely quite high. However, if the R-22 was replaced with a more environmentally-responsible alternative such as R-410A, it would only cost $4/lb or $330 for all units. The marginal cost of reduction in this case is very low - less than $5/MT - although this does not include the cost of labor or proper hazardous material disposal/recovery fees. The cost of completely replacing the refrigerant units with ones that are designed for clean alternative refrigerants is higher - around $4,000/unit for a total of $24,000. The marginal cost of reduction in this scenario is $354/MT CO_2, but the project could ultimately result in energy savings from using newer, more efficient machines.

Reputational Benefits

The Bren School has the potential to gain reputational benefits as a leading graduate program that prepares students to address climate change impacts and adaptations. Expertise amongst our faculty include climate modeling, life cycle assessment, carbon accounting, climate change policy, renewable energy technology, and corporate sustainability, to name a few. Furthermore, the increasing recognition and need for those technical and analytical skills creates a growing professional market for Bren graduates across various sectors. The Bren network will also increase in value as our alumni population moves into leadership roles in the climate change related environmental management field. In all likelihood this will increase the desirability of degrees from the Bren School and result in more applicants and the opportunity to expand and create more programs.

Conclusions

Table 5: Total Utility Exposure

	Current	2025	2030	2050
Projected Annual Water Cost ($)	8,146.79	11,726.10	Uncertain	Uncertain
Projected Annual Natural Gas Cost ($)	18,501.69	18,993.75	20,297.73	21,872.34
Projected Annual Electricity Cost ($)	129,026.48	127,797.66	127,797.66	117,967.07
Total Annual Cost	**155,674.96**	**158,517.51**	**148,095.39** (excl. water)	**139,839.41** (excl. water)

With full certainty, water rates could only be projected until 2025. Water has been historically underpriced for years, which is why the percent increase is higher than inflation. It is uncertain whether

[34] California Air Resources Board: High GWP Refrigerants https://ww2.arb.ca.gov/resources/documents/high-gwp-refrigerants

water rates will continue to rise faster than inflation post 2025 or if the percent increase for rates will lower due to the water district no longer needing to recover or make up costs.

In regard to natural gas and electricity prices, the EIA data projected through 2050 and using those percentage increases, the projected natural gas and electricity prices were found. This allows for the totaling of these utility rates to find total exposure to risk and consequently room for opportunity. Totaling all utilities, the exposure risk is currently $155,674.96 and will be $158,517.51. The 2030 and 2050 totals were projected, but since water rates are less predictable the projected exposure from utilities only included natural gas and electricity, which totaled $148,095.39 and $139,839.41 respectively.

Table 6: Estimated Climate Risk Costs

	Current	**2025**	**2030**	**2050**
Estimated Flood Insurance Costs	$7,804.13	$9,047.13	$10,488.10	$18,942.67
Estimated Carbon Tax Costs	$0	$87,219	$145,965	Uncertain
Estimated Wildfire Energy Disruption	$1,894	$1,894	$1,894	$23,764
Total	**$9,698.13**	**$105,730.13**	**$158,347.10**	**$42,706.67** (excl. carbon tax)

The total physical and transition risks listed in Table 6 represent additional costs that may accrue due to climate change. These numbers were calculated with less certainty and should be re-examined over time as we learn more information. The flood and wildfire costs may be improved with more accurate climate models and as climate policy changes, the carbon tax cost may be estimated more accurately. The annual weather related energy disruption cost was determined by taking the average of the 2 non-fire years in our data and would benefit from reviewing more years. The 2050 wildfire energy disruption cost includes the cost of the Thomas fire. We included that cost so that our analysis would take into account the risk of experiencing a single wildfire between now and 2050.

Limitations and Future Research

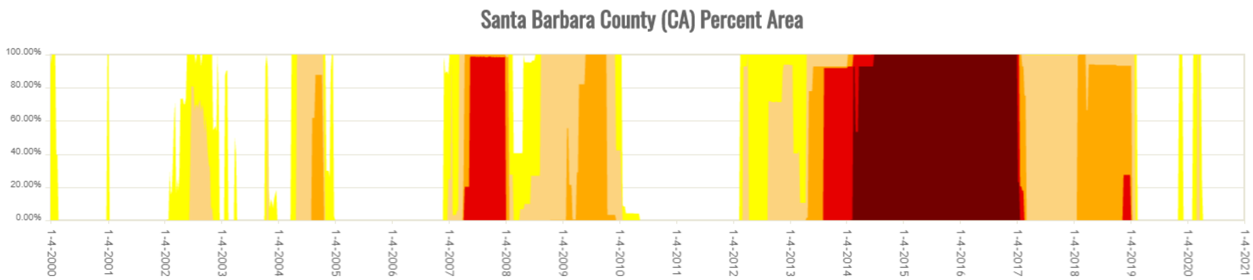
Limitations for all physical risks analyzed included the inability to predict actual, future events, such as flooding, wildfires, or drought. Additionally, for all risks, it is unclear whether policy will change or what new legislation will pass in the future. For example, as stated previously, if direct potable reuse becomes legal in California, then UCSB and Bren Hall could potentially expect a decrease in water costs. Another limiting factor is predicting human behavior. Water consumption could lower if more of Bren Hall's students or workers were, even more, conscious of their water usage. Similar to wildfires, if less people started outside fires or took more safety precautions, then a certain amount of fires could be prevented. Model accuracy of all risks could be improved if more of the data used was specific to the system boundaries analyzed. Recommendations for future research for Bren Hall's financial risks due to climate change are listed in Appendix F: Table F.1.

Acknowledgements

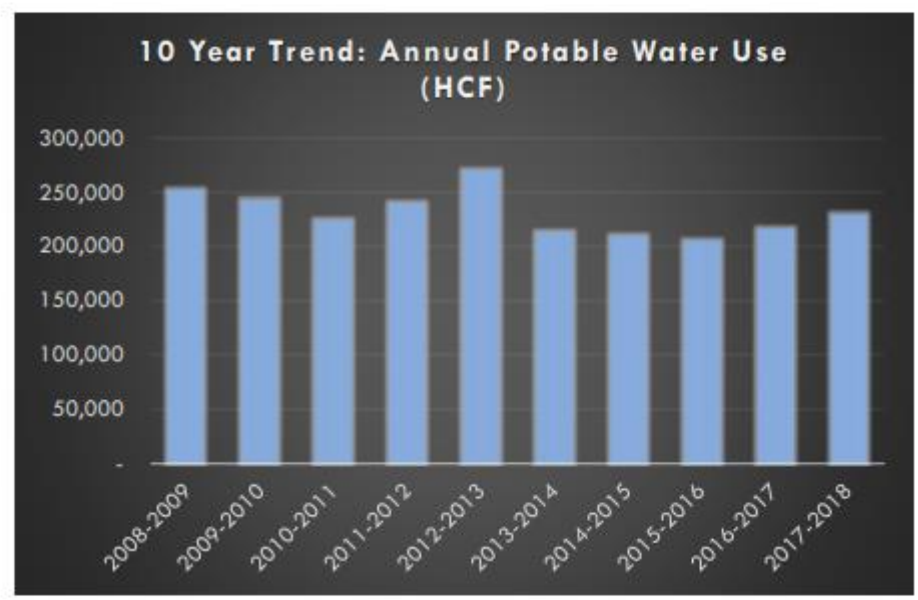
This report would not have been possible without help from UCSB faculty and staff. We would like to extend our gratitude to Professor Sangwon Suh for his guidance and support, as well as to Jordan Sager, Sage Davis, and Kim Fugate for their time and knowledge of UCSB and Bren systems and operations.

Appendices

Appendix A: Water Supply



<u>Figure A-1.</u> Santa Barbara County Percent Area that is considered abnormally dry (yellow), moderate drought (beige), severe drought (orange), extreme drought (red), and exceptional drought (maroon). Source: United States Drought Monitor



<u>Figure A-2 and A-3.</u> UCSB annual potable water use for the past ten years Source: UCSB

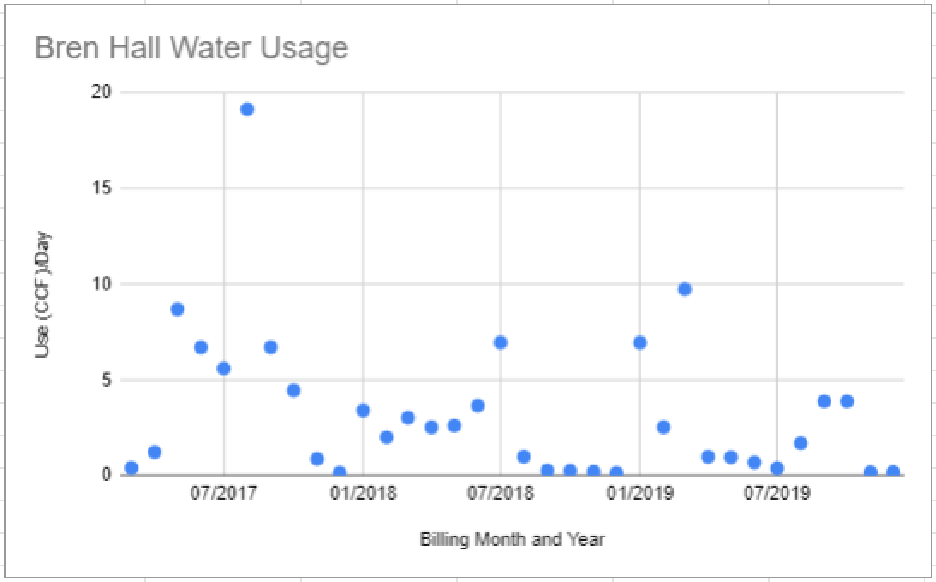


Figure A-3. Bren Hall's monthly water usage for 2017-2019. Source: UCSB

Appendix B: Utilities

Table B-1. Natural Gas Price Forecast through 2050

Year	Price/MMBtu	Price/therm	% Increase Year over Year	% Increase from 2019	Expected Average Unit Cost ($/therm)	Expected Total Daily Cost ($)	Expected Total Annual Cost ($)
2019	7.52	0.752					
2020	7.16	0.716	-4.79%	-4.79%	0.476	48.263	17615.969
2021	7.3	0.73	1.96%	-2.93%	0.486	49.207	17960.415
2022	7.32	0.732	0.27%	-2.66%	0.487	49.341	18009.622
2023	7.38	0.738	0.82%	-1.86%	0.491	49.746	18157.242
2024	7.5	0.75	1.63%	-0.27%	0.499	50.555	18452.481
2025	7.72	0.772	2.93%	2.66%	0.514	52.038	18993.754
2026	7.86	0.786	1.81%	4.52%	0.523	52.981	19338.200
2027	7.99	0.799	1.65%	6.25%	0.532	53.858	19658.043
2028	8.06	0.806	0.88%	7.18%	0.536	54.329	19830.267
2029	8.08	0.808	0.25%	7.45%	0.538	54.464	19879.473
2030	8.25	0.825	2.10%	9.71%	0.549	55.610	20297.729
2031	8.22	0.822	-0.36%	9.31%	0.547	55.408	20223.920
2032	8.24	0.824	0.24%	9.57%	0.548	55.543	20273.126
2033	8.34	0.834	1.21%	10.90%	0.555	56.217	20519.159
2034	8.4	0.84	0.72%	11.70%	0.559	56.621	20666.779
2035	8.41	0.841	0.12%	11.84%	0.560	56.689	20691.382
2036	8.4	0.84	-0.12%	11.70%	0.559	56.621	20666.779
2037	8.45	0.845	0.60%	12.37%	0.562	56.958	20789.796
2038	8.49	0.849	0.47%	12.90%	0.565	57.228	20888.209
2039	8.51	0.851	0.24%	13.16%	0.566	57.363	20937.415
2040	8.52	0.852	0.12%	13.30%	0.567	57.430	20962.019
2041	8.55	0.855	0.35%	13.70%	0.569	57.632	21035.829
2042	8.58	0.858	0.35%	14.10%	0.571	57.835	21109.639
2043	8.6	0.86	0.23%	14.36%	0.572	57.969	21158.845
2044	8.62	0.862	0.23%	14.63%	0.574	58.104	21208.052
2045	8.66	0.866	0.46%	15.16%	0.576	58.374	21306.465

2046	8.7	0.87	0.46%	15.69%	0.579	58.644	21404.878
2047	8.76	0.876	0.69%	16.49%	0.583	59.048	21552.498
2048	8.79	0.879	0.34%	16.89%	0.585	59.250	21626.308
2049	8.85	0.885	0.68%	17.69%	0.589	59.655	21773.928
2050	8.89	0.889	0.45%	18.22%	0.592	59.924	21872.341

Table B-2. Electricity Price Forecast Through 2050

Year	Projected Price (Cents/kWh)	Projected Price ($/kWh)	% Increase Year over Year	% Increase from 2019	Expected Average Unit Cost ($/kWh)	Expected Total Monthly Cost ($)	Expected Total Annual Cost ($)
2019	10.5	0.105					
2020	10.3	0.103	-1.90%	-1.90%	0.08	10,547.40	126,568.84
2021	10.2	0.102	-0.97%	-2.86%	0.08	10,445.00	125,340.01
2022	10.2	0.102	0.00%	-2.86%	0.08	10,445.00	125,340.01
2023	10.2	0.102	0.00%	-2.86%	0.08	10,445.00	125,340.01
2024	10.2	0.102	0.00%	-2.86%	0.08	10,445.00	125,340.01
2025	10.4	0.104	1.96%	-0.95%	0.08	10,649.80	127,797.66
2026	10.5	0.105	0.96%	0.00%	0.08	10,752.21	129,026.48
2027	10.6	0.106	0.95%	0.95%	0.09	10,854.61	130,255.31
2028	10.5	0.105	-0.94%	0.00%	0.08	10,752.21	129,026.48
2029	10.4	0.104	-0.95%	-0.95%	0.08	10,649.80	127,797.66
2030	10.4	0.104	0.00%	-0.95%	0.08	10,649.80	127,797.66
2031	10.3	0.103	-0.96%	-1.90%	0.08	10,547.40	126,568.84
2032	10.2	0.102	-0.97%	-2.86%	0.08	10,445.00	125,340.01
2033	10.3	0.103	0.98%	-1.90%	0.08	10,547.40	126,568.84
2034	10.3	0.103	0.00%	-1.90%	0.08	10,547.40	126,568.84
2035	10.2	0.102	-0.97%	-2.86%	0.08	10,445.00	125,340.01
2036	10.1	0.101	-0.98%	-3.81%	0.08	10,342.60	124,111.19
2037	10.1	0.101	0.00%	-3.81%	0.08	10,342.60	124,111.19
2038	10.1	0.101	0.00%	-3.81%	0.08	10,342.60	124,111.19
2039	10.1	0.101	0.00%	-3.81%	0.08	10,342.60	124,111.19
2040	10	0.1	-0.99%	-4.76%	0.08	10,240.20	122,882.37

2041	10	0.1	0.00%	-4.76%	0.08	10,240.20	122,882.37
2042	9.9	0.099	-1.00%	-5.71%	0.08	10,137.80	121,653.54
2043	9.9	0.099	0.00%	-5.71%	0.08	10,137.80	121,653.54
2044	9.9	0.099	0.00%	-5.71%	0.08	10,137.80	121,653.54
2045	9.8	0.098	-1.01%	-6.67%	0.08	10,035.39	120,424.72
2046	9.8	0.098	0.00%	-6.67%	0.08	10,035.39	120,424.72
2047	9.8	0.098	0.00%	-6.67%	0.08	10,035.39	120,424.72
2048	9.7	0.097	-1.02%	-7.62%	0.08	9,932.99	119,195.89
2049	9.7	0.097	0.00%	-7.62%	0.08	9,932.99	119,195.89
2050	9.6	0.096	-1.03%	-8.57%	0.08	9,830.59	117,967.07

Appendix C: Wildfire

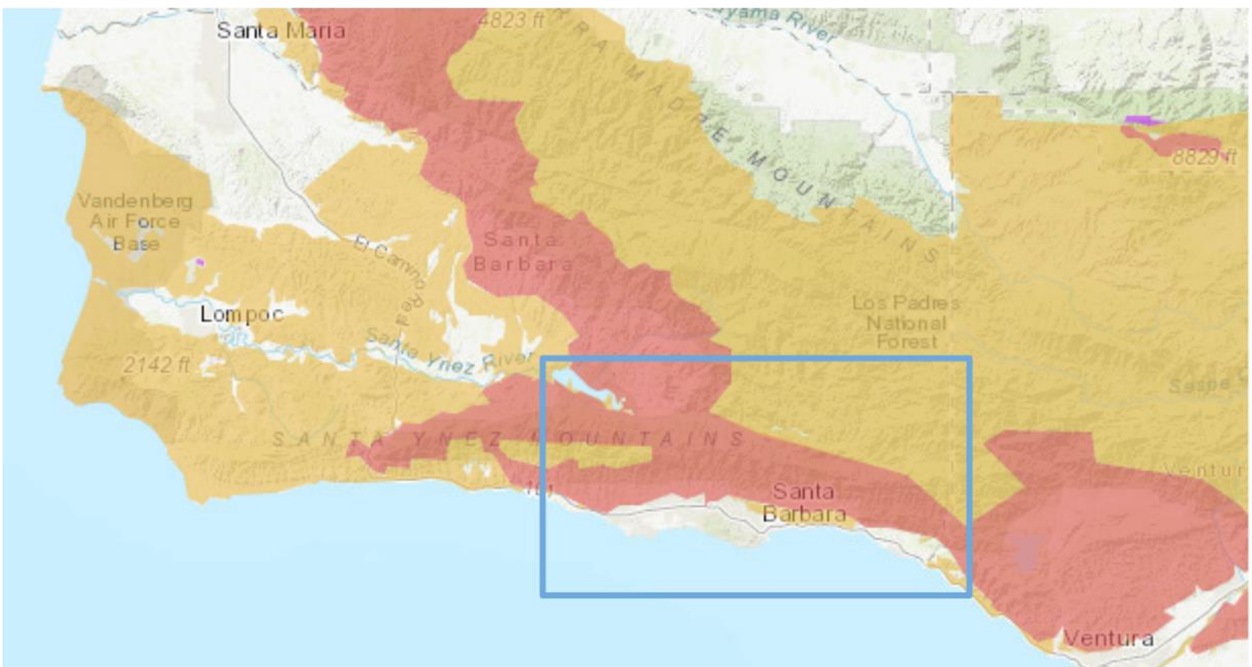


Figure C-1: CPUC High Fire Threat District Map for Santa Barbara County and parts of Ventura County. The red areas are Tier 3 extreme fire threat and yellow are Tier 2 high fire threat. The area in the blue box includes the UCSB campus and is shown in Figures C-2 and C-3.

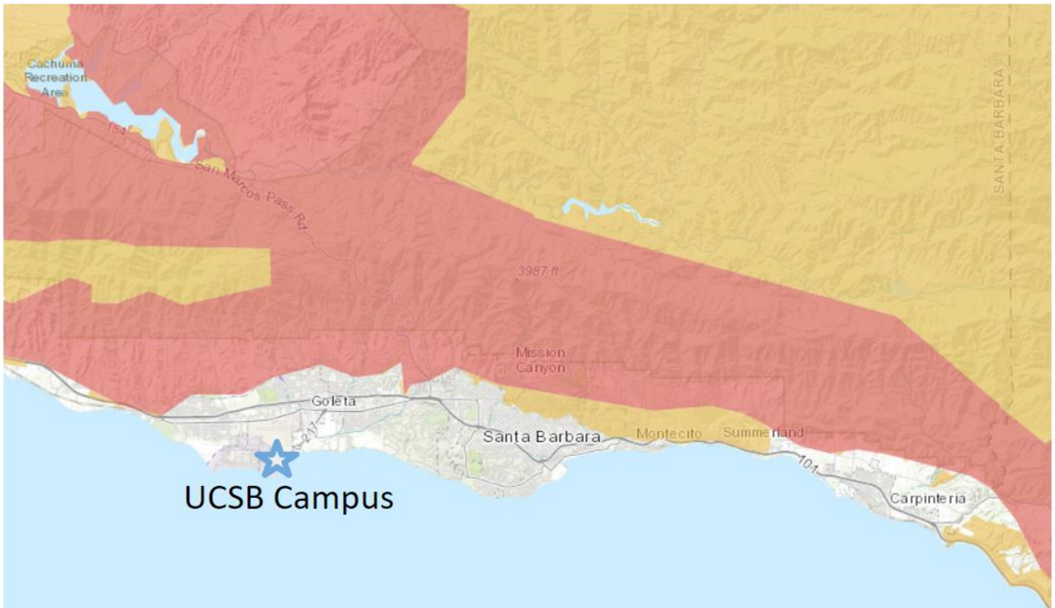


Figure C-2: CPUC High Fire Threat District Map for Santa Barbara. The red areas are Tier 3 extreme fire threat and yellow are Tier 2 high fire threat. The UCSB Campus is not under direct fire threat.

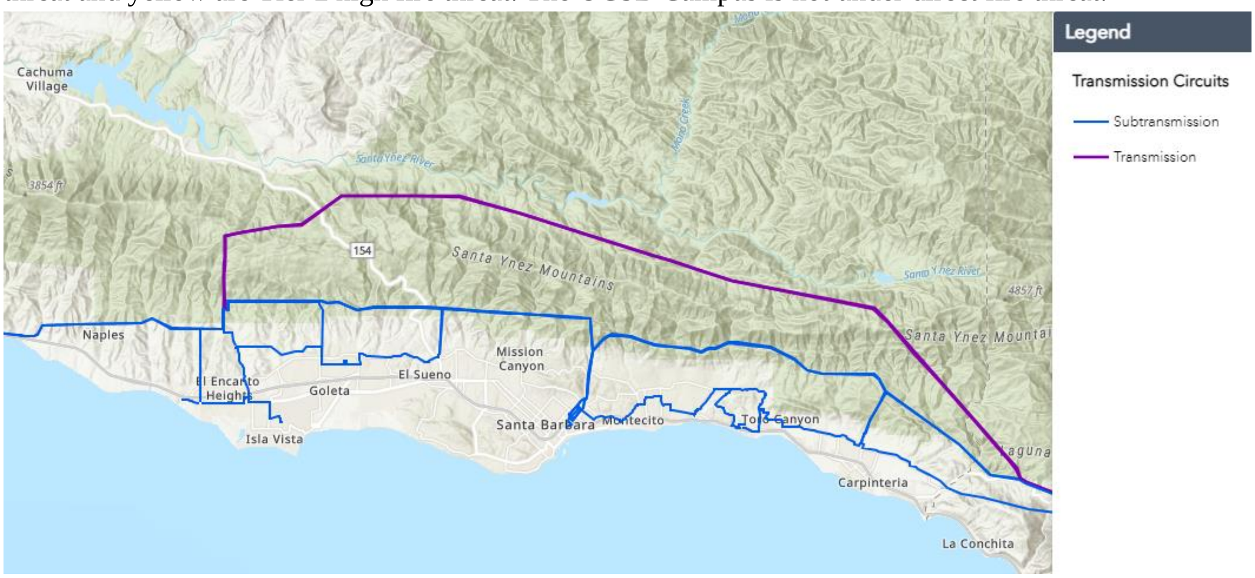


Figure C-3: SCE transmission map with the same map area as Figure Y. Major transmission lines that serve the UCSB campus cross through Tier 3 high threat zones.

Appendix D: Flood Insurance Estimates

Table D1: Projected Annual Flood Insurance Costs

Year	# Properties	Low	Middle	High	Low Projection	Medium Proj	High Proj
2020	2185	$534.45	$996.18	$1,530.63	$1,167,771.79	$2,176,660.58	$3,344,432.37
2021	2251	$534.45	$996.18	$1,530.63	$1,202,804.94	$2,241,960.40	$3,444,765.34
2022	2318	$534.45	$996.18	$1,530.63	$1,238,889.09	$2,309,219.21	$3,548,108.30
2023	2388	$534.45	$996.18	$1,530.63	$1,276,055.76	$2,378,495.79	$3,654,551.55
2024	2459	$534.45	$996.18	$1,530.63	$1,314,337.43	$2,449,850.66	$3,764,188.10
2025	2533	$534.45	$996.18	$1,530.63	$1,353,767.56	$2,523,346.18	$3,877,113.74
2026	2609	$534.45	$996.18	$1,530.63	$1,394,380.58	$2,599,046.57	$3,993,427.15
2027	2687	$534.45	$996.18	$1,530.63	$1,436,212.00	$2,677,017.97	$4,113,229.97
2028	2768	$534.45	$996.18	$1,530.63	$1,479,298.36	$2,757,328.50	$4,236,626.87
2029	2851	$534.45	$996.18	$1,530.63	$1,523,677.31	$2,840,048.36	$4,363,725.67
2030	2936	$534.45	$996.18	$1,530.63	$1,569,387.63	$2,925,249.81	$4,494,637.44
2031	3025	$534.45	$996.18	$1,530.63	$1,616,469.26	$3,013,007.30	$4,629,476.57
2032	3115	$534.45	$996.18	$1,530.63	$1,664,963.34	$3,103,397.52	$4,768,360.86
2033	3209	$534.45	$996.18	$1,530.63	$1,714,912.24	$3,196,499.45	$4,911,411.69
2034	3305	$534.45	$996.18	$1,530.63	$1,766,359.61	$3,292,394.43	$5,058,754.04
2035	3404	$534.45	$996.18	$1,530.63	$1,819,350.39	$3,391,166.27	$5,210,516.66
2036	3506	$534.45	$996.18	$1,530.63	$1,873,930.91	$3,492,901.25	$5,366,832.16
2037	3611	$534.45	$996.18	$1,530.63	$1,930,148.83	$3,597,688.29	$5,527,837.12
2038	3720	$534.45	$996.18	$1,530.63	$1,988,053.30	$3,705,618.94	$5,693,672.24
2039	3831	$534.45	$996.18	$1,530.63	$2,047,694.90	$3,816,787.51	$5,864,482.41
2040	3946	$534.45	$996.18	$1,530.63	$2,109,125.74	$3,931,291.13	$6,040,416.88
2041	4065	$534.45	$996.18	$1,530.63	$2,172,399.52	$4,049,229.87	$6,221,629.38
2042	4187	$534.45	$996.18	$1,530.63	$2,237,571.50	$4,170,706.76	$6,408,278.27
2043	4312	$534.45	$996.18	$1,530.63	$2,304,698.65	$4,295,827.97	$6,600,526.61
2044	4442	$534.45	$996.18	$1,530.63	$2,373,839.61	$4,424,702.81	$6,798,542.41
2045	4575	$534.45	$996.18	$1,530.63	$2,445,054.79	$4,557,443.89	$7,002,498.68
2046	4712	$534.45	$996.18	$1,530.63	$2,518,406.44	$4,694,167.21	$7,212,573.65

2047	4854	$534.45	$996.18	$1,530.63	$2,593,958.63	$4,834,992.22	$7,428,950.85
2048	4999	$534.45	$996.18	$1,530.63	$2,671,777.39	$4,980,041.99	$7,651,819.38
2049	5149	$534.45	$996.18	$1,530.63	$2,751,930.71	$5,129,443.25	$7,881,373.96
2050	5304	$534.45	$996.18	$1,530.63	$2,834,488.63	$5,283,326.55	$8,117,815.18
Total					$58,391,716	$108,838,858	$167,230,575

Table D2: Insurance Quotes

Source	**Premium**
https://www.privatemarketflood.com/calculate-your-own-premium	$2,178.37
https://neptuneflood.com/consumer-app/coverage	$682.00
https://www.betterflood.com/california-flood-insurance/	$930.00
Hippo	$799
Travelers	$1,370.00
Nationwide	$1,946.00
Floodprice	$288
Geico	$633.00
Policy Genius	$805.83
Private Market Flood Insurance	$806.00
Bank Rate	$642.00
Statefarm	$874.00
Average	**$996.18**
Standard Deviation	**$534.45**

Appendix E: Carbon Pricing

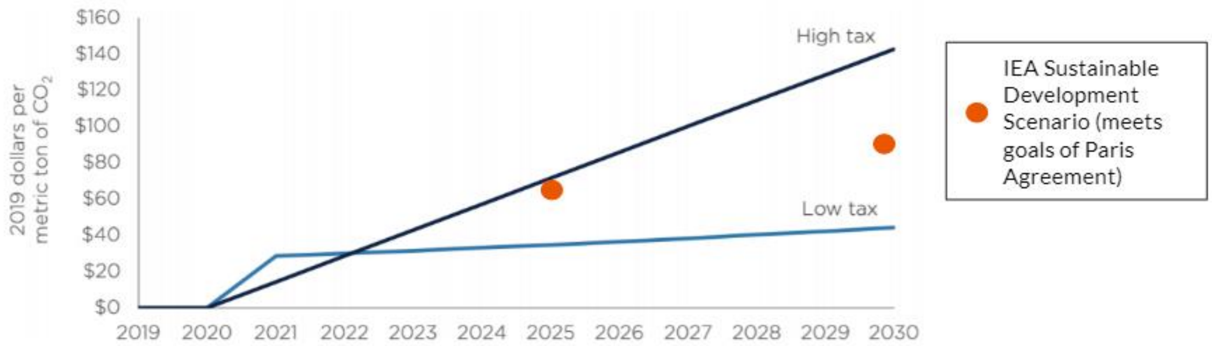


Figure E-1: High and low taxes proposed by the 116th US Congress compared to IEA Sustainable Development Scenario (Larsen et. al, 2020; IEA, 2020)

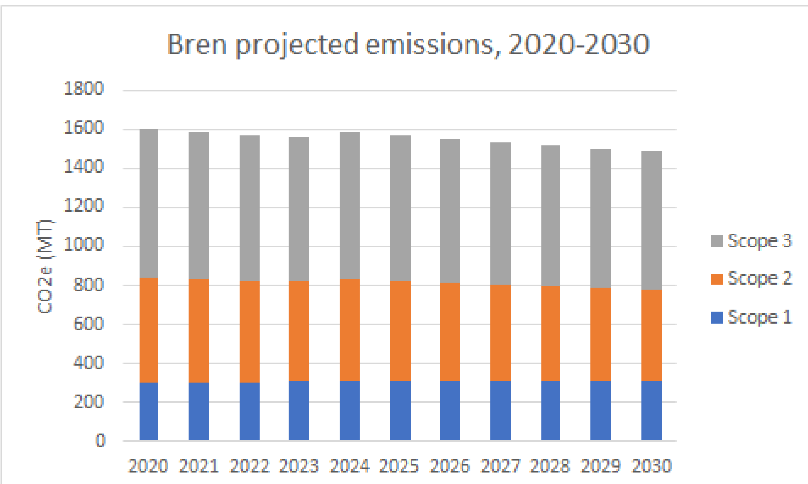


Figure E-2: Bren School Scope 1, 2 and 3 GHG emissions, projected for 2020-2030

Table E-1: Bren School Scope 1, 2 and 3 GHG emissions and associated annual carbon tax risk, projected for 2020-2030

Year	Scope 1 (MT CO2e)	Scope 2 (MT CO2e)	Scope 3 (MT CO2e)	Bren Total (MT CO2e)	Low tax scenario	High tax scenario	Average tax
2020	304	537	760	1601	$ -	$ -	$ -
2021	305	528	752	1584	$47,527	$23,763	$35,645
2022	305	519	744	1568	$49,378	$47,027	$48,203
2023	306	512	739	1557	$51,507	$70,078	$60,792
2024	308	523	751	1581	$54,922	$94,887	$74,905
2025	308	514	743	1565	$57,066	$117,371	$87,219
2026	308	505	735	1549	$59,299	$139,386	$99,342
2027	308	497	728	1533	$61,618	$160,931	$111,275
2028	308	488	720	1517	$64,021	$181,993	$123,007
2029	308	480	713	1501	$66,525	$202,619	$134,572
2030	308	472	705	1485	$69,128	$222,802	$145,965

Appendix F: Physical and Transition Risks

Table F-1: Physical and transition risks for Bren Hall.

	Risk Type	Risk/Opportunity	Timeframe	Translate to Financial Risk
Physical	Acute	Wildfire	short (<5 years)	Time lost, building damage
	Acute	Extreme storms (King's Tide?)	long (10+ years)	
	Acute	Flooding	short/medium	
	Acute	Power outages	short	Time/data lost
	Acute	COVID/disease	short/medium	Lost tuition, cost of adaptation
	Chronic	Coastal erosion	long (10+ years)	Erosion ultimately threatens building foundation
	Chronic	Sea Level Rise	medium/long	
	Chronic	Drought	medium/long	Increased water price if SB water portfolio shifts to expensive desal
	Chronic	Workforce impact	short (<5 years)	time/pay lost by days off, increased benefits
	Chronic	Air Quality Impacts	short/medium	healthcare costs
Transition	Policy/Legal	GHG emissions limits	medium (5-10 years)	Cost of reduction technology/new fuel sources
	Policy/Legal	Carbon Tax	short/medium	Taxes on emissions (easy)
	Policy/Legal	Potential Litigation (failure to mitigate/report)	short/medium	
	Technology	Mandated update of building tech	short (<5 years)	Cost of upgrades (easy) Savings from energy efficiency
	Market	Fuel price increases	short (<5 years)	
	Market	Utility price increases	short/medium	
	Market	Output like waste treatment costs	short/medium	

	Market	Insurance premiums increase/decrease	short/medium	
	Reputation	Bren shamed for not meeting standards	short/medium	Lost revenue from incoming students