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Climate Change Cost Impacts on California Households

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Climate Change Cost Impacts on California Households

By Bruce Severance, Mitsubishi Electric US
Submitted to California Public Utility Commission, January 2019, Updated August 2019
Submitted to both CEC Docket #19-IEPR-06 and CPUC Docket #R.19-01-011 on Aug. 8, 2019

Estimating Climate Change Costs is Critical to Electrification Policy

In the 2018 AGA-sponsored study entitled “Implications of Policy Driven Residential Electrification”, the American Gas Association claims that electrification of the US economy will increase “the average residential household energy-related costs (amortized appliance and electric system upgrade costs and utility bill payments) of affected households by between $750 and $910 per year, or about 38 percent to 46 percent.”*[1] As a counterpoint, a 2018 study from RMI points to credible accounting that when both the cost of replacing retiring gas generation plants and the falling price of gas are accounted, renewable generation capacity is significantly cheaper in most regions across the US, providing as much as 60% cost savings in some cases.*[2] Furthermore, a gas versus electrification cost analysis by RMI demonstrates that consumer costs to switch to all-electric appliances is at cost parity with replacing gas appliances in most California homes including fuel costs, especially in cases wherein: a) new construction where neighborhood gas mains can be eliminated from the project, b) both the existing furnace and AC must be replaced, and c) anytime direct electric (resistance heat), fuel oil or propane are the existing primary fuels. The only case wherein costs were not near parity were on existing buildings wherein only the furnace or the existing AC need replacement, but not both. *[3]

One of the key differences in assumptions between the RMI and AGA studies is the extent to which renewables are projected to grow over the coming decades and the extent of “grid harmonization” achieved. By making worst case assumptions about growth in renewables and the extent that grid managers are able to match power demand and supply curves with DR technologies, optimal EV charging and the addition of ‘baseload renewables’ to the grid, the AGA study reaches very cynical conclusions about the cost of electrification to average households.

The AGA study goes onto affirm projections that emissions from the generation of electricity supplied to the residential sector will account for about “10 percent of total GHG emissions in 2035, or more than twice the GHG emissions from the direct use of natural gas in the residential sector”.*[4] This is an aggregated national projection which in reality will vary widely by region relative to the fuel mix that supplies regional grids and this figure again reflects the very low market penetration of renewables that they assume in the study, about a 9% improvement from 2016 to 2035 which is not consistent with the targeted 80% decrease by 2050 stated in the Paris agreement and cited elsewhere in the study.*[5]

The AGA study further claims that any reduction in emissions from switching to electric appliances is “partially offset by an increase in emissions from the power generation sector, even in a case where all incremental generating capacity is renewable.”*[6] This choice of words is ambiguous in regards to the implication that emissions will increase if we decarbonize the economy, and the assumptions underlying the scenarios investigated in the AGA study are as questionable as the conclusions. As a counterpoint, the RMI studies clearly show total carbon reductions benefits for electrification in all regions of the country except the areas that are currently heavily dependent on coal and where solar is less viable, such as the northern mid-west states and the Great Lakes region.

Clearly, for the emissions and cost-effectiveness benefits of electrification in these more challenging markets, hinges on renewable baseload generation such as off-shore wind. The AGA analysis clearly chooses the assumptions and scenarios that represent gas technology in the most favorable light and makes no effort to look for viable grid harmonization strategies and it is not been generally their job to do so. Their failure to recognize or acknowledge key grid harmonization strategies such as DR technologies, storage, improved thermal performance of buildings, and integration of baseload renewables allows them to draw the most pessimistic conclusions about actual carbon and cost impacts of electrification.

Rather than chase through all the holes in the AGA study, it is more important to focus on what is missing from this analysis: any accounting of climate externalities and their fiscal impact on households across America. The more relevant omission of the climate change impacts of the gas industry, is not incidental. It has been a strategy for many decades.*[7] Their analysis makes no mention of the 16 billion tons of CO2 emissions that proposed gas plants will emit by 2050 and that can be averted if a more immediate transition to renewable baseload generation such as off-shore wind is made.*[8] Their analysis also makes no mention of the well-site and infrastructure leakage of methane that has been found to be *five times higher than reported to the EPA* and contributes significantly to overall GHG emissions.*[9]

Gas leaks at well sites and through aging infrastructure is a critical unfactored externality which contributes significantly to GWP gasses, methane being a global warming precursor roughly 85 times more potent than CO2. If included in the life-cycle cost analysis, this unwanted release of methane through infrastructure leaks makes electrification of household appliances less polluting even if electrical generation comes from gas-fired plants. The RMI study uses leakage estimates ranging from “2%, EPA’s 2016 estimate, to 3.8%, from Robert Howarth’s research at Cornell”. Factoring these externalities, their research found electrification to be at a near CO2 footprint parity in even Chicago where the grid mix is very coal-dependent (40%)*[10] The more recent EDF data, if it may be extrapolated to apply to regions beyond Pennsylvania borders, suggests much higher leakage rates of 5 times the EPA levels, which would put electrification at a clear and immediate CO2-footprint advantage. Given these assertions that have significant scientific evidence to substantiate them, the societal benefits of electrification already seems irrefutable, and this is before the grid mix has been shifted to 100% renewable, which is the inevitable direction we must go if society is to avoid much more expensive climate impact costs that will affect the quality of life of every American if not averted.

However, the only coherent approach to evaluating the real costs to consumers and the societal costs and benefits of electrification is to factor all life-cycle costs and “externalities” of all technologies on a level playing field, with the intent of clarifying what is really best for the American consumer, the American household, and for citizens of the world. Anything else is presenting a partial story that is usually skewed in favor of the presenter and usually an industrial interest. This paper attempts to transcend those agendas, and to be fair, refrigerant leakage from HVACR equipment, and the GWP (global warming potential) of various refrigerant options should be on the table as well.*[11] What is here presented is only a synopsis, a white paper of the types of very real costs homeowners are likely to incur at some time in the coming decades due to anthropogenic climate impacts, either in the form of higher taxes, higher insurance costs, higher energy costs or higher food and water costs, a rough projection of expected losses to California households based on prevailing scientific opinion: “Without substantial and sustained global mitigation and regional adaptation efforts, climate change is expected to cause growing losses to American infrastructure and property and impede the rate of economic growth over this century….Regional economies and industries that depend on natural resources and favorable climate conditions, such as agriculture, tourism, and fisheries, are vulnerable to the growing impacts of climate change."*[12]

Climate Externalities Impacting Californian Households Amortized Over 2020-2060 Period

The following is a "back-of-the-napkin" calculation of projected fiscal impacts on California households as a result of climate change externalities that should be considered as the CPUC evaluates the appropriateness of aligning current ratepayer protections with SB350 and SB1477 legislative requirements. The fact that climate externalities are not currently factored into the projected fiscal impacts on California households gives the appearance that ratepayer protections are being compromised by changes in rules such as the "Three Prong Test" which is intended to protect ratepayers from higher electricity costs if they switch to all-electric appliances rather than gas. However, given the immediacy of climate change and major climate related events, the few dollars saved by remaining on gas will incur other much more costly climate externalities, which are likely to be long term (lasting at least a millennium), and which directly impact household budgets through water and food scarcity, as well as property and infrastructure damage that are foreseeable and predictable. These costs, even if assuming a moderate to low impact scenario as this analysis does, significantly add to the cost of living for California households and far outweigh any cost advantage the natural gas may have in specific market segments. As already stated, the RMI electrification analysis makes it clear that the cost of electrification is at a combined equipment and fuel cost parity in nearly all California market segments except retrofits wherein only the furnace or AC units need replacement, but not both. These unfactored externalities show that even with conservative assumptions, the long term cost benefits to individual ratepayers work out to be five times greater in favor of electrification. This back-of-the-napkin calculation warrants a more formal analysis by a more credible analytical group such as LBNL or ACEEE, and the intent of this white paper is to encourage the CPUC and the CEC to request proposals for a more detailed study.

1) **Wildfire Damages:** Wildfire damage since 2000 seem to be escalating exponentially. Comparing the last four fire seasons (2015 to 2018) to the prior ten year period, a number of trends become clear: While the number of fires per year stays relatively constant, the average size of fires (acres consumed) has increased by 45%, despite increasing fire suppression costs, which indicates greater difficulty suppressing fires due to lower humidity and dryer fuel. Simultaneously, comparing the last four years to the previous decade, the average annual fire damage has increased twelve-fold from $532 million to $6.67 billion.*[13] Notably, average fatalities have increased 6-fold from 6.8 per year to 42. In the last two fire seasons (2017-2018), over 29,000 structures were lost including over 19,000 homes bringing despair, trauma and financial hardship to nearly 60,000 Californians, not to mention the many thousands evacuated, lost business, lost work time and regional economic impacts from which it will take time to recover. Given that the cost of fires are eventually paid by consumers either in the form of higher insurance, higher taxes to replace infrastructure, higher utility costs, or higher cost of goods and services, it is reasonable to look at the distributed cost of the average fire damages from the last four years. Taking the total average fire damage cost from the last four years

($6.67 billion annually) divided by the total number of California households (12 million), yields an average distributed cost of **$555** per household if amortized over a 40 year period.*[14] Although this cost is not actually distributed to households immediately, if drought and wildfire trends continue, such costs would likely be passed onto consumers in the form of higher fire insurance costs, higher utilities and higher rent.

2) **Sea Level Rise Property Damage:** The Union of Concerned Scientists has completed an analysis of projected property damage due to sea level rise over the coming decades. This analysis looks at best and worst case scenarios (low, intermediate and high) to evaluate probable damage to residential property at various projected dates: 2045, 2060, 2100, etc. The low, intermediate and high scenarios for 2060 project $300 billion, $344 billion and $399 billion respectively.*[15] Honing in on the intermediate scenario for 2060 just to provide one example of projected loss to homeowners, $344 billion distributed over 12 million homes for the intervening years between 2020 and 2060 amounts to **$717** per household per year. Again these costs may not actually be distributed directly to all California homeowners and the number of households will increase to change that distribution, but it gives you an idea of the amortized annual impact if it does become distributed in the form of higher flood insurance costs. This includes only flooding and erosion damage to property due to sea level rise and does not include higher flood damage costs.
3) **Sea Protection Infrastructure Costs:** Levees to protect urban centers from sea storm surges may become necessary to protect major ports such as San Diego, San Pedro, and San Francisco. Smaller levy systems may be necessary to protect other coastal metropolitan areas wherever the cost of demolishing existing infrastructure and retreating from the sea is greater than the cost of building levees that will confidently withstand the threat of projected sea level rise over the coming century. The levy system in New Orleans cost approximately $14 billion.*[16] For the much larger metropolitan areas of Southern California and San Francisco, locks would need to be constructed. The shoot from the hip cost of such coastal protection could be anywhere from $60 billion to $400 billion. Taking the low number and amortizing that over 40 years amounts to **$125** per household annually from 2020 to 2060. The worst case figure would be 10 times that amount.
4) **Transportation Infrastructure Costs:** airports, ports, roads, bridges: The 2018-19 fiscal year budget for CalTrans for road repair was $13.6 billion.*[17] It is not uncommon for Cal Trans and other transportation department allocations to increase by 20% in a given year. This fiscal year it increased by 23%. If we assume climate-related damage to roads and infrastructure requires a 7.5% increase in expenditures over the coming 40 year period that amounts to a $1 billion increase per year or **$85** per household every year over the next forty years.
5) **Water Management Infrastructure:** As sea level rises, sewage and city drainage systems that have been installed near sea level may cease to operate and require costly upgrades. Sewage treatment plants and sewer systems may need to be completely relocated. The metropolitan areas large and small are located on or near ocean front including San Francisco, San Diego and many beach communities in the greater Los Angeles area. Even more highly impacted will be smaller beach communities with smaller operating budgets such as Bolinas, Stimson Beach, Pismo Beach and numerous others: It is extremely difficult to assess the cost of such infrastructure upgrades that stem directly from climate change. However, Morro Bay is in the process of building a new sewage treatment plant at a projected cost of over $100 million for a

town of less than 11,000 people. The City of Los Osos (population 14,200) has a sewer system renovation project that is currently ongoing and appears to be coming within budget at $173 million. This amounts to a cost of $12,000 per resident and about $30,000 per household. Projecting such project costs for small communities to the scale of larger metropolitan areas would require a more detailed analysis of areas most affected and the miles of sewer system lines near the coast that would be affected by sea level rise. There are approximately 110 miles of highly developed coastline in the greater Los Angeles Area between Ventura and Newport Beach. There is approximately 65 miles of highly developed coastline in the San Diego Area from Oceanside to the border. There is approximately 320 miles of highly developed coastline in the San Francisco Bay Area including areas just outside the bay. If Infrastructure costs were estimated at the lowest level of $25 million per mile, the total for just these larger communities would approach $12.5 billion. On the high side, the costs could be ten times this figure. Assuming the low scenario, and that costs would be paid out of tax revenues over many years on an as needed basis, the total cost per household only amounts to **$26** per year over the 2020-2040 period.

6) **Flood Damage Costs and Levee Repairs:** Lloyd's of London published a projection of flood liabilities in California in 2015 which assessed that the entire Central Valley and specifically the Sacramento Valley that are at risk of catastrophic flood damage. "The Central Valley contains over 20,000km of levees and flood control structures, and around 150 reservoirs on tributaries. Generally, defenses have a standard of protection for less than the 1-in-100-year flood. This level of protection will be eroded if infrastructure is not maintained. Analysis of the available data for some counties suggests that current budgets are insufficient to cover present and projected operation and maintenance costs. We assess that, even if upkeep programs maintain the 1-in-100-year protection, such protection will be gradually eroded by climate change."*[18] Given the current condition of levies in the Central Valley, and the population approaching seven million, the potential for catastrophic floods are significant, but only as predictable as the weather. Historically, the most damaging, catastrophic floods occurred about once every twenty years at the turn of the last century and began to occur with greater frequency in the 70s and 80s, about once every 12-15 years interrupted only by the recent droughts. Damage from the 95', '97, 2017 and 2018 floods were in the billions of dollars compared to hundreds of millions in damage in pre-1970's floods. Nevertheless, the predictability of these floods will be used here as an argument to invest in levy improvements to mitigate future disasters. According to the Climate Science Special Report published by NASA in December of 2018: "To date, no comprehensive assessment exists of the climate-related vulnerability of U.S. water infrastructure (including dams, levees, aqueducts, sewers, and water and wastewater distribution and treatment systems), the potential resulting damages, or the cost of reconstruction and recovery."*[19] Based on Oroville Dam repair costs from 2018, levy and flood control repairs, especially in the Central Valley are likely to total $1.1 billion per year by 2030 continuing through 2060. This amounts to **$100** annually per household in higher taxes over the coming 40 years.

7) **Disappearing Water Resources:** Due to the combined strain of population growth, expanded agricultural production and recent drought, water levels in wells have fallen by more than 100 feet since 1995 in parts of Los Angeles, Fresno, Kern, Riverside and San Bernardino counties, according to U.S. Geological Survey data. During the past decade of drought in California, many

thousands of households did not have water flowing at the taps. Wells ran dry and smaller farmer operations and households could not afford to double or triple the depth of their wells to reach water. Jay Famiglietti, a UC Irvine hydrologist and senior water scientist at NASA's Jet Propulsion Laboratory says: “What that means is that only the wealthier individuals and the bigger farms will be able to survive with respect to groundwater, and that’s unfair. It’s become this true tragedy of the commons and a race to the bottom of the Central Valley.”*[20] Farm operations in the Central Valley have suffered significantly, many operations going out of business during the drought. U.S. Geological Survey data indicates that subsidence of soil due to groundwater depletion in the Central Valley has caused the earth to drop as much as seven inches in the last decade. “Significant changes in water quantity and quality are evident across the country. These changes, which are expected to persist, present an ongoing risk to coupled human and natural systems and related ecosystem services. Variable precipitation and rising temperature are intensifying droughts, increasing heavy downpours, and reducing snowpack. Reduced snow-to-rain ratios are leading to significant differences between the timing of water supply and demand. Groundwater depletion is exacerbating drought risk. Surface water quality is declining as water temperature increases and more frequent high-intensity rainfall events mobilize pollutants such as sediments and nutrients.”*[21] (No cost estimate is offered for individual residential wells or commercial well cost impacts on food prices in this section.)

8) **Desalinization, Aqueducts and Dams:** Despite environmentalist resistance, more dams will likely need to be built in an attempt to offset the water resources lost to much lower winter snow pack and earlier spring runoff.*[22] Many Coastal Communities have depended on imported California Aqueduct water but may no longer have access to this water due to farming demands in the Central Valley and the availability of water from desalinization. The cost of this technology is presumed to fall, but the typical desalinization plant costs $250 to $300 million and operations are energy intensive. So this is not a viable source of water for farming at this time. Water infrastructure upgrades including building 6 to 10 additional dams in the Sierras would amount to hundreds of billions of dollars over the coming decades: $200 billion distributed across 12 million homes amortized over 40 years amounts to $400 per household annually. Here the figure is conservatively estimated at **$200** per household annually in the form of tax revenue.

9) **Higher Water Bills:** Inevitably, water scarcity will drive up water bills for ordinary households and farmers will likely be less impacted to minimize impact on food prices. During the 2014-2016 drought, 25% reductions in household water prices were mandated by the governor, and many communities that required new water infrastructure improvements to secure access to water resources passed those costs onto consumers. For example, in 2014 the Nipomo Community Service District (NCSD) installed a pipeline to connect to the City of Santa Maria aquifer with an agreement that they would provide 2500 acre-feet annually in an attempt to replenish a groundwater “depression” on the Nipomo Mesa. Those infrastructure investments were passed on to customers in the form of higher water bills in the amount of $225 to $400 per year to offset pipeline costs and water purchases.*[23] The new pipeline which cost more than $20 million was offset even by ratepayers with no direct access to the pipeline on the theory that replenishing an aquafer four miles away would also replenish wells in surrounding areas. Remarkably, the City of Santa Maria’s obligation to sell water can be terminated at any time if water provided to them by the coastal branch of the California State Water Project pipeline dries up at any time. So this minimum $225 per ratepayer cost does not fully guaranty Nipomo

Mesa rate-payers water security. If California State Water Project sources dry up, Nipomo will be forced to build a desalinization plant at a cost of about $250 million – over ten times the cost of the pipeline. Given projected water scarcity, and stories such as these from all over California, water costs will most likely triple by mid-century (in 2018 dollars). The additional cost per household for water local water delivery costs is in addition to higher taxes paid for major state infrastructure costs such as major dams and canals is **$225.**

10) **Lost Farmland:** University of California researchers reviewed 89 scientific research papers investigating climate trends and the current and future effects on farming in California. Among the key findings "more than half of the Central Valley is projected to be no longer suitable for growing crops like apricots, peaches, plums and walnuts sometime around the middle of the century. By the end of the century, that's projected to grow to 90 percent or more of the valley."*[24] A 50% loss in farmland in the Central Valley amounts to a loss of $20 billion per year in state GDP*[25] and approximately 235,000 jobs both direct agricultural as well as downstream AG-related jobs*[26], and also factors into projected increases in food prices to consumers.
11) **Rising Food Prices:** Loss of arable land in the Central Valley, water scarcity and higher energy and fuel costs would conspire to increase food costs across the board. Due to the water intensity of raising livestock and poultry, meat prices will double or triple by mid-century, and all other food products are likely to double. "Heat waves are likely to become more frequent with global warming (Tebaldi et al., 2006; IPCC, 2007b). In 2010, when more than 20% of Russian agricultural producing areas were affected by unprecedented extreme high temperatures, wheat prices increased by up to 50% in the international market (FAO, 2010; NOAA, 2011b). Peaks of high temperature, even when occurring for just a few hours, can drastically reduce the production of important food crops (Porter and Semenov, 2005; Prasad et al., 2000)."*[27] If the typical household of three currently spends $225 per week ($11,700 annually), this figure could easily double by 2060 (adjusted for inflation), and triple by end of century. In realistic terms, this means that diets will evolve, and the abundance we now enjoy in our pantries and refrigerators will be adapted to a more affordable diet due to inflation and scarcity. Because these price increases will occur unpredictably and over a period of time, projected household annual budget increases are estimated based on prices increasing by only 50% at: **$2,000** per household.

The above climate impacts amount to increases have all been estimated conservatively given potential costs, yet if the costs were amortized over a 40 year period starting in 2020, the average annual household budget will increase over $4000. In actuality this amortization of externalities is contrived, and the household annual cost will ramp up over time, because human nature is such that many prefer to wait until there is a crisis before paying for the damages. The damages when they occur are more likely to appear suddenly and catastrophically in a manner that causes so much economic disruption that many households are left homeless, destitute and unemployed, as has occurred in the recent California firestorms and floods. Although projecting these costs over many years is artificial, it offers some sense of the opportunity costs and lifecycle costs that are currently swept under the table by gas industry stakeholders. By forgoing current opportunities to increase household efficiencies, perform energy upgrades on homes, and switching to heat pump heating systems, dryers, water heaters, inductive cooktops and electric vehicles, we forgo an opportunity to invest in economic stability, and a sustainable quality of life for generations to come. Compared to the annual cost premium of about $800 per year that the 2018 Gas Industry Electrification Report projects, the near-term climate impacts are momentous, and will affect the quality of life for all Californians and will cost households conservatively five times that amount and perhaps much more when all the variables that are excluded from this summary analysis are also factored. "Our understanding of the magnitude and timing of risks that can be avoided varies by sector, region, and assumptions about how adaptation measures change the exposure and vulnerability of people, livelihoods, ecosystems, and infrastructure. Acting sooner rather than later generally results in lower costs overall for both adaptation and mitigation efforts and can offer other benefits in the near term."*[28]

The Hollow Arguments Against Electrification

The key argument against electrification has been that switching to all electric appliances can increase total utility bills in the near term, and it is therefore unfair to ratepayers to either allow electric utilities to incentivize that transition. This is rarely the case if whole house energy upgrades are performed simultaneously in accordance with BPI and CEC proven techniques. Where the typical forced air system is operating at 59% efficiency*[29] due to poor system and duct sizing and duct leakage and refrigerant charge, far more than the lost 40% efficiency can be gained when whole house improvements are made simultaneously including attic air sealing, attic ventilation, R-50 insulation, deeply burying ducts and oversizing return ducts and filter grills whenever possible. Research performed by the CEC points to gaining most of the 40% losses back through better quality installation and doubling system performance in addition to the 40% gains by halving thermal losses through the envelope and ducts through whole-house energy upgrades that are cost-effective.*[30] So the electric bills of the all-electric retrofit home are not likely to increase if HVAC system loads are simultaneously halved, especially in cooling load climates.

Although investment in upgrading home efficiency (doubling thermal performance of existing homes) and electrifying everything can produce significant energy savings in virtually all climate zones in the long run, the real economic benefit will occur when the State has invested in renewable baseload generation such as offshore wind to replace nuclear and gas fired plants. Such renewable baseload is key to address the grid harmonization challenges, since it is now clear that solar alone cannot provide night-time baseload for heating colder regions. Although batteries, thermal storage, DR and optimized EV charging can help 'harmonize' the supply and demand power curves, these technologies need to be supplemented with various forms of renewable baseload, either offshore wind or geothermal in order for renewables to cost effectively match and better all fossil fuel applications at all times of the year. The decarbonization of the California economy will be viable when these large scale infrastructure investments are made, and Californians will be better off if the State actively promotes investment in such strategies in the coming decade rather than attempting to react to real devastation 40 to 50 years from now.

Exclusions

The following factors are not included in the above analysis because they may not directly impact household budgets, however there are scenarios where they would indirectly impact ratepayer budgets.

12) **Underground Utilities:** Underground utilities and subways in coastal and riverfront communities are vulnerable to flood damage due to flooding and storm surges is not analyzed
13) **Commercial Property:** Commercial property loss due to sea level rise is not analyzed
14) **Lost Farmland:** Lost farmland due to drought and sea level rise, Sacramento Delta, Central Valley – mentioned as it pertains to food scarcity and food costs, but not quantified.

15) **Property Stranded Without Water:** Value impacts in homes where taps have run dry and that are not connected to municipal water systems has been mentioned relative to infrastructure costs, but not projected or quantified. During the last drought, over 700 homes were without water at the tap or to flush toilets.*[31] These homes were basically unsellable during the drought and barely habitable. What happens when this affects tens of thousands of homes?
16) **Impacts on Fisheries**: Warmer more acidic sea water is already having impacts on California fisheries as well as broader marine ecology impacts. "Many coastal resources in the Southwest have been affected by sea level rise, ocean warming, and reduced ocean oxygen—all impacts of human-caused climate change— and ocean acidification resulting from human emissions of carbon dioxide….marine flora and fauna, and people who depend on coastal resources face increased risks under continued climate change."*[32]
17) **Fire and Drought Damage to Lumber Resources**: - Loss of lumber resources are not analyzed above, but are factors into replacement cost for homes lost to flood or fire as well as affordability of new homes. Currently, about one-fifth of all the standing pines between 5500 and 7500 ft are dead in the Sierras due to a combination of beetle infestation, acid rain and drought. This represents a huge loss of timber resources as well as a fire liability that is likely to result in further firestorms and loss of property at a scale similar to what has been seen in the last few years. Never in the history of the state have so many dense standing trees been completely dead and covered with very flammable dry pine needles.
18) **Lost Jobs**: Impacts on tourism, agriculture, lumber and fisheries will lead to lost jobs and state GDP in all of these areas.
19) **Medical and Mental Health Costs:** "The health and well-being of Americans are already affected by climate change, with the adverse health consequences projected to worsen with additional climate change. Climate change affects human health by altering exposures to heat waves, floods, droughts, and other extreme events; vector-, food- and waterborne infectious diseases; changes in the quality and safety of air, food, and water; and stresses to mental health and well-being."*[33]

Footnotes:

1. Implications of Policy Driven Electrification, An American gas Association Study produced by ICF, July 2018.
2. The Economics of Clean Energy Portfolios, Rocky Mountain Institute, Mark Dyson, Alexander Engels and Jamil Farbes, pg.8, 2018, online at: https://rmi.org/insight/the-economics-of-clean-energy-portfolios/
3. The Economics of Electrification, Rocky Mountain Institute, Sherri Billimoria, Michael Henchen, Pg.6-7, July 2018, located online at: https://rmi.org/insight/the-economics-of-electrifying-buildings/
4. Implications of Policy Driven Electrification, An American gas Association Study produced by ICF, July 2018, pg. iii
5. Implications of Policy Driven Electrification, An American gas Association Study produced by ICF, July 2018, pg. 3 (The EIA 2017 AEO Reference Case cited as the baseline for the AGA analysis projects renewable power generation to increase from 14 percent of total power generation in 2016 to 23 percent by 2035)
6. Implications of Policy Driven Electrification, An American gas Association Study produced by ICF, July 2018, pg. 26
7. The Climate Deception Dossiers, Union of Concerned Scientists, Kathy Mulvey and Seth Schumann, 2015, Pages 1-40, online at: https://www.ucsusa.org/global-warming/fight-misinformation/climate-deception-dossiers-fossil-fuel-industry-memos#.XCpELPLQY2w
8. The Economics of Clean Energy Portfolios, Rocky Mountain Institute, Mark Dyson, Alexander Engels and Jamil Farbes, pg.6, 2018
9. Methane Emissions from Oil and Gas Sites 5 Times Higher Than Previously Reported, The Philadelphia Inquirer, Frank Kummer, Feb. 14 2018, Report on study by EDF.
10. The Economics of Electrification, Rocky Mountain Institute, Sherri Billimoria, Michael Henchen, Pg.26, July 2018

11. It should be noted, that the HVACR industry has embraced compliance to fast-track reductions in the GWP of refrigerant gasses in accordance with the Montreal Protocols and the Kigali Agreement despite the EPA's recent attempts to deregulate the industry, and these GWP impacts will steeply decline over the coming decade.
12. USGCRP, 2018: *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II* [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, 1515 pp., page 21, available online at: nca2018.globalchange.gov
13. Wikipedia, review of California Wildfire Damage by Year, 2018, online at: https://en.wikipedia.org/wiki/2018_California_wildfires, and also Cal Fire and State government reports at: http://www.fire.ca.gov/fire_protection/fire_protection_fire_info_redbooks, and http://www.fire.ca.gov/communications/downloads/fact_sheets/Top20_Destruction.pdf
14. A forty year period between 2020 and 2060 is chosen for this study rather than typical 15 or 30 year amortization schedules to reflect the period during which the most significant climate impacts will have lasting impacts on the economy. For example, sea level rise is expected to have significant cost impacts on both residential property and public infrastructure costs during this time frame. In reality, it is human nature to wait until a crisis occurs rather than distribute payments over years, and it is not likely that segments of society will be able to afford to bear the cost of climate impacts if they are not averted in advance, but this artificial distribution over time and conservative projection allows us to compare relative annual costs over time.
15. Underwater: Rising Seas, Chronic Floods, and the Implications for US Coastal Real Estate, Union of Concerned Scientists, Excel spread sheets modified to total all California regions accounted, online at: https://www.ucsusa.org/global-warming/global-warming-impacts/sea-level-rise-chronic-floods-and-us-coastal-real-estate-implications#.XDCJf_LQY2w
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