Springfield District Liaison to the CECAP Task Force's Consolidated and Summarized Focus Group Input on Considerations Relevant to Establishing Greenhouse Gas Goals

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Purpose of this Focus Group Liaison Report

Springfield District Supervisor Herrity has directed the Springfield District CECAP Focus Group Liaison to provide the CECAP Task Force and the general public a summary of the Group's considerations relevant to establishing carbon dioxide (CO_2) emission reduction goals, and in a timely manner. Pursuant to the Liaison Position Description, such a summary will reflect the diverse views of the Focus Group Members. Thus, this summary does not represent a consensus statement of the Focus Group. Rather, it identifies issues relevant to setting emission reduction goals and presents the varying perspectives of the Springfield District Focus Group members.

The starting point for Focus Group discussions is laid out in the CECAP Operating Guidance.

CECAP has three purposes:

- Establishing Greenhouse Gas (GHG) Emission Reduction Goals
- Determining how to create heightened awareness of existing initiatives
- Determining how to create heightened awareness of potential community member actions to reduce GHGs

These purposes are inextricably linked. As a guiding principle, the GHG Goals are to be science-based, aspirational, and achievable. In simple terms, to meet its goals, the Task Force will need information on what will heighten awareness to a point where households and businesses in our community are willing and able to further reduce GHG/CO_2 emissions. At core, the fundamental question is: "what we are willing to do." It is a matter of attitudes toward climate change. Attitudes can change, and thus the task is how to identify and change those attitudes that would not support meeting Task Force Goals. The Focus Group deliberations began from this point of view.

Although a simplistic formulation, basically the Focus Group members identified three categories of attitudes in Fairfax County – those who are willing to spend more to reduce GHGs, those who admit GHGs are a problem but are reticent about spending more, and those who are unconcerned about claims of catastrophic climate change. There are no crisp bright lines dividing these three groups. It is more of a gradient – one based on cost and other considerations. Focus Group members noted that everyone should be willing to take an action that would have little or no cost to the household or business and which would save money. Focus Group members identified some such actions and that 100% of the GHG emission reductions associated with these actions should be considered achievable emission reduction goals to which the Task Force should aspire, although these less costly actions, alone, will not likely provide the levels of CO_2 reductions needed meet emission reduction goals the Task Force is likely to propose.

As the costs of actions rise, those actions will not be affordable to low-income households and low-profitability businesses, absent government assistance such as through subsidies. We cannot aspire to 100% participation in those actions without some way to reduce costs to those

unable to bear such costs. And yet, significant CO_2 emission reductions can be attained county-wide without 100% participation. One Focus Group member took the position that higher reductions among higher contributors could compensate for the inability of some residents to bear the costs of significant emission reductions. Another Focus Group member stated that the only significant reductions would likely be in the commercial and industrial sectors. The Focus Group examined both residential and business sources.

In addition, there are technological limits that are unrelated to cost. Some Focus Group members recognized that our society has been waiting for non-incremental technical breakthroughs that can allow GHG reductions to leap forward dramatically; and that the society has not yet had such a breakthrough in electrical energy storage. Some Focus Group members noted that society has had advances, but no major breakthrough on automobile, truck and off-road engineering, mass-transit or electricity generation that will reduce costs to a point where there will be universal adoption of these technologies. Some Focus Group members took the position that while the society aspires to see additional technological breakthroughs, the Task Force need not wait for them before setting actionable emission reduction goals. Some Focus Group members take the position that when a breakthrough happens, Fairfax County can then change its emission reduction goals to account for the resultant new opportunities. Some Focus Group members have concluded that, in the meantime, many residents, though not all, can take measures to reduce GHG emissions, and the degree to which residents and businesses will act is a matter of attitude. Some Focus Group members note that the Task Force's ability to change attitudes should be factored into setting emission reduction goals.

The Springfield District Focus Group has discussed several aspects of the goal setting issue. These are briefly addressed in the sections below. Technical appendices offer more in-depth analysis.

Who Does and Who Does Not Support Emissions Reductions?

Some Focus Group members recognized that setting GHG reduction actions will involve understanding the willingness of our community to take action and the means to alter that willingness. Some Focus Group members note that there is a division in the level of concern about climate change. Surveys document that a majority of county residents recognize climate change as a problem requiring attention and support movement toward the reduction of GHG emissions. A minority of residents take the opposite view. Some Focus Group members believe those differences in climate change viewpoint establish the need to develop a range of persuasive arguments needed to shift attitudes toward greater emissions reductions. Other Focus Group members would have the Task Force rely on educational outreach programs to support increases in understanding of the cost/risk benefits. All Focus Group members recognize that some attitudes will not change, and hence the need for alternative persuasive arguments unrelated to directly addressing the risks from climate change.

The Focus Group members obtained and presented empirical information suggesting who is willing and who is unwilling to invest in GHG emission reductions, thus establishing the nature

of whom to target with which outreach programs and alternative arguments. Appendix I provides detail on surveying attitudes about climate change.

Based on a compilation of studies, 16% of Fairfax County voters don't believe stricter environmental laws and regulations are worth the cost. A December 2019 Mason Dixon poll verifies this, finding 17% of Northern Virginia registered voters oppose joining a coalition that seeks to improve transportation, develop the clean energy economy and reduce carbon emissions from the transportation sector, while 76% support such an initiative.[1] However, the Mason Dixon poll followed up by asking about support "If joining the Climate Initiative meant an additional tax on automotive gasoline and diesel, starting at 18 cents per gallon and rising higher, while reducing money set aside for road repairs and new road construction. Northern Virginia registered voter support for the initiative dropped from 76% to 44% and opposition rose from 17% to 44% (each $\pm$ 7.25%).[2]

The Table I is a first approximation on who are in these groups and what arguments may change their attitudes on GHG emission reduction.

Table I: Climate Concern Attitudes

Attitudinal Group	Illustrative Members	Potential Arguments
Climate is important **Willing to pay**	88% Liberal Democrats 74% Moderate/Conservative Dems 60% Moderate/Liberal Republicans 35% Conservative Republicans 44% Northern Virginia voters 68% households (higher incomes)	▪ Climate leadership is a duty ▪ We have an intergenerational responsibility ▪ GHG reduction is more important than philanthropy ▪ Investment in low-GHG technologies paves the way for lower future costs and wider adoption of them
Climate is important **Less willing to pay**	44% Northern Virginia voters 33% Democrat voters 20% Republican voters 34% Independent voters 20% Households (lower incomes)	▪ We have an intergenerational responsibility ▪ Many actions are reasonably priced ▪ There are opportunities to reduce GHGs while making routine investments (e.g. hybrid cars)

[1] Mason-Dixon Polling & Strategy (Dec. 2019)

[2] One Focus Group member rejects the Mason-Dixon survey, arguing that the sample size was too small. Another Focus Group member, one with expertise in statistics and survey design, indicated the sample size was in line with what statistical theory requires for an outcome that is statistically significant at the 95% confidence level. The Virginia level data requires a sample size of no fewer than 600 respondents. The survey had 625 respondents. The "Northern Virginia" sub-category sample of 183 supports a statistically significant result with an error band of 7.25%. For those without the background necessary to calculate necessary sample sizes, a simple calculator is available here. Population inputs would be the number of registered voters (in Virginia or in Northern Virginia).

Attitudinal Group	Illustrative Members	Potential Arguments
Climate is not important	65% Republican voters 29% Independent voters 4% Democrat voters 10% Households (very low income)	▪ There are low/no-cost actions that save money ▪ There are assistance and subsidy programs that allow lower income households to acquire new technologies

Why are Some Climate Scientists Unconvinced of the Need to Reduce CO_2 Emissions?

The CECAP Focus Groups and Task Force have been provided information reflecting one side of the climate science debate, as represented in the summary for decision-makers in the IPCC AR5 report. Some Focus Group members note there is another side. Some Focus Group members recognize that the public has a need or may simply wish to understand why some do not endorse the need for greater investment in CO_2 emissions reductions. Some Focus Group members find that those who seek to alter the attitudes of the "climate is not important" portion of our community will need to know these arguments so as to understand the intransigence of these attitudes.

Some Focus Group members recognize that projection[3] of climate change from groups like the Intergovernmental Panel on Climate Change involves both analysis of past and current weather patterns and a large number of data-based assumptions about both future human behavior and assumptions about climate physics. Two sets of assumptions are particularly important. One is the assumption about the use of future fossil fuel use. The other is the responsiveness of climate to increases in CO_2 emissions. Both of these are discussed in more detail in Appendix II.

The climate science community has developed five future fossil fuel scenarios. These are called "Representative Concentration Pathways" and are used by all climate scientists who model future climate conditions. Table II provided the Focus Group members the significance of these scenarios with regard to the degree to which global warming will rise.

Table II: Future Climate Scenarios

Scenario	Assumption	2100 Global Temperature Change
RCP8.5	Worst-case, no policy. 500% increase in coal use. Basis for IPCC BAU estimates in the summary for policy makers chapter.	+5 – 8.5°C

[3] One Focus Group member characterizes the IPCC model outputs as "predictions". The IPCC and climate modelers insist on use of the term "projection." One Focus Group member noted that predictions contain uncertainty bounds. Projections do not. The IPCC's 102 projections do not contain uncertainty bounds because they are based on assumptions and do not claim to be predictions.

Scenario	Assumption	2100 Global Temperature Change
RCP3	No policy, voluntary reversal of some current practices. Less coal use.	+3 – 7°C
RCP4	Weak mitigation using current policies.	+4 – 7°C
RCP 4.5	Modest mitigation. Natural gas substitutes for coal.	+2 – 4.5°C
RCP 2	Paris accord mitigation	+ 1 – 1.9°C

The second assumption involves "Climate Sensitivity." The "Climate Sensitivity" is the amount global temperatures will rise from a doubling of CO_2. The physics of CO_2's greenhouse gas effect are not intuitive. An increase in CO2 concentrations from 283 parts per million (ppm), as observed in 1800, to 411 ppm today (2020)[4] has resulted in a temperature warming of 1°C (1.8°F).[5] This results in a climate sensitivity of about 1.5°C (2.7°F) for a doubling of CO_2 and assumes all temperature increase is due to CO_2 emissions, an assumption known to be untrue. The IPCC reports that half the warming is from human endeavor. Using climate sensitivity physics, a doubling of CO_2 from today's level (411 ppm) to 822 ppm would result in a 1.5°C increase. Under the RCP8.5 worst case scenario, we would reach the 822 ppm level in year 2090. Under the RCP4.5 scenario, we would remain below 550 ppm.

Some Focus Group members noted that the ICPP uses both the RCP8.5 scenario and a much higher climate sensitivity estimate of 3.2. Under those assumptions, temperatures would rise by 6 – 8.5 °C by 2100.

These differing assumptions result in deep difference in projections of climate events. These differences reflect hardened positions. The Springfield District Focus Group has scientifically trained members reflecting both sides of this scientific debate and are representative of this scientific controversy. These members politely agree to disagree on the level of risk, but find that need not get in the way of cooperating on strategies for CO_2 emission reduction. They agree that there will be a group of Fairfax County citizens who would be hard to motivate toward CO_2 emission reductions on a voluntary basis and others that would embrace further emissions reductions. As discussed in the previous section, the unmotivated group is, however, subject to rational arguments that encourages actions which, nevertheless, would reduce CO_2 emissions, and those arguments augur a higher emissions reduction goal than would otherwise result from a simple presumption that this group would never act to reduce emissions.

Affordability and Achievability

Various Focus Group members define the term "achievable" in dramatically different ways. Some believe a goal is achievable after taking cost into account. Another member believes

[4] SealLevel.info

[5] Quora.com – What is the estimated global change in temperature from 1800 to 1900?

achievable is unrelated to cost. Reflecting the position that costs matter when setting goals, this section provides background on affordability that has not been presented to the Task Force and that some Focus Group members believe is an important factor when setting emission reduction goals. However, as stated earlier, the Task Force can set significant GHG reduction goals even assuming less than 100% community participation. One Focus Group member opines that ability to pay is not relevant to setting goals.

On average, the Fairfax County community is wealthy. Averages do not, however, tell the whole story. One in five of our households (20th percentile) has income less than $54,600, with an average value of $30,200. The poverty line for a family of five is $30,700. Low-income families spend 84% of their income on essential goods and services, including housing (40.4%), transportation (14.5%), food (15.4%), health care (7.9%) clothing (3.2%), and education (2.8%). That leaves 16% for other things; about $4,800 per year. Appendix III provides a detailed examination of Fairfax County citizens' income and thus our ability to pay for various potential emission reduction actions.

Two climate proposals that Virginia's Governor has endorsed show the impact forced climate initiatives could have on the poorest 20% of our community. The Virginia Legislature is considering a Renewable Portfolio Standard (RPS) for electricity sales within the Commonwealth. The intent would be to reach 100% renewable electricity by 2045. The National Renewable Energy Laboratory (NREL) considers such a program as a "High Renewable Energy" program. NREL estimates that such a program would raise household energy rates by 4.2 cents per kilowatt-hour.[6] This would raise the typical household electricity bill by $461.

A second program would force reduced gasoline and diesel sales by 22.5% and go downward from there; and, impose a carbon car tax that begins at 17 cents/gal and goes up from there. In 2022, the annual cost per household of this initiative would be $536, rising to nearly $600 by 2026, and go up from there.

These two programs would reduce disposable income to our poorest households by nearly $1,000 a year in the short term, and go up from there. Some Focus Group members recognize that such cost increases would be very challenging to 20% of our community. One Focus Group member believes that as the county leaders adopt GHG reduction programs, they concurrently adopt policies that will relieve undue economic impacts on the residents least able to pay.

Some Focus Group members recognize that when cost is considered, some actions, like replacing all gasoline powered cars with electric vehicles over a 20-year period, is not achievable. If, however, one took cost out of the equation, an alternative definition as to what is achievable would simply be what could be achieved regardless of cost. One Focus Group member suggests that if the Task Force applies the "regardless of cost" approach, it could do so only on the assumption that local, state or federal governmental subsidies would need to be available to the lower income members of our community.

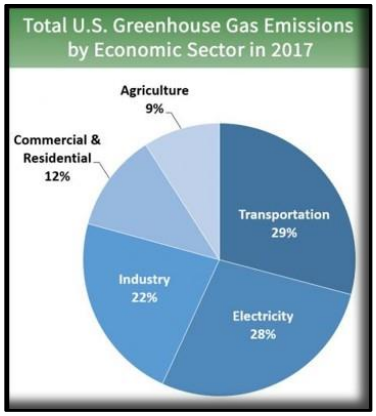
[6] NREL, "A Prospective Analysis of the Costs, Benefits, and Impacts of U.S. Renewable Portfolio Standards"

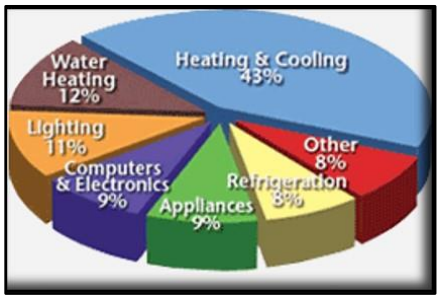
Appendix III provides an in-depth examination on Fairfax County's economic demographics, thus providing perspective on what our community may be able to afford out of their own pockets.[7]

What Actions Should Be Considered

Traditional analysis of alternatives focusses on "what gives the biggest bang for the buck." The first step in assessing options to reduce CO_2 emissions generally begins with understanding how we use carbon-based energy. The second step would be to assess what actions would most reduce those uses. The Focus Group examined these two questions.

The U.S. Environmental Protection Agency identifies the baseline of emissions before us. CECAP is aimed at the 12% of total GHG emissions associated with commercial & residential sources and the 29% associated with transportation. It is unclear where "governmental activities" fit into these slices of pie. Clearly transportation offers the biggest target. Within the household, the biggest target is heating and cooling.

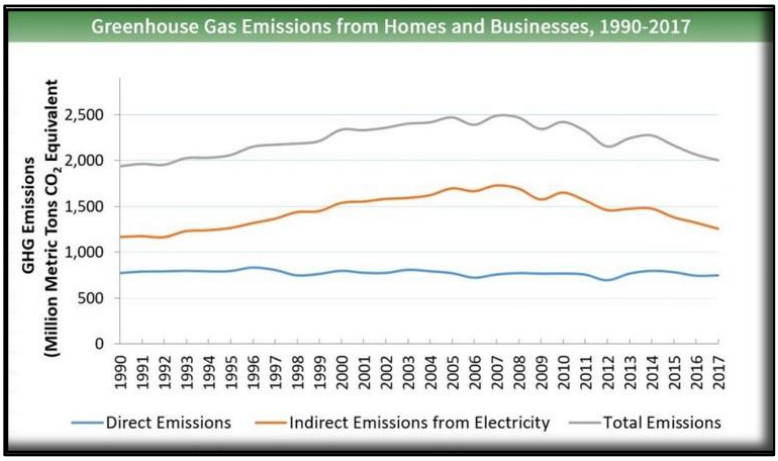




Emissions from households and businesses come in two forms – direct emissions from the home or business and indirect emissions from power plants that supply electricity to homes

[7] One Focus Group member believes this economic and financial data fails to account for all economic factors such as high health costs, extended family indebtedness, etc. and that the Focus Group cannot see all these variables. Another Focus Group member noted that all the data that is available is presented in the appendix.

and businesses. The indirect emissions from electricity are double the direct emissions. Direct emissions are mostly from use of natural gas to heat homes and heat stoves.



The Metropolitan Council of Governments has identified some actions that it considers technically feasible, shown in Tables III through V. To that some Focus Group members have added (*in italics*) additional actions the Some Focus Group members recognize may be useful.

Table III: Technically Feasible Activities – Transportation

Households	Commercial/Industrial
Private electric vehicles	Commercial electric vehicles
Hybrid vehicles	*Hybrid vehicles*
Increased use of mass transit	Travel Demand Management (*telework*)
	Replace non-road engines with battery-power
	Commercial Aviation improvements
Distributed electricity generation (e.g., solar panels)	Distributed electricity generation (e.g., solar panels, enterprise zone nuclear)
Voluntary Green Power	Voluntary Green Power

Table IV: Technically Feasible Activities – Direct Emissions

Households	Commercial/Industrial
Net zero new homes (all electric w/ solar)	Net zero new buildings (all electric w/ solar)
Waste policy (recycling)	Waste policy (recycling)
Sequestration (trees and lawn clippings left on the lawn)	Sequestration (electric utilities carbon capture & natural capture)
	Natural gas leak detection and repair (industry mostly)

Table V: Technically Feasible Activities – Indirect Emissions

Households	Commercial/Industrial
Net zero new homes (Net zero electric grid use)	Net zero new buildings (Net zero electric grid use)
Energy Audits and Shallow Retrofits	*Energy Audits, Shallow Retrofits and Cost Efficient Operational Changes*
New appliance efficiency (hot water, furnace/air conditioners, stoves, lighting, refrigerators, dishwashers, clothes washers, clothes dryers, computers and monitors)	*New appliance efficiency (hot water, furnace/air conditioners, lighting, commercial equipment, computers and monitors)*
Deep Retrofits	Deep Retrofits
Behavioral Change, Moderated heating and cooling,	Moderated heating and cooling
Distributed electricity generation (e.g., solar panels)	Distributed electricity generation (e.g., solar panels, enterprise zone nuclear)
Voluntary Green Power	Voluntary Green Power

Most of these actions do not eliminate all emissions from the source at issue. In general, for direct and indirect reductions from buildings, they reduce emissions in varying amounts. For example, reasonably expected rooftop solar electricity reduces emissions per building from 15% to 58%. Use of all available rooftops for solar PV could reduce electricity-related emissions by 32%. Solar hot water as a supplement or possibly as a replacement for electric or gas water heaters reduces emissions by 20%. Changes in lifestyle could reduce building emissions (mostly indirect) by up to 44%. Commercial building use of one energy saving measure could reduce its emissions level by 13% in new buildings and 16% in existing buildings.

Notably, some of these actions are available and for free. For example, Columbia Gas of Virginia offers a free energy efficiency kit as well as many "tips" on obtaining greater energy efficiency.[8] Some Focus Group members suggest it would be useful to know the level of penetration this assistance has had in Fairfax County and any information Columbia Gas has about how to increase that outreach, and recommends the CECAP support contractor investigate and report on this.

The Local Energy Alliance Program (LEAP), a non-profit energy service organization, offers a higher cost audit, from $400 - $600, using local contractors. One such audit resulted in home upgrades, mostly attic insulation, costing $2,000. LEAP may have information on the rate of pay-back from such upgrades and also may be able to speak to its successes and failures in outreach. Some Focus Group members believe that information from these two energy audit groups can assist the Task Force in understanding how to target greater community action and

[8] See Columbia Gas energy efficiency kit

the degree to which such action can result in greater community action, the latter useful in setting goals.

Some Focus Group members who investigated found that information on how changes in transportation behavior have or will affect CO_2 emissions is scarce on the ground. Some Focus Group members note electric vehicles remain a fairly expensive option, one not available to the majority of Fairfax County households. Another Focus Group member argues that the Task Force must find means to produce a significant change in attitude about how families and small businesses will use their disposable income, and in result, purchase EVs. Some Focus Group members found data showing that sales of EVs accounts for only 1.8% of the automobile market.[9] 2019 sales of EV's dropped by about 10% from 2018 sales and Chevrolet has stopped producing its lowest cost EV, the Bolt. Hybrid vehicles are more cost competitive with traditional gasoline fueled cars, but remain more expensive. Fuel savings offset the higher price of hybrids after from 5 to 12 years.[10]

Some Focus Group members found that use of mass transit as an option to personal vehicles could reduce CO_2 emissions, but attitudes on use and utility of mass transit would need to change significantly as ridership in 2018 was lower than in 2017, a trend we see continuing in the first quarter of 2019.[11] Table VI provides a snapshot of this problem.

Table VI: Mass Transit Ridership

Ridership in Virginia by System FY2017

System	FY2016	FY2017	Percent Change FY2016-FY2017
Arlington Transit (ART)	3,136,514	3,422,208	+9.1%
Alexandria DASH	4,160,094	3,897,696	-6.3%
Fairfax County Connector	8,984,792	8,631,906	-3.9%
Fairfax City CUE	678,967	645,687	-4.9%
Loudoun County Transit (LCT)	1,761,715	1,755,100	-0.4%
PRTC Omni Ride & Omni Link	2,805,181	2,570,127	-8.4%
Virginia Railway Express (VRE)	4,352,814	4,676,123	+7.4%
Metrobus (Virginia only)	19,997,471	19,124,426	-4.4%
Metrorail (Virginia only)	101,604,032	89,497,280	-11.9%
Total	**147,481,580**	**134,220,553**	**-9.0%**

Source: WMATA, NVTC, and local and regional transit providers. Ridership is in unlinked passenger trips.

Some Focus Group members noted that while these various direct and indirect, building and transportation emission reduction actions have a real potential to reduce CO2 emissions, the IPCC has warned against possible inefficacy of CECAP:

[9] Edison Electric Institute, "Electric Vehicle Sales: Facts & Figures" (April 2019).
[10] Murray, C. "The Cost of Driving a Hybrid", in Money under 30 (April 17, 2019).
[11] Northern Virginia Transportation Commission, Ridership reports.

> *There is no systematic accounting to evaluate the efficacy of city climate action plans (Zimmerman and Faris, 2011). Studies that have examined city climate action plans conclude that they are unlikely to have significant impact on reducing overall emissions (Stone et al., 2012; Millard-Ball, 2012a).*[12]

For this reason, some Focus Group members believe it essential to know and broadly disseminate information on the potential for savings, both immediate and future, to households and commercial enterprises as well as the overall economic value of mitigation actions, and to take into consideration the potential for changing attitudes when setting emission reduction goals. Appendix III provides the IPCC's evaluation of some of these actions.

Conclusory Statement

Some Focus Group members recognize that we will never have as much information about the risks of climate change or the means to mitigate or otherwise adapt to the effects of actual climate change as we would like. Nevertheless, all Focus Group members recognize the utility in taking steps in line with the likely public benefits.

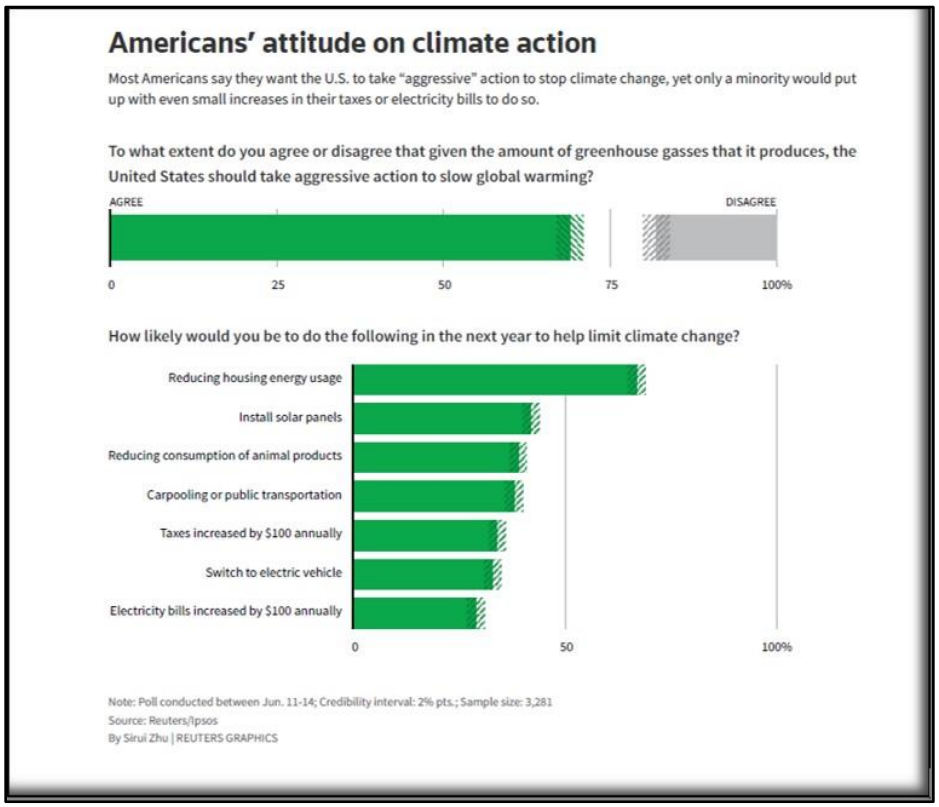
In setting CECAP goals, Some Focus Group members recommend first identifying "no regrets" options, i.e., those things that will reduce CO2 emissions that have low buy-in and save money. Those members believe the Task Force should aspire toward maximum buy-in from myriad cross-sections of our community on such approaches. And, when setting goals, the Task Force should aspire to claim all emissions reductions associated with those actions. Some Focus Group members believe that additional actions that may have a higher buy-in cost, but which also save money in the long run plus issues with high risk/benefit ratio should be appropriately factored in goal setting. One Focus Group member believes any higher cost action must be considered only with county recognition and support where necessary for households' ability to pay such buy-in costs. Finally, some Focus Group members recognized that those actions that would significantly reduce households' disposable income (over the short and long term) should be addressed with anticipated participation among only mid to high income households and mid -high profit businesses.

[12] Intergovernmental Panel on Climate Change, AR5 Climate Change 2014: Mitigation of Climate Change. Chapter 12, p.978.

Appendix I: Climate Attitude Demographics

The Focus Group had the following information before it. Attitudes about the need to reduce CO_2 emissions control the amount of emissions reductions likely to be achieved voluntarily. A review of current attitudes, and who holds those attitudes, identifies the targets for various efforts to heighten willingness to reduce CO_2 emissions. This appendix provides information on who holds what attitudes.

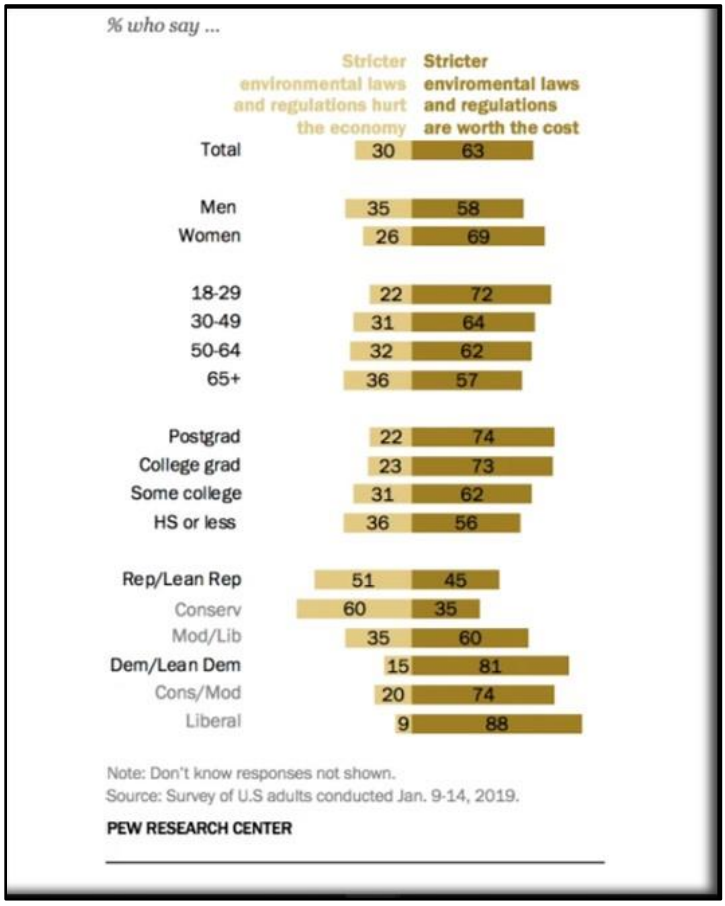
In general, most American's favor "aggressive" action to stop climate change, but only a minority would agree to pay increases in taxes or electricity bills of $100 annually.



Data available to the Focus Group identifies the group that is least willing to expend effort or treasure on climate actions. There is a strong political/philosophical divide on this issue. For example, thirty-seven percent (37%) of Fairfax county voters are republican voters.[13] Of these, about 73% are "conservative".[14] Of these, about 60% don't believe stricter environmental laws and regulations are worth the cost; given the math, this group equates to roughly 16% of our county population.[15] Smaller percentages of independents and democrats (9 – 20%) also take this position. This is clearly a minority population of Fairfax County voters who are likely not

[13] Based on 2019 election results for opposed races.
[14] Based on Gallup, "U.S. Still Leans Conservative, but Liberals Keep Recent Gains" (January 8, 2019).
[15] Pew Research Center (February 7, 2019).

interested in investing their own time and money on the basis of a need to address climate change. However, members of this group may be subject to arguments resting on, for example, cost savings. The rest of our community, roughly 84% of county voters, can be expected to show some willingness to invest in GHG emissions reductions.



The Transportation Climate Initiative (TCI) is a proposed regional collaboration of 12 Northeast and Mid-Atlantic states that seeks to improve transportation, develop the clean energy economy and reduce carbon emissions from the transportation sector. It would limit gasoline and diesel sales, eventually to near zero. It would also impose a gasoline tax beginning at about 17 cents per gallon and increasing thereafter, up to $3.00 per gallon.

In December 2019, Mason-Dixon Polling first asked if registered voters would support such an initiative, without explaining the costs. It then asked whether they would continue to support TCI taking costs into account. The full results are shown below.

MASON-DIXON
POLLING & STRATEGY
WASHINGTON, DC - 202-548-2680
JACKSONVILLE, FL - 904-261-2444

HOW THE POLL WAS CONDUCTED

This poll was conducted by Mason-Dixon Polling & Strategy, Inc. of Jacksonville, Florida from December 12 through December 16, 2019. A total of 625 registered Virginia voters statewide were interviewed live by telephone.

Those interviewed were randomly selected from a phone-matched Virginia voter registration list that included both landline and cell phone numbers. Quotas were assigned to reflect voter registration by county.

The margin for error, according to standards customarily used by statisticians, is no more than ± 4 percentage points. This means that there is a 95 percent probability that the "true" figure would fall within that range if all voters were surveyed. The margin for error is higher for any subgroup, such as a gender or age grouping.

MASON DIXON POLL DECEMBER 2019

QUESTION: Governor Northam wants Virginia to join the Transportation Climate Initiative, a regional collaboration of 12 Northeast and Mid-Atlantic states that seeks to improve transportation, develop the clean energy economy and reduce carbon emissions from the transportation sector. Do you support or oppose joining the Transportation and Climate Initiative?

	SUPPORT	OPPOSE	UNDECIDED
STATE	61%	29%	10%
REGION	**SUPPORT**	**OPPOSE**	**UNDECIDED**
Northern Virginia (+ 7.25%)	76%	17%	7%
Shenandoah/Piedmont	56%	31%	13%
Richmond Metro	61%	31%	8%
Hampton Roads	67%	21%	12%

	SUPPORT	OPPOSE	UNDECIDED
Lynchburg/Southside	50%	37%	13%
Roanoke/Southwest	33%	56%	11%
SEX	**SUPPORT**	**OPPOSE**	**UNDECIDED**
Men	55%	34%	11%
Women	67%	24%	11%
AGE	**SUPPORT**	**OPPOSE**	**UNDECIDED**
<50	69%	25%	6%
50+	54%	33%	13%
RACE	**SUPPORT**	**OPPOSE**	**UNDECIDED**
White	55%	34%	11%
Black	81%	13%	6%
PARTY ID	**SUPPORT**	**OPPOSE**	**UNDECIDED**
Democrat	89%	4%	7%
Republican	19%	65%	16%
Independent	63%	29%	8%

QUESTION: If joining the Transportation Climate Initiative meant an additional tax on automotive gasoline and diesel, starting at 18 cents per gallon and rising higher, while reducing money set aside for road repairs and new road construction, would you support or oppose Virginia joining the Transportation Climate Initiative?

	SUPPORT	OPPOSE	UNDECIDED
STATE	34%	58%	8%
REGION	**SUPPORT**	**OPPOSE**	**UNDECIDED**
Northern Virginia (+ 7.25%)	44%	44%	12%
Shenandoah/Piedmont	22%	74%	4%
Richmond Metro	33%	59%	8%
Hampton Roads	38%	55%	7%
Lynchburg/Southside	27%	66%	7%

Roanoke/Southwest	26%	67%	7%
SEX	**SUPPORT**	**OPPOSE**	**UNDECIDED**
Men	27%	66%	7%
Women	40%	51%	9%
AGE	**SUPPORT**	**OPPOSE**	**UNDECIDED**
<50	47%	46%	7%
50+	23%	68%	9%
RACE	**SUPPORT**	**OPPOSE**	**UNDECIDED**
White	28%	64%	8%
Black	57%	36%	7%
PARTY ID	**SUPPORT**	**OPPOSE**	**UNDECIDED**
Democrat	53%	37%	10%
Republican	9%	85%	6%
Independent	**31%**	**63%**	6%

DEMOGRAPHICS

PARTY REGISTRATION	
Democrat	265 (42%)
Republican	185 (30%)
Independent or Other	175 (28%)

AGE	
18-34	106 (17%)
35-49	183 (29%)
50-64	178 (29%)
65+	151 (24%)
Refused	6 (1%)

RACE/ETHNICITY	
White/Caucasian	441 (71%)
Black/African American	127 (20%)
Hispanic	27 (4%)
Other	20 (3%)

RACE/ETHNICITY	
Refused	10 (2%)

SEX	
Male	304 (49%)
Female	321 (51%)

REGION	
Northern Virginia	180 (29%)
Shenandoah/Piedmont	90 (14%)
Richmond Metro	90 (14%)
Hampton Roads	125 (20%)
Lynchburg/Southside	70 (11%)
Roanoke/Southwest	70 (11%)

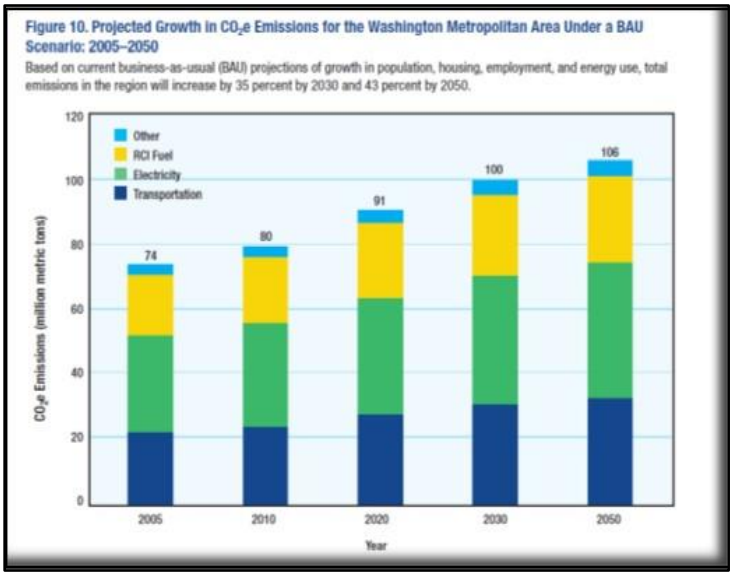
Appendix II: Climate Science

There are divisions within the climate science community, within the population at large and within the Springfield District Focus Group with regard to whether or not we confront an existential and catastrophic threat from climate change. Because a number of Fairfax County voters dismiss concerns about climate change, and because that group's buy-in would increase the likelihood of achieving the maximum amount of CO_2 emissions possible, some Focus Group members find that understanding the strength of this lack of concern becomes critical to understanding what kinds of community education arguments will work best to persuade them.

The Focus Group Liaison notes that this appendix is not intended to change minds. The Focus Group Liaison notes that positions among the various groups, and within the Focus Group, have so hardened that it is rare, if impossible, to achieve consensus on core scientific issues. Nevertheless, it is important to understand that no group responds well to being dismissed out of hand. Thus, a successful GHG reductions program should aim to appeal to common values held with those individuals the Task Force is trying to persuade.

The Focus Group Liaison recognizes that there is significant diversity of view with regard to the level of hazard GHGs pose. Presentations to the Task Force regarding GHG emissions relied on the 2008 National Capital Area Climate Change Report.[16] Other recent authoritative publications[17] offer a significantly different perspective. Figure II-1 presents the "Business-as-usual" (BAU) projections for CO_2 emissions for the Washington Metropolitan Area. Figure II-2 presents the International Energy Agency (IEA) projections, noting that BAU projections are "highly unlikely".

Figure II-1 (Source: National Capital Area Climate Change Report)

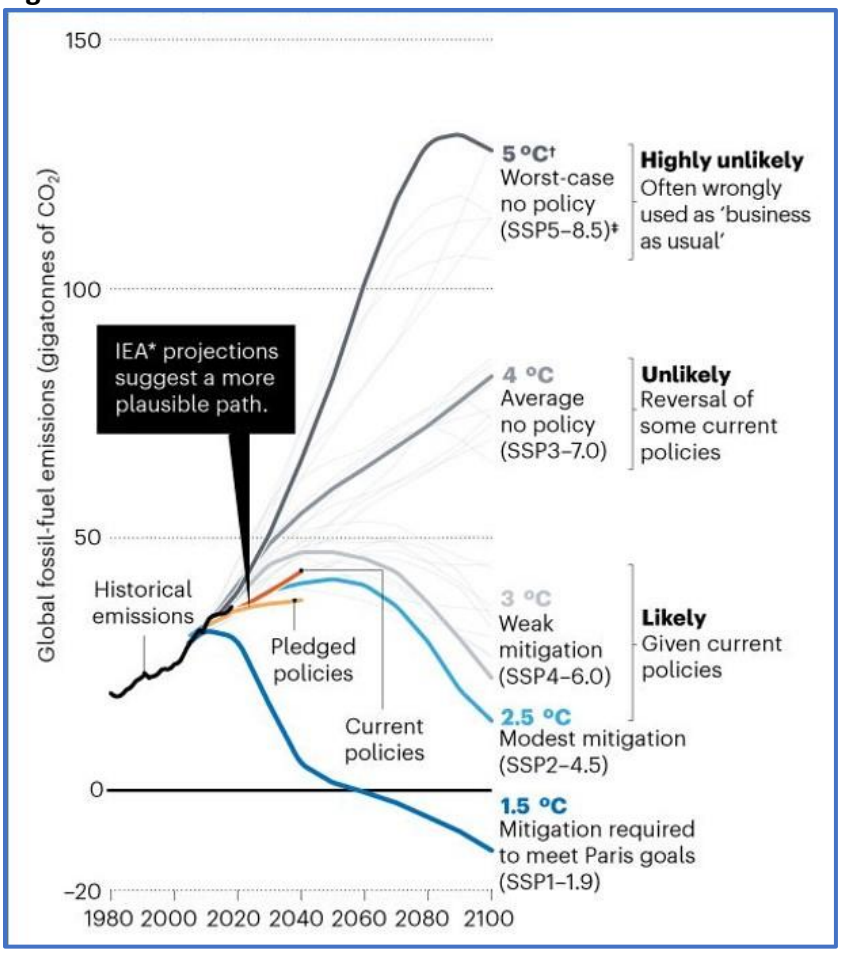


[16] 2018 National Capital Area Climate Change Report

[17] Hausfather, Z. & Peters, G.P. "Emissions – the 'business as usual story is misleading', Nature, January 219, 2020.

The significance of diversity in projections lies in the amount of warming expected. Under the BAU Representative Carbon Pathway (RCP8.5), maximum global temperatures would increase near 6°C (10.8°F). Under their "Likely" pathways, which includes both "current practices" and "weak mitigation", temperatures would rise 2.5 to 3°C (4.5 to 5.4°F).

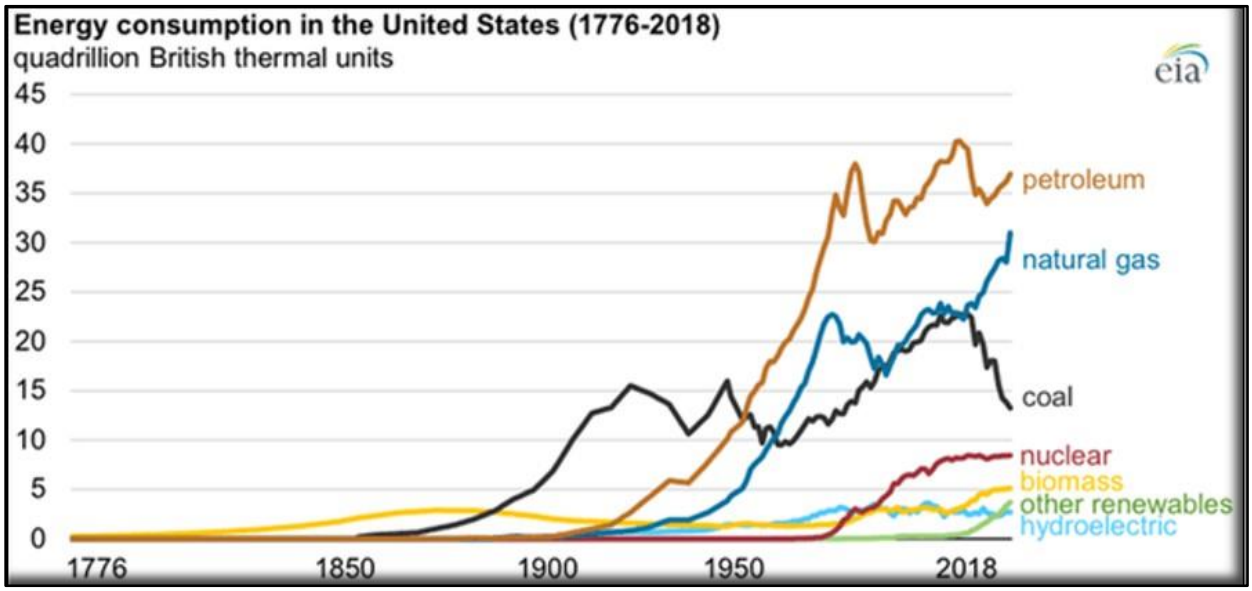
Figure II-2



Source: International Energy Agency, citing to Hausfather & Peters.

The RCP8.5 BAU projection assumes a 500% increase in the use of coal, now considered highly unlikely. The U.S. Energy Information Administration documents the rapid decline in use of coal.

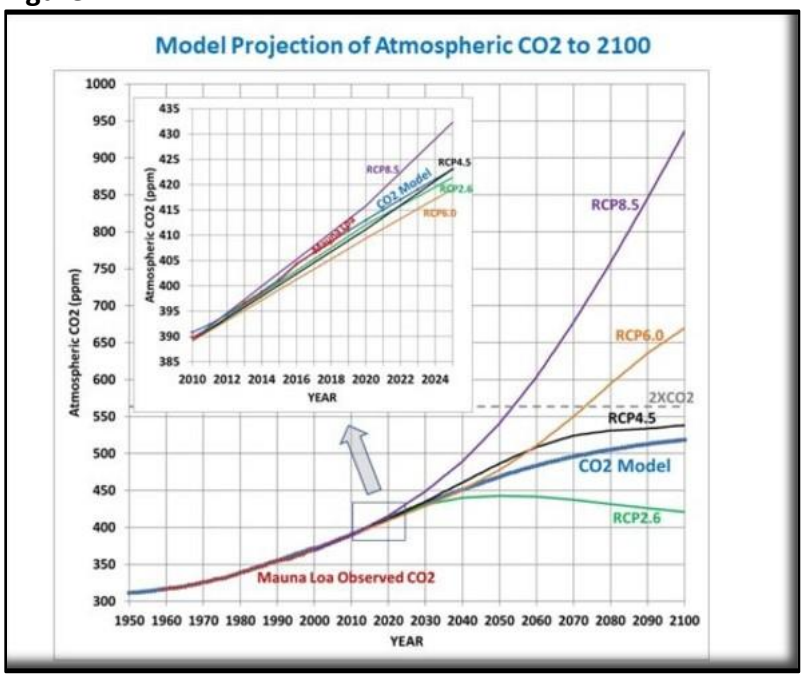
Figure II-3



Source: U.S. Energy Information Administration

More problematic, the BAU and Most Likely CO_2 projections may be much higher than climate physics would indicate is likely. Using a CO_2 budget model that very closely tracks actual CO_2 levels as measured at Mauna Loa, the "Most Likely" (RCP4.5) estimate of future CO_2 levels is less than a doubling of CO_2[18].

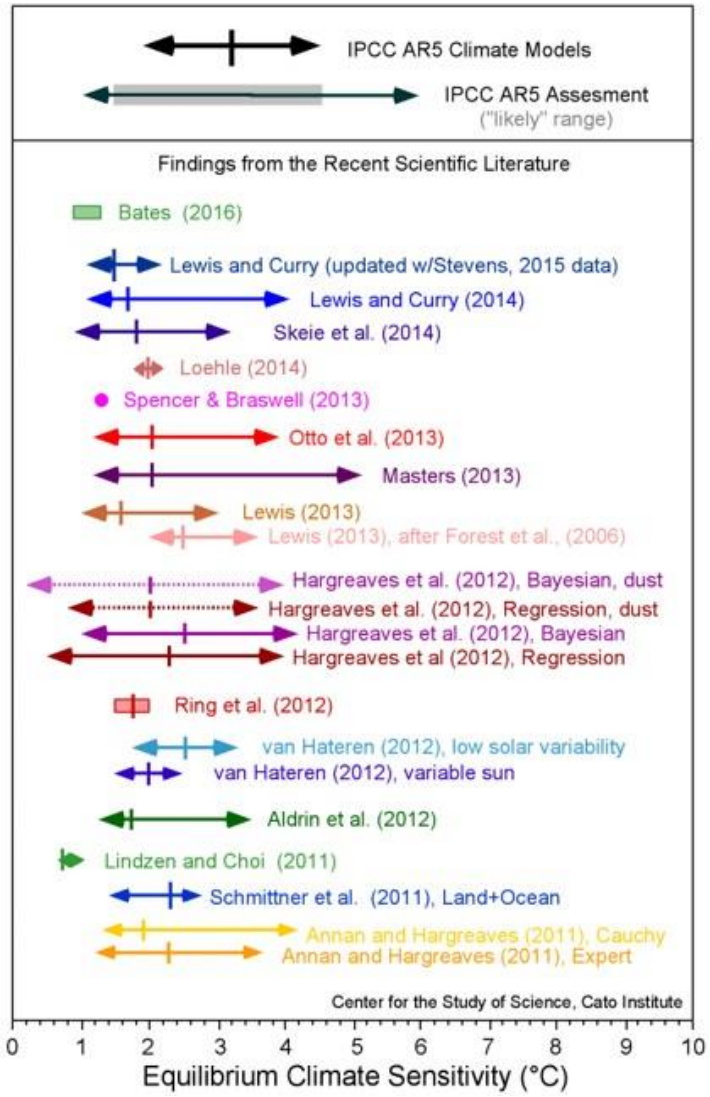
Figure II-4



Source: Spencer, 2020.

[18] Spencer, R.W., "Will Humanity Ever Reach 2xCO2?"

Climate scientists convert CO_2 increases into temperature increases using the "Climate Sensitivity" algorithm. Climate Sensitivity" is the amount global temperatures will rise from a doubling of CO_2.[19] The most recent climate sensitivity estimates suggests a range of warming of about 1.7 to 3.2°C (3-5.8°F) if there is a doubling of CO_2 levels, and less than that if CO_2 levels do not double from current levels.



Source: [Center for the Study of Science, CATO Institute]

[19] This is a simplified explanation. There are three main measures of climate sensitivity that scientists use. The first is equilibrium climate sensitivity (ECS). The Earth's climate takes time to adjust to changes in CO_2 concentration. ECS is the amount of warming that will occur once all these processes have reached equilibrium. The second is transient climate response (TCR). This is the amount of warming that might occur at the time when CO_2 doubles, having increased gradually by 1% each year. A third way of looking at climate sensitivity, Earth system sensitivity (ESS), includes very long-term Earth system feedbacks, such as changes in ice sheets or changes in the distribution of vegetative cover. TCR tends to be notably lower than ECS. In this Focus Group report, we use ECS.

The Focus Group members have divergent views on the degree to which humans contribute to rises in global temperature. Some Focus Group members firmly believe there is a 97% consensus that humans are the cause of climate change, that change is now manifest in extreme weather events and that society faces an existential threat. One Focus Group member cites to news media and an undergraduate powerpoint presentation as the basis for this viewpoint.[20] Another Focus Group member cites to the Cook 2004 paper for the 97% consensus figure.

Some Focus Group members find these sources unpersuasive, relying on peer-reviewed published scientific papers that debunk the Cook paper and state there is no 97% consensus on this issue. Schulte attempted to replicate the Cook paper and found multiple methodological errors. Using the same search criteria, he reported only 45% of scientific, peer-reviewed climate science publications explicitly or implicitly endorse the consensus that humans are responsible for at least half of observed warming.[21]

Some Focus Group members also relied on the Verheggen et al report. Verheggen reported that among **1,868 IPCC authors** surveyed, only 41% were "confident" that humans are responsible for at least half of observed warming.[22]

Some Focus Group members also pointed to a survey of scientists in the U.S. conducted by the National Registry of Environmental Professionals which found 41 percent disagreed the planet's recent warmth "can be, in large part, attributed to human activity," and 71 percent disagreed recent hurricane activity is significantly attributable to human activity.[23]

With regards to whether "there is urgent need to interrupt this cycle", some Focus Group members have found that less than 5% (~2%) of scientific, peer-reviewed climate science publications explicitly or implicitly endorse any consensus that the levels of CO2 we might experience would result in an existential threat to human civilization. Those Focus Group members note the IPCC reports a less than 3% likelihood of a greater than 6 deg. C. rise in temperature, and that would pose risks, but not ones that are existential. For a deep discussion of this issue of existential risk, those Focus Group members point to Halstead, J., "Is climate change an existential risks?"

[20] States at Risk: Virginia, Environment Virginia: Extreme Weather Map & Fact Sheet, Center for Climate and Energy Solutions: Extreme Weather and Climate Change, USA Today, "Here Are 20 Places Where Weather is Getting Worse Because Of Climate Change," Virginia Business: "Extreme Events, Changing Weather Patterns Create New Risks For Business."

[21] Schulte, K-M. 2008. Scientific consensus on climate change? Energy & Environment 19 (2 March): 281–286. doi: 10.1260/095830508783900744

[22] Verheggen, B., Strengers, B., Cook, J., van Dorland, R., Vringer, K., Peters, J., Visser, H., and Meyer, L. 2014. Scientists' views about attribution of global warming. Environmental Science & Technology 48 (16): 8963–8971. doi: 10.1021/es501998e.

[23] Taylor, J.M. 2007. Warming debate not over, survey of scientists shows. Environment & Climate News (February).

Data on Extreme Weather Events

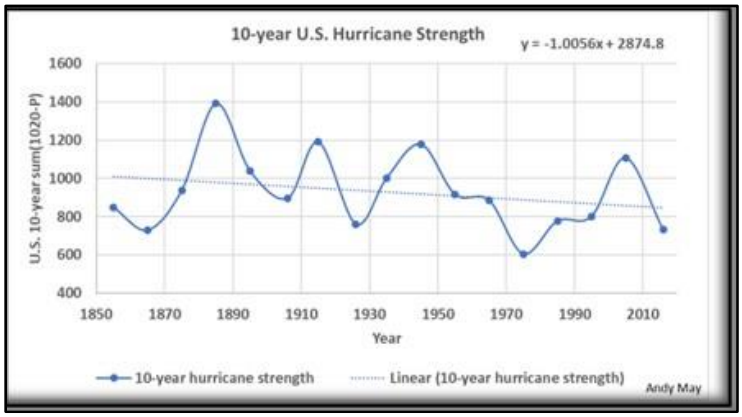
In regard to whether observed global warming has caused, or is otherwise associated with extreme weather events, one Focus Group member suggested present day impacts of climate change have been observed around the globe, including in Fairfax County, in the form of increased incidence of extreme weather events such as drought and flooding, relying on the presentations made to the Focus Group by the CECAP consultants.

Other Focus Group members take the position that this is a controversial statement because federal and international governmental organizations present data indicating there is insufficient evidence of a causal relationship between GHG levels and extreme weather events. One Focus Group member argues that current weather patterns do not assist in understanding which projection is most likely. There is evidence both for and against the existence of a detectable anthropogenic signal in temperature, precipitation and tropical storms. That Focus Group member offered the following information.

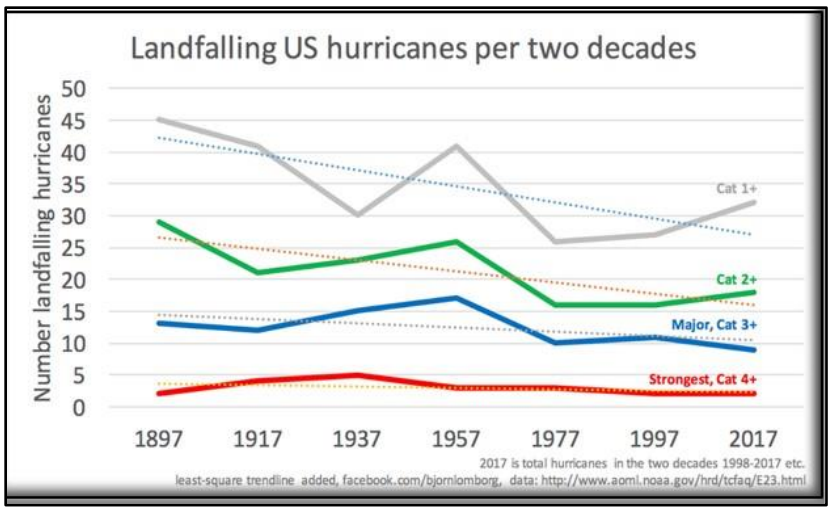
Consensus Statements by International Workshop on Tropical Cyclones-VI (IWTC-VI) Participants:

1. **Though there is evidence both for and against the existence of a detectable anthropogenic signal in the tropical cyclone climate record to date, no firm conclusion can be made on this point.**
2. No individual tropical cyclone can be directly attributed to climate change.
3. The recent increase in societal impact from tropical cyclones has largely been caused by rising concentrations of population and infrastructure in coastal regions.

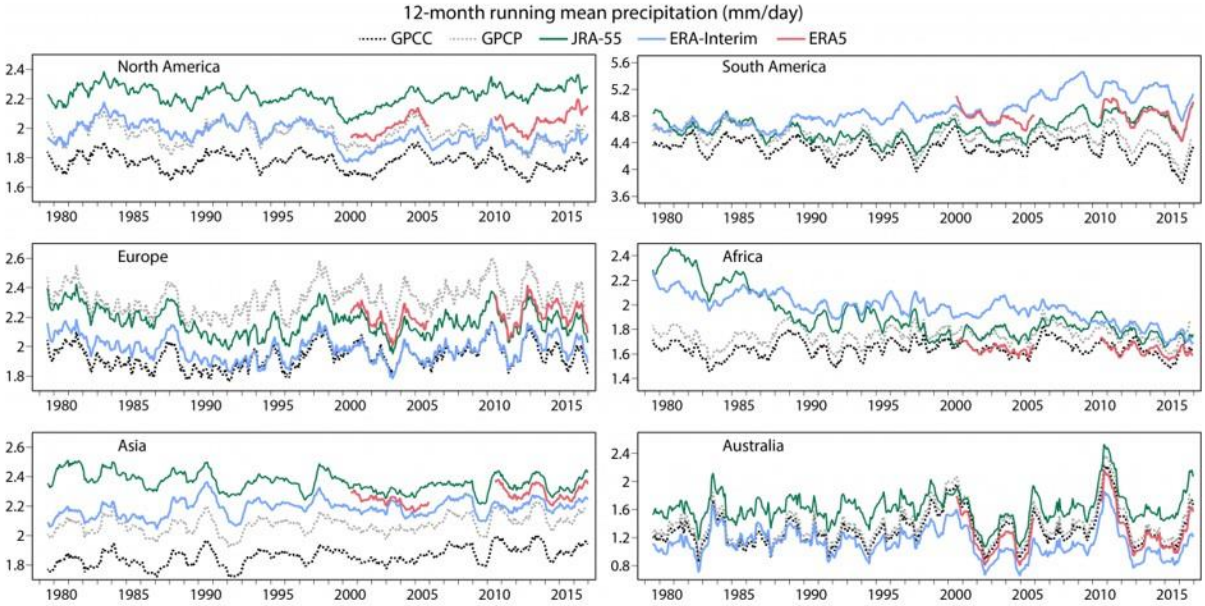
Source: NOAA Hurricane Research Division



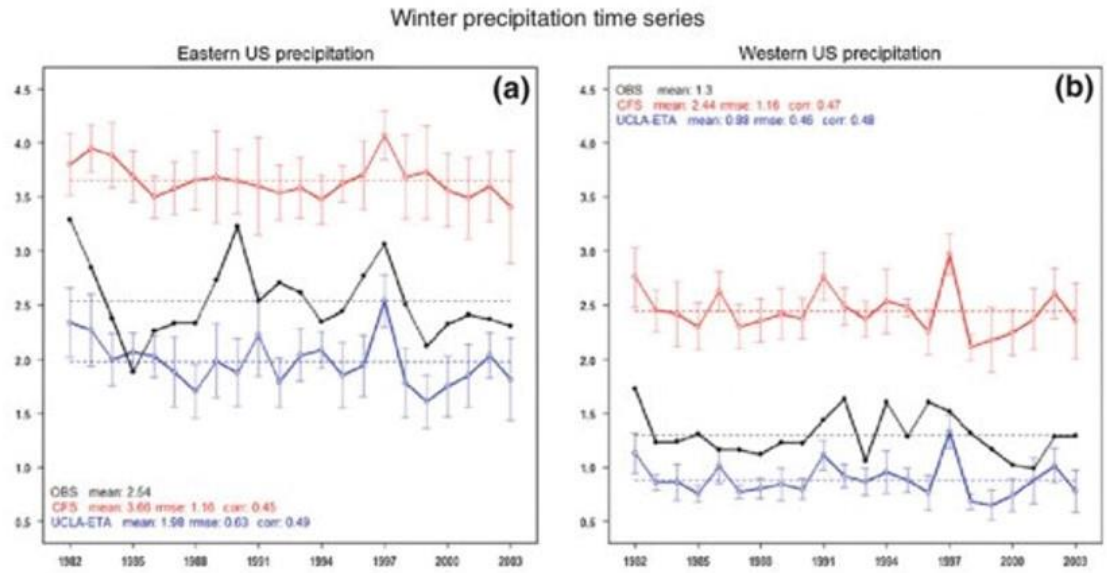
Source: NOAA Hurricane Research Division



The European Centre for Medium-Range Weather Forecasts precipitation has not significantly changed in the past 38 years.

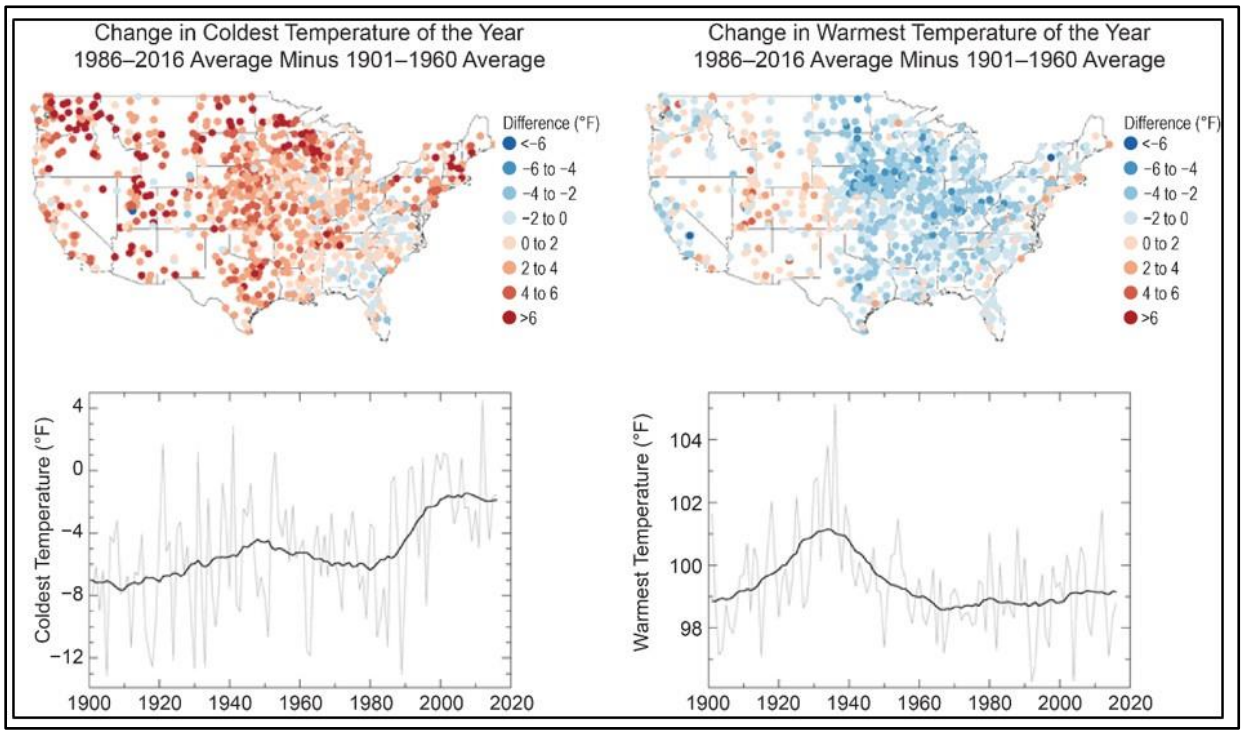


Source: [European Centre for Medium-Range Weather Forecasts, using five data sources.]



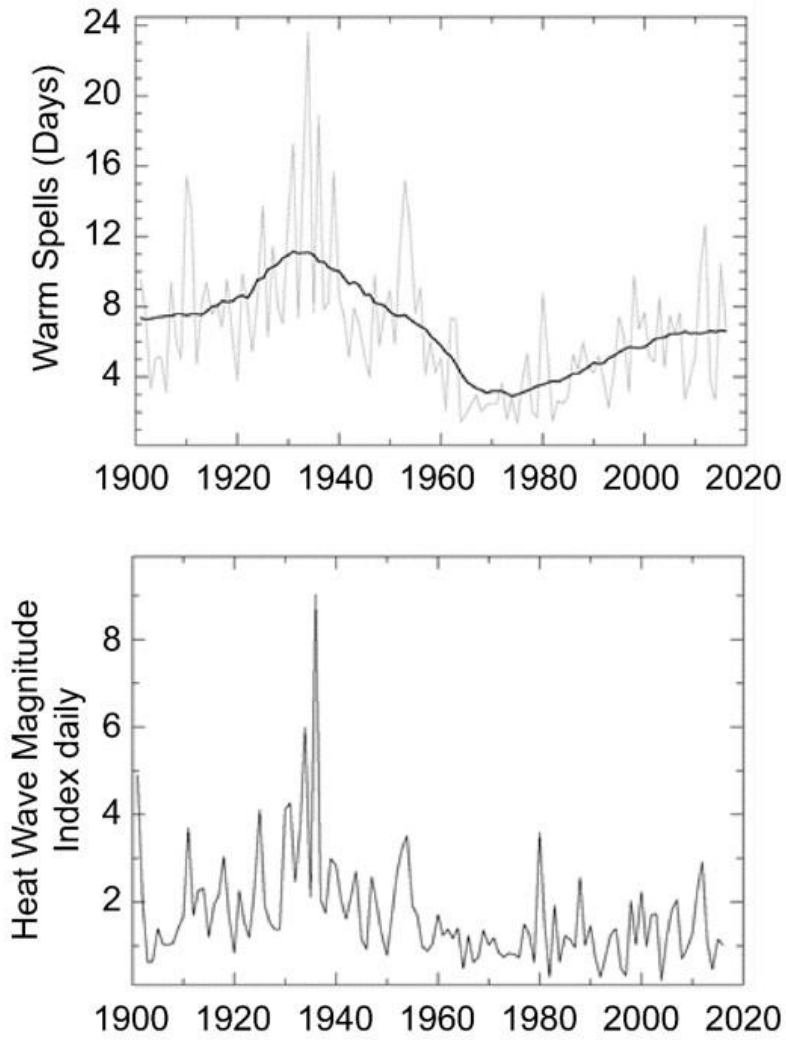
Time series of winter mean precipitation from observation, CFS, and UCLA-ETA averaged over the eastern (a) and western (b) sub-domains. For example, 1982 refers to the average between Dec 1982 and Apr 1983. Vertical bars indicate one standard deviation. Source: [Clim. Dyn. (2013) 41:255-257]

And, the U.S. Climate Assessment prepared under the Obama administration documented that neither cold nor heat waves are increasing.



Observed changes in the coldest and warmest daily temperatures (°F) of the year in the contiguous United States. Maps (top) depict changes at stations; changes are the difference

between the average for present-day (1986–2016) and the average for the first half of the last century (1901–1960). Time series (bottom) depict the area-weighted average for the contiguous United States. Estimates are derived from long-term stations with minimal missing data in the Global Historical Climatology Network–Daily dataset. (Figure source: NOAA/NCEI).
Source: [Climate Science Special Report, U.S. Global Change Research Program]



Source: [Climate Science Special Report, U.S. Global Change Research Program]

Appendix III: Fairfax County Economic Demographics

Some Focus Group members find that "achievable" GHG emissions goals must reflect two economic factors of our community: (i) ability to pay; and, (ii) willingness to pay for actions that reduce GHG emissions. The latter, willingness to pay, can be influenced by knowledge, peer-pressure, wealth, ethnic group affiliation and political party affiliation. The former, affordability, is not subject to influences likely to emerge from the CECAP program. GHG emission reduction goals thus must reflect both of these parameters. This presentation of the Focus Group discussions begins with affordability, the ability of members of our community to make new investments with no new income.

Ability to Pay

The Fairfax County community is wealthy. According to the U.S. Census Bureau[24], more than two-thirds of our labor force is employed, well above the national average. Some 68% of us own our own homes, 32% do not. The median value of our homes is $550,000. Median household income is $121,133, twice the national average. About 8% of our children live in poverty, less than half the national average. We are well educated, 61% having a bachelor's degree and half of that group have a graduate or professional degree. There are about 31,000 businesses with employees in our community and they have significant revenues, $14.6 million in retail sales, $25.2 million in wholesale sales, $6.9 million in health care revenue and $2.8 million in hotel and food services.

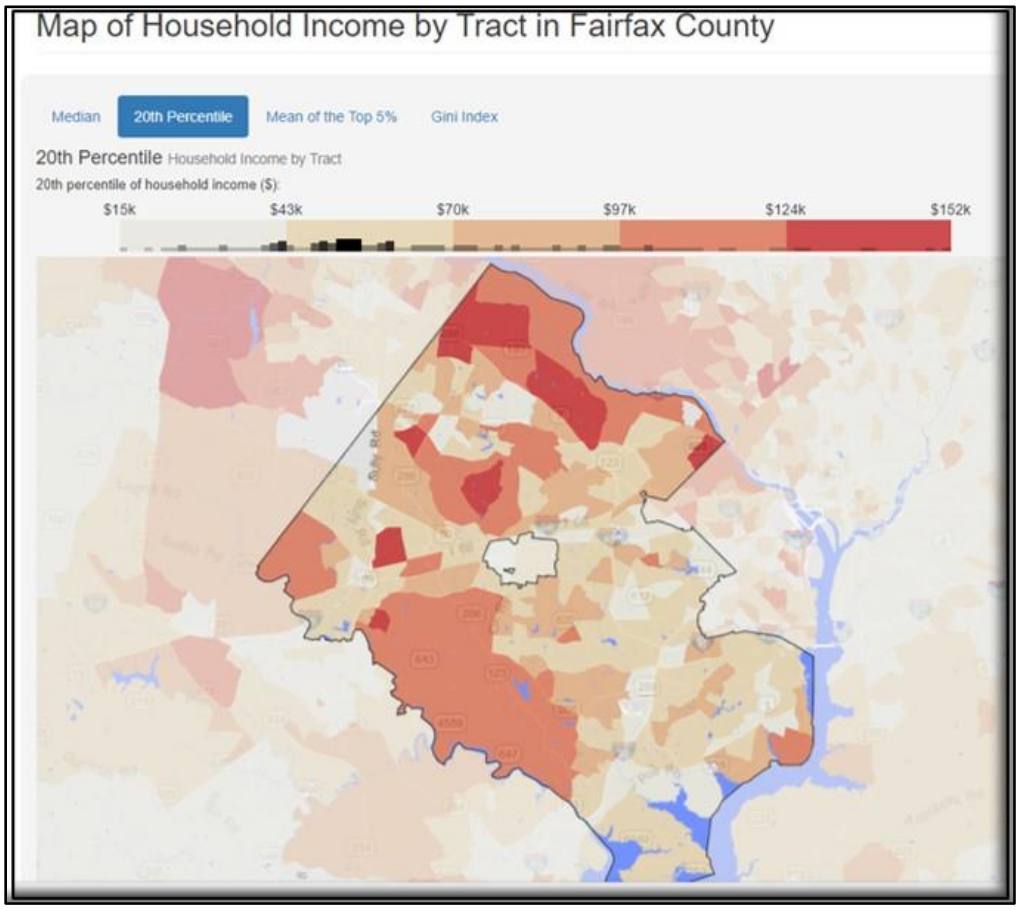
However, averages and median values do not tell the entire story about our community. The One Fairfax Policy requires us to consider all members of our community. Thus, when examining an ability-to-pay-based GHG emissions reduction goal, we need to understand to whom potential actions are affordable as that may limit some elements of our community on whom we can rely for significant emissions reductions. We need to know who can afford what as we design the plan, including who will pay for what. The StatisticalAtlas.com website gives us a deeper understanding of who we are.[25]

One in five or our households (20th percentile) have incomes less than $54,600, with an average value of $30,200. The poverty line for a family of five is $30,700.[26] Seventy-three percent (73%) of our households with incomes below the poverty line are non-White, non-Asian minority families. These poorest households are concentrated in the Mason and Mount Vernon magisterial districts, but low-income census tracts can be found in every district. (See Figure 5).

Approximately 16,000 of our households are on food stamps and these families have a median income of $34,700.[27] Sixty percent (60%) of these households have children, a quarter of them are single Mom families and 36.5% have incomes below the poverty line. Of the households on food stamps, 43% have at least one family member over the age of 60.

[24] All data in this paragraph comes from "data.census.gov" and is based on the 2017 Economic Census and 2018 American Community Survey.
[25] StatisticalAtlas.com is a website owned by Cedar Lake Ventures, Inc. It uses U.S. Census data. The data in this section reflects the 2012-2016 American Community Survey.
[26] U.S. Federal Poverty Guidelines for 2020.
[27] StatisticalAtlas.com, Fairfax County food stamp data.

Figure III-1



Source: StatisticalAtlas.com (2012)

The One Fairfax Policy requires careful attention to the low-income, minority and aged members of our community. This is of special concern should we consider asking our community to increase spending on new initiatives, including CO_2 emissions reductions. A look at the lowest-income fifth of our community is revealing.

Low-income families spend 84% of their income on essential goods and services[28], including housing (40.4%), transportation (14.5%), food (15.4%), health care (7.9%) clothing (3.2%), and education (2.8%). That leaves 16% for other things; about $4,800 per year.

[28] Morrell, A. & Kiersz, A. "Seeing how the highest and lowest-earners spend their money will make you think differently about 'rich' vs 'poor'", Business insider (Dec. 4, 2017)

Table III-1
Discretionary Spending for the Lower 20th Percentile
Mean Income of Fairfax County Households

Expenditure	Percent of Income	Purchasing Power
Personal insurance and pensions (*i.e.* savings)	2.5%	Collision and liability insurance on one car, no home insurance and no savings.
Entertainment	4.2%	Three months of cable, internet and family mobile phone service.
Donations	2.4%	$17.50 a week.
Personal care products and services	1.0%	One cut and one color/braid/style visit a year.
Alcohol	0.6%	One six-pack of beer every two weeks.
Smoking	1.0%	1.4 packs of cigarettes a week.
Reading	0.1%	15 weeks of the Washington Post.
Miscellaneous	1.8%	$10.46 a week.

To place the affordability question in context of a recent climate initiative, the Governor is considering joining the Transportation Climate Initiative (TCI). This is a program that would ration gasoline and apply a carbon car tax. That tax would begin at 17 cents a gallon in 2021 and rise to $3.00 a gallon.[29]

Currently, the typical Fairfax County driver uses about 500 gallons of gasoline a year. Because we live in a suburban environment, the U.S. Energy Information Administration finds that gasoline prices tend to have little effect on demand for car travel.[30] Thus, the TCI would impose new annual gasoline costs of $85, rising to $1,500 for transportation. Based on what our poorest 20 percent of households have to spend, it does not seem clear that the TCI would be affordable to them. One can only speculate what the family would cut to pay for this climate program if the county did not make provisions to consider their extreme need relative to any new plans it implements.

Another example highlights the size of climate investments as compared to our household pocketbooks. The Virginia Legislature is considering a Renewable Portfolio Standard (RPS) for electricity sales within the Commonwealth. The intent would be to reach 100% renewable electricity by 2045. The National Renewable Energy Laboratory (NREL) considers such a program as a "High Renewable Energy" program. NREL estimates that such a program would raise household energy rates by 4.2 cents per kilowatt-hour.[31] This would raise the typical household electricity bill by $461, or just over $38 a month. As usual, averages do not tell the

[29] Rhode Island Executive Climate Change Coordinating Council, "Rhode Island Explains Program for Cutting Transportation Emissions"
[30] U.S. EIA, "Gasoline Prices Tend To Have Little Effect On Demand For Car Travel"
[31] National Renewable Energy Laboratory, "A Prospective Analysis of the Costs, Benefits, and Impacts of U.S. Renewable Portfolio Standards"

entire story; those living in large single-family homes would see larger cost increases while those living in smaller dwellings such as townhomes and apartments would see less than average increases.

These costs add up quickly for those with little to no disposable income. While half of Fairfax County households have income sufficient to cover some of these increases in the price of essential goods, many would not. We are a white-collar county dominated by two worker households. In married families with children, two-thirds (67.3%) of the time both parents work. In families without children, more than half (53.5%) of the time, both spouses work.[32] This means, our families are not in a position to increase their income by simply working more.

[32] Statistical Atlas, Fairfax County Employment Status.

Appendix IV: IPCC Evaluation of Mitigation Actions

Intergovernmental Panel on Climate Change, AR5 Climate Change 2014: Mitigation of Climate Change. Chapter 9 tables evaluating various means to mitigate CO_2 emissions in buildings.

Table 9.2 | Savings or off-site energy use reductions achievable in buildings for various end uses due to on-site active solar energy systems, efficiency improvements, or behavioural changes.

End Use	On-site C-Free Energy Supply[1]	Device Efficiency	System Efficiency	Behavioural Change
Heating	20 %–95 % [2]	30 %[3]–80 %[4]	90 %[5]	10 %–30 %[6]
Hot water	50 %–100 % [7]	60 %[8]–75 %[9]	40 %[10]	50 %[11]
Cooling	50 %–80 % [12]	50 %[13]–75 %[14]	67 %[15]	50 %–67 %[16]
Cooking	0–30 % [17]	25–75 %[18]–80 %[19]		50 %[20]
Lighting	10–30 %	75 %[21]; 83 %–90 %[22]; 99.83 %[23]	80 %–93 %[24]	70 %[25]
Refrigerators		40 % [25a]		30 %[26]; 50 %[27]
Dishwashers		17+%[27a]		75 %[28]
Clothes washers		30 %[28a]		60 %–85 %[29]
Clothes dryers		50+%[29a]		10 %–15 %[30]–100 %[31]
Office computers & monitors		40 %[31a]		
General electrical loads	10 %–120 %[32]			

Table 9.4 | Summary of estimates for extra investment cost required for selected very low-/zero-energy buildings.

Case	Location	Type	Energy performance	Extra investment costs	CCE (USD_{2010}/kWh)	References
Passive House Projects	Central Europe	New	Passive House standard	5–8 % (143–225 USD_{2010}/m^2)	–	(Bretzke, 2005; Schnieders and Hermelink, 2006)
5 Passive Houses	Belgium	New	62 $kWh/m^2/yr$ total	16 % (252 USD_{2010}/m^2)	–	(Audenaert et al., 2008)
Passive House apartment block	Vienna	New	Passive House standard	5 % (69 USD_{2010}/m^2)	–	(Mahdavi and Doppelbauer, 2010)
12 very low or net zero-energy houses	United States	New		0.07–0.12 USD_{2010}/kWh (CCE)	–	(Parker, 2009)
10 buildings in the SolarBauprogramme	Germany	New	< 100 $kWh/m^2/yr$ primary energy vs. 300–600—conventional	Comparable to the difference in costs between alternative standards for interior finishes	–	(Wagner et al., 2004)
High performance commercial buildings	Vancouver	New	100 $kWh/m^2/yr$ total vs. 180—conventional	10 % lower cost	–	(McDonell, 2003)
Offices and laboratory, Concordia University	Montreal	New		2.30 %	–	(Lemire and Charneux, 2005)
Welsh Information and Technology Adult Learning Centre (CaolfanHyddgen)	Wales	New	Passive House standard	No extra cost compared to BREEAM 'Excellent' standard	–	(Pearson, 2011)
Hypothetical 6,000 m^2 office building	Las Vegas	New	42 % of energy savings	USD_{2010} 2,719	–	(Vaidya et al., 2009)
10-story, 7,000 m^2 residential building	Denmark	New	14 $kWh/m^2/yr$ (heating) vs. 45	3.4 % (115 USD_{2010}/m^2)	–	(Marszal and Heiselberg, 2009)
Leslie Shao-Ming Sun Field Station, Stanford University	California	New	NZEB	4–10 % more based on hard construction costs	–	(NBI, 2011)
Hudson Valley Clean Energy Headquarters	New York	New	NZEB	665 USD_{2010}/month in mortgage payments but saves 823 USD_{2010}/month in energy costs	–	(NBI, 2011)
IAMU Office	Ankeny, IA	New	NZEB	None	–	(NBI, 2011)
EcoFlats Building	Portland, OR	New	NZEB	None	–	(NBI, 2011)
10-story, 7,000 m^2 residential building	Denmark	New	NZEB	24 % (558 USD_{2010}/m^2)	–	(Marszal and Heiselberg, 2009)
Toronto towers	Toronto	Retrofit	194/95 %	259 USD_{2010}/m^2	0.052	(Kesik and Saleff, 2009)
Multi-family housing	EU	Retrofit	62–150/52 %–86 %	53–124 USD_{2010}/m^2	0.014–0.023	(Petersdorff et al., 2005)
Terrace housing	EU	Retrofit	97–266/59 %–84 %	90–207 USD_{2010}/m^2	0.13–0.023	(Petersdorff et al., 2005)
High-rise housing	EU	Retrofit	70 %–81 %	2.5–5.8 $USD_{2010}/m^2/yr$	0.018–0.028	(Waide et al., 2006)
1950s MFH	Germany	Retrofit	82–247/30 %–90 %	48–416 USD_{2010}/m^2	0.023–0.065	(Galvin, 2010)
1925 SFH	Denmark	Retrofit	120	217 USD_{2010}/m^2	0.071	(Krogh and Rose, 2011)
1929 MFH	Germany	Retrofit	140–200/58 %–82 %	167–340 USD_{2010}/m^2	0.060–0.088	(Hermelink, 2009)
19th century flat	UK	Retrofit	192–234/48 %–59 %	305–762 USD_{2010}/m^2	0.068–0.140	(United House, 2009)

Table 9.5 | Potential savings in energy consumption by household appliances and equipment.

Item	Savings potential	Reference
Televisions	Average energy use of units sold in the United States (largely LCDs) was 426 kWh/yr in 2008 and 102 kWh/yr in 2012. Further reductions (30–50 % below LCD TVs) are expected with use of organic LED backlighting (likely commercially available by 2015).	(Howard et al., 2012; Letschert et al., 2012)
Televisions	Energy savings of best available TVs compared to market norms are 32–45 % in Europe, 44–58 % in North America, and 55–60 % in Australia	(Park, 2013)
Computer monitors	70 % reduction in on-mode power draw expected from 2011 to 2015	(Park et al., 2013)
Computing	At least a factor of 10 million potential reduction in the energy required per computation (going well beyond the so-called Feynman limit).	(Koomey et al., 2013)
Refrigerator-freezer units	40 % minimum potential savings compared to the best standards, 27 % savings at ≤0.11 USD_{2012}/kWh CCE (Costs of Conserved Energy)	(Bansal et al., 2011; McNeil and Bojda, 2012)
Cooking	50 % savings potential (in Europe), largely through more efficient cooking practices alone	(Fechner and Porter, 1979; Oberascher et al., 2011)
Ovens	25 % and 45 % potential savings through advanced technology in natural gas and conventional electric ovens, respectively, and 75 % for microwave ovens	(Mugdal, 2011; Bansal et al., 2011)
Dishwashers	Typically only 40–45 % loaded, increasing energy use per place setting by 77–97 % for 3 dishwashers studied	(Richter, 2011)
Dishwashers	Current initiative targets 17 % less electricity, 35 % less water than best US standard	(Bansal et al., 2011)
Clothes washers	Global 28 % potential savings by 2030 relative to business-as-usual	(Letschert et al., 2012)
Clothes Dryers	Factor of two difference between best and average units on the market in Europe (0.27 kWh/kg vs. 0.59 kWh/kg). More than a factor of 2 reduction in going from United States average to European heat pump dryer (820 kWh/yr vs. 380 kWh/yr)	(Werle et al., 2011)
Standby loads	Potential of < 0.005 W for adapters and chargers, < 0.05 for large appliances ('zero' in both cases) (typical mid 2000s standby power draw: 5–15 W)	(Harvey, 2010; Matthews, 2011), (Harvey, 2010) for mid 2000s data
Air conditioners	COP (a measure of efficiency) of 2.5–3.5 in Europe and United States, 5.0–6.5 in Japan (implies up to 50 % energy savings)	(Waide et al., 2011)
Air conditioners	COP of 4.2–6.8 for air conditioners such that the cost of saving electricity does not exceed the local cost of electricity, and a potential COP of 7.3–10.2 if all available energy-saving measures were to be implemented (implies a 50–75 % savings for a given cooling load and operating pattern).	(Shah et al., 2013)
Ceiling fans	50–57 % energy savings potential	(Letschert et al., 2012; Sathaye et al., 2013)
Package of household appliances in Portugal	60 % less energy consumption by best available equipment compared to typically-used equipment	(da Graca et al., 2012)
Office computers and monitors	40 % savings from existing low-to-zero cost measures only	(Mercier and Morrefield, 2009)
Circulation pumps for hydronic heating and cooling	40 % savings from projected energy use in 2020 in Europe (relative to a baseline with efficiencies as of 2004) due to legislated standards already in place	(Bidstrup, 2011)
Residential lighting	Efficacies (lm/W) (higher is better): standard incandescent, 15; CFL, 60; best currently available white-light LEDs, 100; current laboratory LEDs, 250	(Letschert et al., 2012)
Residential water-using fixtures	50–80 % reduction in water use by water-saving fixtures compared to older standard fixtures	(Harvey, 2010)
Residential water heaters	Typical efficiency factor (EF) for gas and electric water heaters in the USA is 0.67 and 0.8 in EU, while the most efficient heat-pump water heaters have EF=2.35 and an EF of 3.0 is foreseeable (factor of 4 improvement)	(Letschert et al., 2012)

Table 9.6 | Summary of literature on aggregated mitigation potentials in buildings categorized by key mitigation strategies.[a]

Region (Study)[b]	Description of mitigation measures/package (year)[c]	End-uses[d]	Type[e]	Sector[f]	Base-end yrs	% change to baseline	% change to base yr[g]
CARBON EFFICIENCY							
EU [1]	Additional solar thermal for water system	HW	T	RS	2010–20		20 %, p.a.
AU [2], AT [3] CA [4], DK [5] FI, [6], SE [7] IT [8], JP [9] NL [10], ES [11] SE [12], CH [13] UK [14], US [15]	Solar electricity generation through buildings' roof-top PV installations	EL	T	RS	yearly	-4.6%, -21%, -31%, -32%, -19%, -30%, -40%, -15%, -32%, -48%, -20%, -31%, -31%, -58%	
IL [16]	All available rooftops are assumed for producing solar energy	EL	T	RS	yearly	-32%	
EL [17]	An optimal implementation of the Greek Technical Building Code and usage of 12% of the available roof surface area	W	T-E	RS	2030	-68.4 %	
TECHNOLOGICAL EFFICIENCY							
World [18]	Significant efforts to fully exploit the potential for EE, all cost-effective renewable energy sources [RES] for heat and electricity generation, production of bio-fuels, EE equipment	ALL	T	RS	2007–50	-29%	
US [19]	The cost-effective energy saving targets, assessed for each end-use on the basis of several earlier studies, are achieved by 2030	ALL	T-E	RS	2010–30	-48%	
NO [20]	Wide diffusion of heat pumps and other energy conservation measures, e.g., replacement of windows, additional insulation, heat recovery etc.	ALL	T	RS	2005–35	-9.3.0 %	-21 %
TH [21]	Building energy code and building energy labelling are widely implemented, the requirements towards (nearly) zero energy building (NZEB) are gradually strengthened by 2030	ALL	T	CS	by 2030	-57 %	
Northern Europe [22]	Improvements in lamp, ballast, luminaire technology, use of task/ambient lighting, reduction of illuminance levels, switch-on-time, manual dimming, switch-off occupancy sensors, daylighting	L	T	CS	2011	-12 %	
Catalonia, ES [23]	Implementation of Technical Code of Buildings for Spain, using insulation and construction solutions that ensure the desired thermal coefficients	H/C	T	RS	2005–15		-29 %
BH [24]	Implementation of the envelope codes requiring that the building envelope is well-insulated and efficient glazing is used	C	T	CS	1 year		-21 %
UK [25]	Fabric improvements, heating, ventilation and air-conditioning (HVAC) designs (including ventilation heat recovery), lighting and appliance improvements and renewable energy generation	ALL	T	CS	2005–30		-50 % (CO$_2$)
CN [26]	Best Practice Scenario (BPS) examined the potential of an achievement of international best practice efficiency in broad energy use today	APR	T	RS, CS	2030–50	-35 %	
SYSTEMIC EFFICIENCY							
World [27]	Today's cost-effective best practice integrated design & retrofit becomes a standard	H/C	T-E	RS	2005–50	-70 %	-30 %
World [28]	The goal of halving global energy-related CO$_2$ emissions by 2050 (compared to 2005) based on the deployment of existing and new low-carbon technologies	ALL	T-E	RS	2007–50	-34%	
World [29]	High-performance thermal envelope, maximized the use of passive solar energy for heating, ventilation and daylighting, EE equipment and systems	ALL	T	RS	2005–50	-45 %	
US [30]	Advanced technologies, infrastructural improvements and some displacement of existing stock, configurations of the built environment that reduce energy requirements for mobility, but not yet commercially available	ALL	T-E	RS	2010–50	-58%	-40 %
EU 27 [31]	Accelerated renovation rates up to 4%, 100% refurbishment at high standards, in 2050 20 % of the new built buildings are at 'High-EE standard', 100% — by 2025	ALL	T	RS	2008–50	-68%	-11 %
DK [32]	Energy consumption for H in new-HS will be reduced by 30 % in 2005, 2010, 2015 and 2020; new-and-HS are upgraded to the energy requirements applicable for the new ones	H	T-E	RS	2005–50		-62 %

Region (Study)[2]	Description of mitigation measures/package (year)[2]	End-uses[4]	Type[5]	Sector[6]	Base-end yrs	% change to baseline	% change to base yr[7]
CH [53]	Compliance with the standard comparable to the MINERGIE-P®, the Passivhaus and the standard A in the 2030 that society with low-carbon systems for H and DW	H/W	T	RS	2008–50	-60 %	-68%
	Buildings comply with zero energy standard (no heating demand)	H/W	T	RS	2008–50	-45 %	-51 %
DE [54]	The proportion of very high-energy performance dwellings increases by up to 30% of the total stock in 2020; the share of (nearly) zero-energy buildings (NZEB) makes up 6 %	H/W	T	RS	2010–20		- 25 %(pr.e) - 50 % (CO2)
ENERGY SERVICE DEMAND REDUCTION							
FR [55]	15 months, information acceleration, learning-by-doing and the increase in energy price. Some barriers to EE, efficiency in H consumption are overcome	H	T	RS	2008–50	-21 %	- 58 %
US [56]	Influence of five lifestyle factors reflecting consumers' behavioural patterns on residential electricity consumption was analyzed	EL	T	RS	2035	-40 %	
IT [57]	Change in lifestyle towards saving energy and reducing waste	ALL	T	RS	1 year	-44 %	
US [58]	Commissioning as energy saving measure applied in 643 commercial buildings	ALL	T	CS	1 year	-16 % (existing buildings) -13 % (new buildings)	

Notes

1) The Table presents the potential of final energy use reduction (if another is not specified) compared to the baseline and/or base year for the end-uses given in the column 3 and for the sectors indicated in the column 5.
2) References: 1: Ürge-Vorsatz (2011), 2 – 15: IEA (2012), 16: Yue and Huang (2011), 17: Vandenbon (2011), 18: Izquierdo et al. (2011), 19: IEA (2010), 20: Brown et al. (2008a), 21: Sathaye et al. (2008), 22: Pehnt et al. (2011), 23: Dubois and Blomsterberg (2011), 24: Garrido-Soriano et al. (2012), 25: Nadel (2009), 26: Taylor et al. (2010), 27: Zhou et al. (2011a), 28: Urge-Vorsatz et al. (2012c), 29: IEA (2010b), 30: Harvey (2010), 31: Levine et al. (2012), 32: Eichhammer et al. (2009), 33: Sommerup and Svendsen (2006), 34: Chan and Yeung (2009), 35: Silke et al. (2007), 36: Schimschar et al. (2011), 37: Grausdorf et al. (2012), 38: Sanquist et al. (2012), 39: Steenhelen and Waechofner (2011), 40: Mills (2011).
3) EE – energy efficiency
4) H – space heating; C – space cooling; W – hot water; L – lighting; APP – appliances; ALL – all end-uses; E – electricity
5) T – technical; TE – techno-economical;
6) RS – the whole building sector; RS – residential sector; CS – commercial sector;
7) p.e. – primary energy.