REFERENCES

1. **Direct air capture (DAC) costs…** Goeppert et al., produced a literature summary of current DAC findings in 2012. It is important to note that considerable false propaganda has been circulated in the media about the infeasibility of DAC based on a report by the American Physical Society. Discussion of this apparent controversy is given below highlights of Geoppert 2012.
   Goeppert et al., Air as the renewable carbon source of the future - CO2 Capture from the atmosphere, Energy and Environmental Science, May 1, 2012.
   $20 per ton (just over) capture and storage… Section 5.1 paragraph 2, "using the K2CO3/KHCO3 cycle is described as being able to capture CO2 from air for less than $20 per ton. The total cost including sub-surface injection was estimated to be slightly above $20 per ton."
   $49 to $80 per ton… Section 5.1 paragraph 3: "An air capture system designed by Keith et al. using a Na/Ca cycle was estimated to cost approximately $500 per ton C ($140 per ton CO2).81,98 The authors added that about a third of this cost was related to capital and maintenance cost. Further development and optimization of the system by Carbon Engineering Ltd.113 for the effective extraction of CO2 from air resulted in the decrease of the estimated cost to $49–80 per tonne CO2."
   $30 per ton long term… Section 5.1, paragraph 5: "Lackner and co-workers developed an anionic exchange resin able to release CO2 in a moisture swing process. The cost of only the energy required per ton of CO2 collected was around $15. The initial cost of air capture including manufacturing and maintenance can be estimated at about $200 per ton of CO2. However, this cost is expected to drop considerably as more collectors are built, possibly putting CO2 capture in the $30 per ton range in the long term."
   Conclusion, first paragraph... "Despite its very low concentration of only 390 ppm, the capture of CO2 directly from the air is technically feasible. Theoretically, CO2 capture from the atmosphere would only require about 2 to 4 times as much energy as capture from flue gases, which is relatively modest considering that at the same time the CO2 concentration is decreased by roughly a factor of 250–300."
2. **Health care in the US…** We spend $2 trillion every year, averaged 2000 to 2009—before Obamacare—on healthcare in the US alone, In 2013 it was $2.9 trillion: National Health Care Expenditure Data, NHE Tables, Table 1.
3. **APS research revealed as significantly incomplete by Nature**… Socolow 2011 evaluated existing WWII Era atmospheric removal techniques and not surprisingly found them economically infeasible to address climate pollution. New technologies were not evaluated. The Climate Change Counter-Movement widely circulated the APS study and even though the third most important scientific journal in the world refuted APS claims—because they did not evaluate current new technologies—the damage has been done; the media cycle has run its course. Today DAC is almost completely discredited in climate pollution mitigation strategies considered by policy makers and advocates, regardless of academic findings counter to this understanding.
   American Physical Society Study:
   Socolow et al., Direct Air Capture of CO2 with Chemicals, The American Physical Society, June 2011.
   Evaluation of APS study by Nature
4. **Clean Power Plan is less stringent than the Kyoto Protocol…** Clean Power Plan is 32 percent below 2005 levels by 2030 vs. Kyoto at 7 percent below 1990 levels by 2012. Kyoto commitments for Phase II were

generally at 80 percent below 1990 by 2020. (The United States, South Sudan and Afghanistan were the only countries to not ratify Kyoto). The US commitment for the current Paris Climate Conference of 80 percent below 2005 (4970 Gt CO2) is 27 percent below the Phase 2 Kyoto commitment of 80 percent below 1990 (3922 Gt CO2). Kyoto's target was 2020, Paris, 2050 (includes offshored emissions.)
Clean Power Plan Fact Sheet
Kyoto Protocol Reference Manual
Phase II Kyoto Protocol
United States 2050 UNFCCC commitment

5. **Everyone else is 7 to 14 times more than the EU…**
Peters et al., Measuring a fair and ambitious climate agreement using cumulative, Environmental Research Letters, October 15, 2015, abstract.
6. **Strong negative emissions…** The IPCC now says that we must remove greater than 100% of annual emissions directly from the sky in order to avoid dangerous climate change. The following quote is from the next to the last statement of fact in the SPM: "A large fraction of anthropogenic climate change resulting from CO2 emissions is irreversible on a multi-century to millennial time scale, except in the case of a large net removal of CO2 from the atmosphere over a sustained period."
Chapter 12 repeats this statement in different language that adds more meaning and clarification to the Summary for Policymakers statement. From the summary of Chapter 12 Long-term Climate Change: Projections, Commitments and Irreversibility, we find: "A large fraction of climate change is largely irreversible on human time scales, unless net anthropogenic CO2 emissions were strongly negative over a sustained period."
Large net removal… IPCC 2013, Summary for Policy Makers, E.8 "Climate Stabilization, Climate Change Commitment and Irreversibility," p 28, second bullet.
Strongly negative… IPCC 2013, Chapter 12, Long-term Climate Change Projections, Commitments and Irreversibility, Executive summary, Page 1033, sixth paragraph.
7. **How much is a large net removal?…** The IPCC did not quantify how much "a large net removal" meant, but it recognized the need. A "large net removal" is "largely" more than emissions reductions alone. This amount has now been published in Nature Communications as 105 to 135 percent of today's annual emissions for the best case scenario (RCP2.6, 450 ppm CO2e, 390 ppm CO2) and 170 to 210 percent of today's emissions with the worst-case scenario (RCP8.5, 1370 ppm CO2e, about 1190 ppm CO2). Because today's emissions in the U.S. are approximately equal to 2005 emissions, Gasser's suggested 135 percent negative emissions is about four times more than the CPP's 32 percent below 2005 and six times more than the U.S. current commitment for 2050 of 80 percent below 2005. From the abstract: "In our best-case illustrative assumption of conventional mitigation, negative emissions of 0.5–3 Gt C (gigatonnes of carbon) per year and storage capacity of 50–250 Gt C are required. In our worst case, those requirements are 7–11 Gt C per year and 1,000–1,600 Gt C, respectively. Because these figures have not been shown to be feasible, we conclude that development of negative emission technologies should be accelerated, but also that conventional mitigation must remain a substantial part of any climate policy aiming at the 2-°C target."
Gasser et al., Negative emissions physically needed to keep global warming below 2C, Nature, August 3, 2015.
8. **Worse than the worst-case Scenario…** The A1FI scenario of IPCC reports from 2007 and prior and RCP8.5 of the IPCC 2013 are basically the worst-case emissions scenario. Allison et al., show current emission rates for CO2 at above that of the A1FI scenario. This scenario's counterpart in the 2013 IPCC has a 2100 CO2 concentration of about 950 ppm. RCP8.5 is 1370 ppm CO2 in 2100, or about 1190 ppm CO2. We are currently at 400 ppm CO2.
Allison et al., The Copenhagen Diagnosis, 2009: Updating the world on the Latest Climate Science, The University of New South Wales Climate Change Research Centre (CCRC), Sydney, Australia, March 2009, page 9, figure 1.1.
Also see:
Raupach et al., Global and regional drivers of accelerating CO2 emissions, PNAS, April 2007, Figure 1.

9. **More than half of observed warming to date (57%) has been masked by aerosols…** Up to (-)1.9 Wm(-2) of warming has been masked by aerosols out of 2.29 Wm(-2) total observed warming, or about 57% of warming observed to date. In context, bullet seven: "The RF of the total aerosol effect in the atmosphere, which includes cloud adjustments due to aerosols, is –0.9 [–1.9 to −0.1] W m−2 (medium confidence), and results from a negative forcing from most aerosols and a positive contribution from black carbon absorption of solar radiation. There is high confidence that aerosols and their interactions with clouds have offset a substantial portion of global mean forcing from well-mixed greenhouse gases. They continue to contribute the largest uncertainty to the total RF estimate."
   IPCC 2013 Summary for Policy Makers (SPM), page 13, C, seventh bullet. Drivers of Climate Change, bullet 7.
10. **More than half of sulfate (SO2) emissions by coal**… This accounting looks at data to 2005. Since 2005, Russia and India have both surpassed the U.S. in SO2 emissions because of greatly increased electrical generation from coal. Smith at al., say half of aerosol sulfate emissions are from coal generation up to 2005.
    Smith et al., Anthropogenic sulfur dioxide emissions 1850 to 2005, atmospheric Chemistry and Physics, 11, 1101-1116, 2011, page 1108, Results and Discussion, paragraph 3.
11. **Abrupt climate change 23 times in the last 100,000 years…** Twenty-three times in the last 100,000 years, as shown in highly robust evidence in Greenland ice cores, our climate has changed 9 to 14 degrees F globally and 18 to 27 degrees F across the Arctic. Sometimes it took millennia, often a century or less and when climate was being pushed the hardest (naturally), in as little as one to three years.
    Alley, Wally Was Right - Predictive ability of the North Atlantic Conveyor Belt Hypothesis for Abrupt Climate Change, Annual Review of Earth and Planetary Science, February 2007, Figure 1 shows the 23 abrupt climate changes.
    Two to three years… As little as one to three years and the methods and techniques to determine: "The high resolution records from the NGRIP ice core reveals that polar atmospheric circulation can shift in 1-3 years resulting in decadal to centennial scale changes from cold stadials to warm interstadials/interglacials associated with astounding Greenland temperature changes of 10K."
    Steffensen et al., High-Resolution Greenland Ice Core Data Show Abrupt Climate Change Happens in Few Years, Science Express, June 12 2008, page three, final paragraph.
12. **Abrupt Change and Icebergs…** from the introductory paragraph of the paper: "The presence of DansgaardOeschger variability in glacial climate archives extending from Greenland ice cores to North Atlantic sediment cores, tropical hydroclimate records and Antarctic ice cores bears witness to a global organizing element of abrupt climate change."
    Gottschalk et al., Abrupt changes in the southern extent of North Atlantic Deep Water during Dansgaard-Oeschger events, Nature Geoscience, October 12, 2015.pdf
13. **Slowed 7 percent per year, 2008 to 2012...** Smeed et al., Observed decline of the Atlantic meridional overturning circulation 2004-2012, Ocean Science, February 6, 2014, abstract.
14. **Deep water corals unique in 1,800 years ...** Sherwood et al., Nutrient regime shift in the western North Atlantic indicated by compound-specific δ15N of deep-sea gorgonian corals, PNAS, January 18, 2011, abstract.
15. **IPCC: Greenland Ice loss increased 532 percent since 2001...** "The rate of ice loss from the Greenland ice sheet has very likely substantially increased from 34 [-6 to 74] gigatons yr-1 over the period 1992 to 2001 to 215 [157 to 274] gigatons yr-1 over the period 2002 to 2011." This is a 10-year average.
    2013 IPCC, Summary for Policy Makers, B3 Cryosphere, Bullet 2, page 9.
16. **Global warming "hole" the key to this new research** ... Rhamstorf et al., Exceptional 20th century slowdown in Atlantic Ocean overturning circulation, Nature Climate Change, March 23, 2015.
17. **Modeling abrupt climate change and the Gulf Stream…** Simulating iceberg armadas in Greenland and the Laurentide Ice Sheet (North American Ice Sheet) 30,000 to 50,000 years ago now produces viable modeling on abrupt climate change.
    Menviel et al., Simulating the Dansgaard-Oeschger Continuum-mechanisms, patterns, timing, Climate of the past, Janyary 14, 2014.

18. **West Antarctic Ice Sheet Collapse has Begun…** We have seen publishing about the West Antarctic ice sheet collapse since 2006.
    Vaughan, West Antarctic Ice Sheet collapse – the fall and rise of a paradigm, Climateic Change, 2006, see the abstract.
19. **West Antarctic Ice Sheer collapse has begun, again…**
    Golledge et al., The multi millennial Antarctic commitment to sea level rise, Nature, October 15, 2015. Link Quote from press release here.
20. **Antarctic ice rafted sediment debris…** Presence of ice rafted debris in Antarctica suggests this ice sheet experiences periods of enhanced iceberg production suggesting dynamical collapse mechanisms at work.
    Weber et al., Millenial scale variability in Antarctic ice sheet discharge during the last deglaciation, Nature, June 5, 2014.
21. **Grounding Line retreat…** From the University of California Jet Propulsion lab and the California Institute of Technology (abstract): "Upstream of the 2011 grounding line positions, we find no major bed obstacle that would prevent the glaciers from further retreat and draw down the entire basin."
    Rignot et al., Widespread, Rapid Grounding Line Retreat of Pine Island, Thwaites, Smith and Kohler Glaciers, West Antarctica From 1992 to 2011, Geophysical Research Letters, May 27, 2014.
22. **100 times more melt below than above…** The study found that the warm waters of the North Atlantic are melting 100 times more ice beneath Greenland's outlet glaciers in their icefjords than melt on the surface. Rignot and his team say "…submarine melting must have a profound influence on grounding-line stability and ice-flow dynamics."
    Rignot, et. al., Rapid submarine melting of the calving faces of West Greenland glaciers, Nature Geoscience, February 2010.
23. **Tearing apart at the seams…** MacGregor et al., Widespread rifting and retreat of ice-shelf margins in the eastern Amundsen sea Embayment between 1972 and 2011, Journal of Glaciology, No. 209, 2012. (Press Release)
24. **Sea level rise of over 10 feet in 100 years…** During the short warm period before our last 100,000 year-long ice age very similar to what we are experiencing today, marine archeologists tell us a reef called Excaret was suddenly drowned. This reef was in a stable area of the Yucatan Peninsula not affected by subsidence or geologic uplift processes. Corals are very picky about the depth of water that they grow in and the Elkhorn coral in particular was devastated by a sea level jump of 12 feet about 121,000 years ago. This time frame matches fairly well with the most recent collapse known of the West Antarctic Ice sheet from research by the British Antarctic Survey in 2010. The jump happened in a time period similar to that of the life of an elkhorn coral, which is 10 to 20 years. First Paragraph, page 884: "During those jumps, direct measurement of rise rates shows that they exceeded 36 mm per year." (1.2 feet per decade)
    Blanchon et al., Rapid sea level rise and reef back stepping at the close of the last interglacial highstand, Nature, April 2009.
25. **Larsen C collapse likely…** Jansen et al., Newly developing rift in Larsen C Ice Shelf presents significant risk to stability, Cryosphere, June 15, 2015, abstract.
    Larsen C collapse imminent… Holland et al., Oceanic and atmospheric forcing of Larsen C ice-shelf thinning, Cryosphere, March 27, 2015, abstract.
26. **Submarine glacial valleys in Greenland…** Morlighem et al., Deeply incised submarine glacial valleys beneath the Greenland Ice Sheet, Nature Geoscience May 18, 2014, second paragraph, page 4.
27. **Warmer than any time in 120,000 years…** Miller et al., Unprecedented recent summer warmth in Arctic Canada, Geophysical Research Letters, October 2013, abstract.
28. **120,000 year quote…** The first paragraph of the American Geophysical Union press release.
    Mosses start growing again… Disappearing Ice Caps – Giff Miller on Baffin Island, You Tube, 2:12