What Can We Do: References

1. https://www.c-span.org/video/?206134-1/oil-price-speculation

2. https://www.npr.org/templates/story/story.php?storyId=91831967

3. https://en.wikipedia.org/wiki/World_oil_market_chronology_from_2003

4. https://en.wikipedia.org/wiki/Bakken_Formation

5. https://www.politico.com/magazine/story/2013/11/congratulations-america-youre-almost-energy-independent-now-what-098985

6. http://www.washingtontimes.com/news/2017/mar/21/us-energy-independence-is-achievable/

7. https://ballotpedia.org/All-of-the-above_energy_policy

8. http://fuelfix.com/blog/2011/12/16/us-shale-gas-to-north-dakota-%E2%80%93-is-it-the-beginning-of-a-new-era-for-us-oil/

9. https://en.wikipedia.org/wiki/Canadian_federal_election,_2015

10. http://www.reuters.com/article/2015/11/05/us-transcanada-keystone-state-idUSKCN0ST2VX20151105

11. https://www.washingtonpost.com/news/wonk/wp/2014/03/20/the-biggest-land-owner-in-canadas-oil-sands-isnt-exxon-mobil-or-conoco-phillips-its-the-koch-brothers/

12. https://www.washingtonpost.com/business/economy/does-koch-industries-hold-most-canadian-oil-sands-leases-its-complicated/2014/04/07/2470e5e4-be70-11e3-b574-f8748871856a_story.html

13. http://strategicstudyindia.blogspot.com/2015/10/its-time-for-united-states-to-start.html

14. http://www.huffingtonpost.com/david-oualaalou/a-possible-coup-in-saudi_b_8325456.html

15. http://www.independent.co.uk/news/world/middle-east/saudi-arabia-power-struggle-between-king-salman-and-mohammed-bin-salman-could-bring-down-the-a6706801.html

16. http://oilprice.com/Energy/Energy-General/Is-Russia-Plotting-To-Bring-Down-OPEC.html

17. http://www.cnbc.com/2015/11/04/crude-futures-edge-up-but-us-inventory-build-drags.html

18. http://benchmarkminerals.com/lithium-ion-batteries-are-now-selling-for-under-140kwh-new-york-hears-on-benchmark-world-tour-2017/

19. https://www.greentechmedia.com/articles/read/were-still-underestimating-cost-improvements-for-batteries

20. https://electrek.co/2017/01/30/electric-vehicle-battery-cost-dropped-80-6-years-227kwh-tesla-

190kwh/

21. https://www.energy-storage.news/news/vizn-claims-to-deliver-energy-storage-for-renewables-at-record-low-price

22. https://www.pv-magazine.com/2017/07/31/study-finds-that-storage-prices-are-falling-faster-than-pv-and-wind-technologies/

23. https://www.pv-magazine.com/2017/06/29/energy-storage-already-cost-competitive-in-commercial-sector-finds-study/

24. https://www.greentechmedia.com/articles/read/the-truth-about-renewables-and-storage-in-lazards-cost-analysis?utm_source=Solar&utm_medium=Newsletter&utm_campaign=GTMSolar

25. http://www.power-eng.com/articles/print/volume-121/issue-3/features/fast-start-combined-cycles-how-fast-is-fast.html

26. https://www.greentechmedia.com/articles/read/aes-betting-on-lithium-ion-batteries-for-long-duration-energy-storage

27. https://www.thesolarfoundation.org/national/

28. http://money.cnn.com/2017/05/24/news/economy/solar-jobs-us-coal/index.html

29. https://www.navigantresearch.com/tag/us-wind-market

30. https://www.norwesthydraulic.com/

31. https://www.janicki.com/about-us/visiting-us/map-directions/

32. https://www.researchgate.net/publication/230720394_Editorial_Trends_in_wind_energy

33. http://www.eesi.org/papers/view/factsheet-offshore-wind-2016

34. https://www.nrel.gov/docs/fy16osti/66599.pdf

35. https://www.nrel.gov/docs/fy11osti/51332.pdf

36. http://www.windpowerengineering.com/business-news-projects/next-generation-4-mw-onshore-turbines-horizon-12-mw-offshore-sight/

37. https://www.cleanenergynews.co.uk/news/solar/offshore-wind-celebrates-astounding-price-reductions-in-3.2gw-cfd-win

38. https://www.linkedin.com/pulse/offshore-wind-how-did-we-get-so-wrong-andrew-mack/?trk=eml-email_feed_ecosystem_digest_01-recommended_articles-13-Unknown&midToken=AQGH1s2HQtX3vw&fromEmail=fromEmail&ut=3xUKLcqUPKXTU1

39. https://www.huffingtonpost.com/steve-kirsch/chu-v-orszag-why-chu-is-r_b_432921.html

40. http://reneweconomy.com.au/nuclear-the-slow-death-of-fast-reactors-21046/

41. https://www.investopedia.com/ask/answers/09/wpps-municipal-bond-default-whoops.asp

42. http://www.historylink.org/File/5482

43. https://en.wikipedia.org/wiki/Vogtle_Electric_Generating_Plant

44. https://en.wikipedia.org/wiki/List_of_cancelled_nuclear_reactors_in_the_United_States

45. https://www.bloomberg.com/news/articles/2017-11-10/

46. https://www.bloomberg.com/news/articles/2017-06-14/half-of-america-s-nuclear-power-plants-seen-as-money-losers

47. https://file.scirp.org/pdf/LCE20110400006_34244752.pdf

48. https://en.wikipedia.org/wiki/Energy_conservation_in_the_United_States

49. http://www.eesi.org/papers/view/the-value-and-impact-of-building-codes

50. https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data

51. https://www.eia.gov/electricity/data/browser/#/topic/0?agg=2,0,1&fuel=vvg&geo=000000000001&sec=8&freq=A&start=2001&end=2016&ctype=linechart&ltype=sourcekey&rtype=s&maptype=0&rse=0&pin=

52. https://www.forbes.com/sites/jamesconca/2014/01/18/wind-energy-of-no-use-in-the-pacific-northwest/#5ecaae62f55d

53. https://www.greentechmedia.com/articles/read/a-tale-of-two-regions

54. http://sdg.iisd.org/news/iea-reports-record-high-investments-in-renewables-amid-global-energy-investment-slump/

55. https://www.greencarreports.com/news/1113115_two-thirds-of-worlds-new-energy-capacity-in-2016-was-renewable-iea

56. http://iopscience.iop.org/article/10.1088/1748-9326/10/3/031001

57. https://en.wikipedia.org/wiki/Tokamak

58. https://en.wikipedia.org/wiki/Inertial_confinement_fusion

59. https://en.wikipedia.org/wiki/Polywell

60. https://en.wikipedia.org/wiki/Molten_salt_reactor

61. https://en.wikipedia.org/wiki/Integral_fast_reactor#Summary

62. https://en.wikipedia.org/wiki/Traveling_wave_reactor

63. https://blogs.scientificamerican.com/guest-blog/its-not-cold-fusion-but-its-something/

64. https://www.carbonbrief.org/in-depth-experts-assess-the-feasibility-of-negative-emissions

65. http://grist.org/science/cutting-carbon-emissions-isnt-enough-we-need-negative-emissions/

66. https://www.vox.com/energy-and-environment/2017/8/18/16166014/negative-emissions

67. https://en.wikipedia.org/wiki/Bio-energy_with_carbon_capture_and_storage#Cost

68. https://en.wikipedia.org/wiki/Stratospheric_aerosol_injection_(climate_engineering)

69. http://science.sciencemag.org/content/315/5812/612

70. https://en.wikipedia.org/wiki/Space_sunshade

71. https://cleantechnica.com/2017/09/06/iea-gets-hilariously-slammed-continuously-pessimistic-renewable-energy-forecasts/

72. https://qz.com/1103874/the-us-government-underestimated-solar-energy-installation-in-the-us-by-4813-along-with-renewable-wind-and-solar-generation/

73. https://www.carbonbrief.org/analysis-global-co2-emissions-set-to-rise-2-percent-in-2017-following-three-year-plateau

74. Ray Kamada's estimates for "how much time do we have left" performed via two different methods. The simpler one is as follows:

METHOD 1:

Inverting the rough climate sensitivity equation yields an estimate of years remaining to exceed an equilibrium surface temperature rise of 2 degs. C.

The simple climate sensitivity equation reads essentially that

delta T (temperature change) = 0.81 degs. C/(W/m^2) x 5.35 W/m^2 x ln (CO_2/CO_2 orig.) (Gavin Schmidt at realclimate.org has used 0.75 rather than 0.81, which isn't quite consistent with the standard assumption of 3 degs. C temperature rise per CO_2 doubling)

Anyway, for doubled CO_2, we get

3.0 degs. C = 0.81 x 5.35 x ln (2) or 4.334 x ln 2

But if we know the original CO_2 level is 280 ppmv and the delta T we want is 2.0 degs. C, then inverting the sensitivity equation to get CO_2 level yields:

CO_2 = 280 ppmv x EXP(2.0/4.334) = 444 ppmv

So, given we're now at ~405 ppmv and adding to it at ~2.3 ppmv per year.

http://co2now.org/Current-CO2/CO2-Trend/acceleration-of-atmospheric-co2.html

That means we have: (444 - 405)/2.3 = ~17 years left to bend the CO_2 emissions curve DOWN A LOT.

That's better than the 14 years indicated by the second, more detailed method. Underscoring this, note that we've already had 0.9 degs. C of warming with 0.6 degs C still in the pipeline.

BTW, I keep reading that we can only burn 20 to 40% of our remaining 1,650 gigatons of global oil reserves, which at 15.5 gigatons per year yields 17 to 38 years remaining. But I haven't sourced that estimate precisely.

Also, BTW, Shell Oil figures +4.6 degs C warming by ~2100 AD.

METHOD 2:

We know that total released atmospheric carbon in the form of CO_2 is the major figure of merit, not just from fossil oil, but from all sources: gas, coal, etc. That is,

a) the signficance of the TOTAL tonnage of fossil carbon (via oil, gas, coal COMBINED) released to the atmosphere, is based on two, initial 2009 papers from the journal, Nature.

Paper 1 says that adding more than 1 trillion tons of carbon (half of which has already been released) to our atmosphere will exceed the +2 degs. C warming level (beyond the pre-industrial era), albeit with rather large 95% confidence limits (+/- 1.3 to 3.9 degs. C).

Paper 2 agrees, but with the added nuance of factoring in other contributing greenhouse gases: methane, nitrous oxide, ozone, HFCs, etc., which drops the solely carbon limit down to about 750B (billion) tons.

Embedded in this issue are several items and caveats to note:

a) We've already warmed ~0.9 degs. C since pre-industrial times.

b) Since 2009, within the rather broad confidence limits, no real holes have been found in the above work. E.g., results from the IPCC modeling suite seem to confirm the basic findings, as have other climate models and many observational data reviews. The first paper is based on ensemble simulations from climate models, while the second is based on extrapolated/interpolated observed data.

c) As yet, the above sizeable confidence limits haven't been narrowed much because Earth's climate is exceedingly complex. Yet, a quick and simple result also comes from the "climate sensitivity" equation, which folds all the above complexities into an estimate of ~3 degs. C (+/- ~1.5 degs. C) per CO_2 doubling from the 280 ppmv (parts per million by volume) pre-industrial value to an anticipated

560ppmv.

http://en.wikipedia.org/wiki/Climate_sensitivity

Meanwhile, given that we're now at ~405 ppmv of CO_2, while adding about 2.3 ppmv per year to the atmosphere, this implies, at our present combustion rate, that we'd reach +3 degs. C (from pre-industrial) in about 65 years (+15 years for equilibrium lag time, so say ~2100AD).

The true current emissions rate is really ~4.5 ppmv per year. So, Earth's oceans and biosphere have been absorbing about half of that (actually ~45%). But whether this airborne fraction will remain roughly constant is debatable.

Now, for the more interesting part:

As of 2015, it seems that oil accounts for ~43% of global fossil fuel emissions, based on the following graph, which accounts for % global energy per fuel source (given natural gas releases ~1/2 the CO_2 of oil per energy equivalent).

https://www.iea.org/newsroomandevents/graphics/share-of-world-primary-energy-supply-by-fuel.html

And from
http://www.epa.gov/cleanenergy/energy-resources/refs.html

we get 0.43 metric tons of CO_2 per barrel of oil.

So, at our present burn rate of 90M barrels/day (from the following
British Petroleum graphic):

https://www.google.com/search?
q=global+oil+consumption&client=gmail&rls=aso&tbm=isch&imgil=SLnYNve7HJJ6pM%253A
%253BMdzGIqvLW_MGxM%253Bhttp%25253A%25252F%25252Fwww.resilience.org
%25252Fstories%25252F2012-07-17%25252Fworld-energy-consumption-facts-figures-and-
shockers&source=iu&pf=m&fir=SLnYNve7HJJ6pM%253A%252CMdzGIqvLW_MGxM
%252C_&usg=__PSv2IUsUWflvgPKeb6pWGvu26Rk
%3D&biw=1334&bih=912&dpr=1.13&ved=0CDUQyjc&ei=A6NwVZipH8HusQWpzIKYAQ#imgrc
=PrDmH0Tl-OFlqM%253A%3BhwLh6Oo-ye1EOM%3Bhttp%253A%252F%252Fkr.nlh1.com
%252Fimages%252Fbpswre3.png%3Bhttp%253A%252F%252Fwww.investingdaily.com
%252F17657%252Fthe-gospel-according-to-bp%3B1409%3B958

x (365 days/year) x (0.43 metric tons/barrel) x (1.1 tons/metric ton) x 90M barrels/day =

we get 15.5B tons of global atmospheric CO_2 per year coming from fossil oil combustion.

Plus, we also have that 15.5B/0.43 = 36B tons from all fossil sources,

So, this agrees totally with detailed carbon inventories and my previous napkin calculations (see below). So, thus far, we pass a basic sanity check.

If so, this would mean from Paper #2 that the atmosphere can only withstand another 250B tons (=

750B tons (according to paper #2) minus the 500B tons we've already emitted) of CO_2 before we hit the +2 degs. C warming limit.

Yet, given that about half of the emitted CO_2 stays airborne (~18B tons per year), that would mean, under the "business as usual" assumption, that we only have ~250/18 =

~14 years of "safe" releases left for regular oil/petrol consumption,

And it also means, unless natural gas peters out quickly, along with coal use, that we can also burn only 15.5B tons x 14 years = another ~217B tons of oil, which is

only 13.2% of the 1,650B tons of proven petroleum reserves.

Which also says, under our business as usual assumptions, that

"the world's existing proven oil reserves are really almost worthless". (No wonder the Shell consortium has begun pleading for a carbon tax.)

Nonetheless, this all seems quite consistent with what some climate scientists have been muttering.

If so, one would hope for:

a) No more "business as usual".

b) that the true climate sensitivity is at the low end of estimates, which might mean we have at most ~25 years to bend the present curve substantially downwards.

c) that those cumulative CO_2 tonnage limits are in reality too low, which is essentially the same as hoping for b),

d) that we have some devastating (stratosphere breaching) volcanic eruptions pretty soon, AND

e) that the airborne fraction (nature's ability to keep absorbing half of the release CO_2) holds up, because there's some evidence that it's in reality slipping already. Witness that for 2016 we added 3.1 ppmv to global CO_2 levels, which is well above the previous average of 2.3 ppmv. This doesn't bode well.

Meanwhile:

Paper 1:
http://www.nature.com/nature/journal/v458/n7242/full/nature08019.html

Abstract: Global efforts to mitigate climate change are guided by projections of future temperatures[1]. But the eventual equilibrium global mean temperature associated with a given stabilization level of atmospheric greenhouse gas concentrations remains uncertain[1, 2, 3], complicating the setting of stabilization targets to avoid potentially dangerous levels of global warming[4, 5, 6, 7, 8]. Similar problems apply to the carbon cycle: observations currently provide only a weak constraint on the response to future emissions[9, 10, 11]. Here we use ensemble simulations of simple climate-carbon-cycle models

constrained by observations and projections from more comprehensive models to simulate the temperature response to a broad range of carbon dioxide emission pathways. We find that the peak warming caused by a given cumulative carbon dioxide emission is better constrained than the warming response to a stabilization scenario. Furthermore, the relationship between cumulative emissions and peak warming is remarkably insensitive to the emission pathway (timing of emissions or peak emission rate). Hence policy targets based on limiting cumulative emissions of carbon dioxide are likely to be more robust to scientific uncertainty than emission-rate or concentration targets. Total anthropogenic emissions of one trillion tonnes of carbon (3.67 trillion tonnes of CO_2), about half of which has already been emitted since industrialization began, results in a most likely peak carbon-dioxide-induced warming of 2 °C above pre-industrial temperatures, with a 5–95% confidence interval of 1.3–3.9 °C.

Paper 2: http://www.nature.com/nature/journal/v458/n7242/full/nature08017.html

Abstract:
More than 100 countries have adopted a global warming limit of 2 °C or below (relative to pre-industrial levels) as a guiding principle for mitigation efforts to reduce climate change risks, impacts and damages[1, 2]. However, the greenhouse gas (GHG) emissions corresponding to a specified maximum warming are poorly known owing to uncertainties in the carbon cycle and the climate response. Here we provide a comprehensive probabilistic analysis aimed at quantifying GHG emission budgets for the 2000–50 period that would limit warming throughout the twenty-first century to below 2 °C, based on a combination of published distributions of climate system properties and observational constraints. We show that, for the chosen class of emission scenarios, both cumulative emissions up to 2050 and emission levels in 2050 are robust indicators of the probability that twenty-first century warming will not exceed 2 °C relative to pre-industrial temperatures. Limiting cumulative CO_2 emissions over 2000–50 to 1,000 Gt CO_2 yields a 25% probability of warming exceeding 2 °C—and a limit of 1,440 Gt CO_2 yields a 50% probability—given a representative estimate of the distribution of climate system properties. As known 2000–06 CO_2 emissions[3] were ~234 Gt CO_2, less than half the proven economically recoverable oil, gas and coal reserves[4, 5, 6] can still be emitted up to 2050 to achieve such a goal. Recent G8 Communiqués[7] envisage halved global GHG emissions by 2050, for which we estimate a 12–45% probability of exceeding 2 °C—assuming 1990 as emission base year and a range of published climate sensitivity distributions. Emissions levels in 2020 are a less robust indicator, but for the scenarios considered, the probability of exceeding 2 °C rises to 53–87% if global GHG emissions are still more than 25% above 2000 levels in 2020.

Also, my own napkin calculations and detailed carbon inventories show that we release ~36 billion tons of man-made, excess CO2 into the atmosphere. This translates to an annual 4.5 ppmv in emissions, about double the annual CO2 rise rate of 2.3 ppmv. I show the translation method as follows:

Earth's radius = ~6,370 kms.

Scale Height of the atmosphere (height if it were all at sea level pressure) ~8 km.

Sea Level Air Density: ~1.29 kg per cubic meter

Mass of the atmosphere is: ~4pi x 6,370,000m2 x 8,000m x 1.29 kg/m3 = ~5.26 quadrillion metric tons.

How much of that is CO_2?

At a current 405 ppmv, it's (405/1,000,000) x 5.26 quadrillion tons = ~2.13 trillion tons.

So, 1 ppm of CO_2 is 2.13T/505 = 5.26 billion tons. But by volume 1 ppmv of CO_2 is 44/29 (relative molecular weights CO_2 vs. air) x 5.26 = 8 billion tons.

Thus, humans are adding 36/8 = ~4.5ppmv of CO_2 annually. That is, human activity adds almost twice as CO_2 as its annual increase. Meanwhile, natural processes, such as: photosynthesis, plankton/shell fish uptake/coral formation and deep sea burial, geological weathering and land burial/sedimentation removes about 55% of the man-made CO_2, leaving a remaining 45% airborne. This certainly suggests that the resulting global warming is entirely man-made.

http://en.wikipedia.org/wiki/Airborne_fraction

Ergo, CO_2 has increased 44%, from ~280 to 405 ppmv in ~170 years.