Summary of Global Warming Slides

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2019

Based on the Book:
"Fundamentals of Global Warming"

Presentation Slides about Global Warming

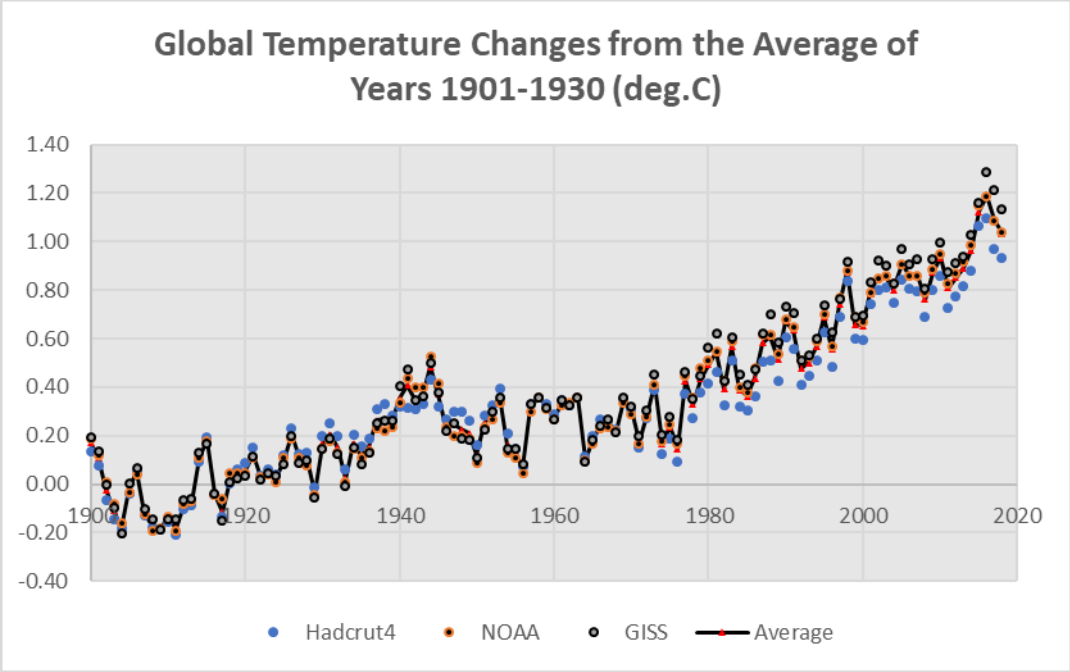
0. Summary
1. Global Warming 1901-2018
2. Influence of the Sun
3. CO2 Emissions and Concentration
4. Forecasting Global Warming
5. Seawater and Ice Conditions
6. Milankovich Cycles
7. Action Plans
8. Target Scenario 2050

Contents

1. Global warming
2. Influence of the sun
3. CO2 emissions and concentration
4. Forecasting of global warming
5. Action Plans

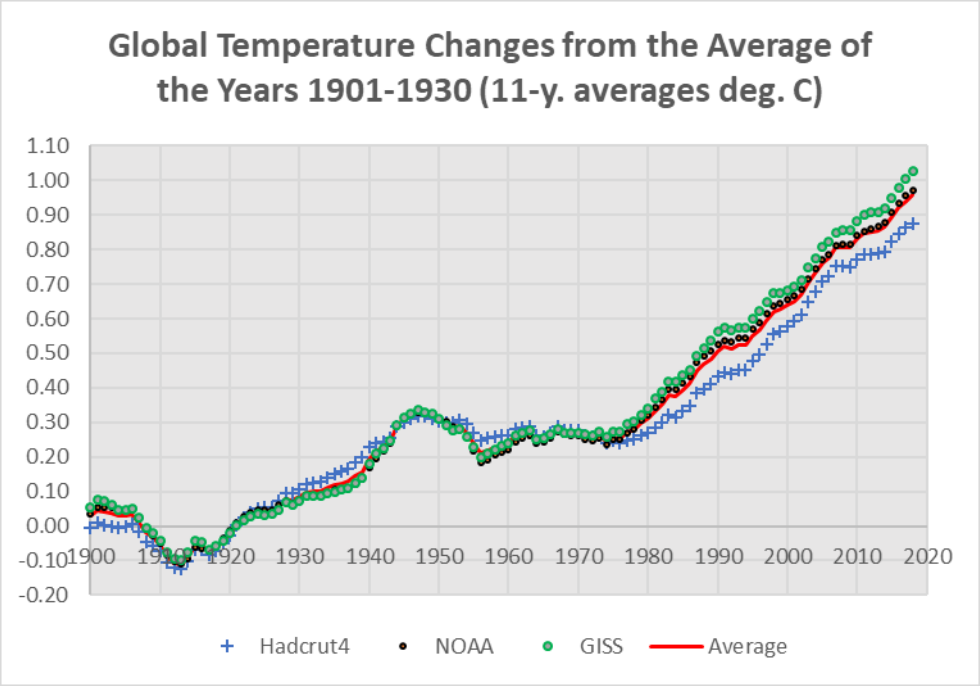
1. GLOBAL WARMING REAL FACTS

Temperature rise from average of years 1901-1930



Annual global temperature was 1.04 deg. C higher in the year 2018 than average tempereture during 1901 - 1930

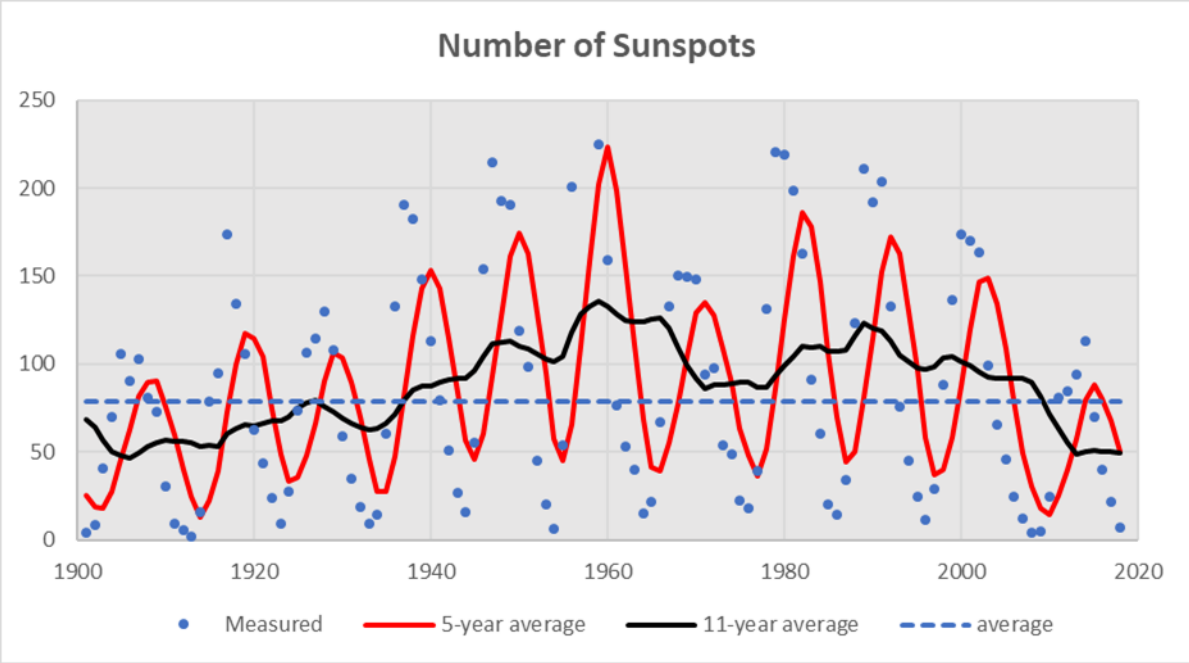
Temperature rise from average of years 1901-1930 (11-y. averages)



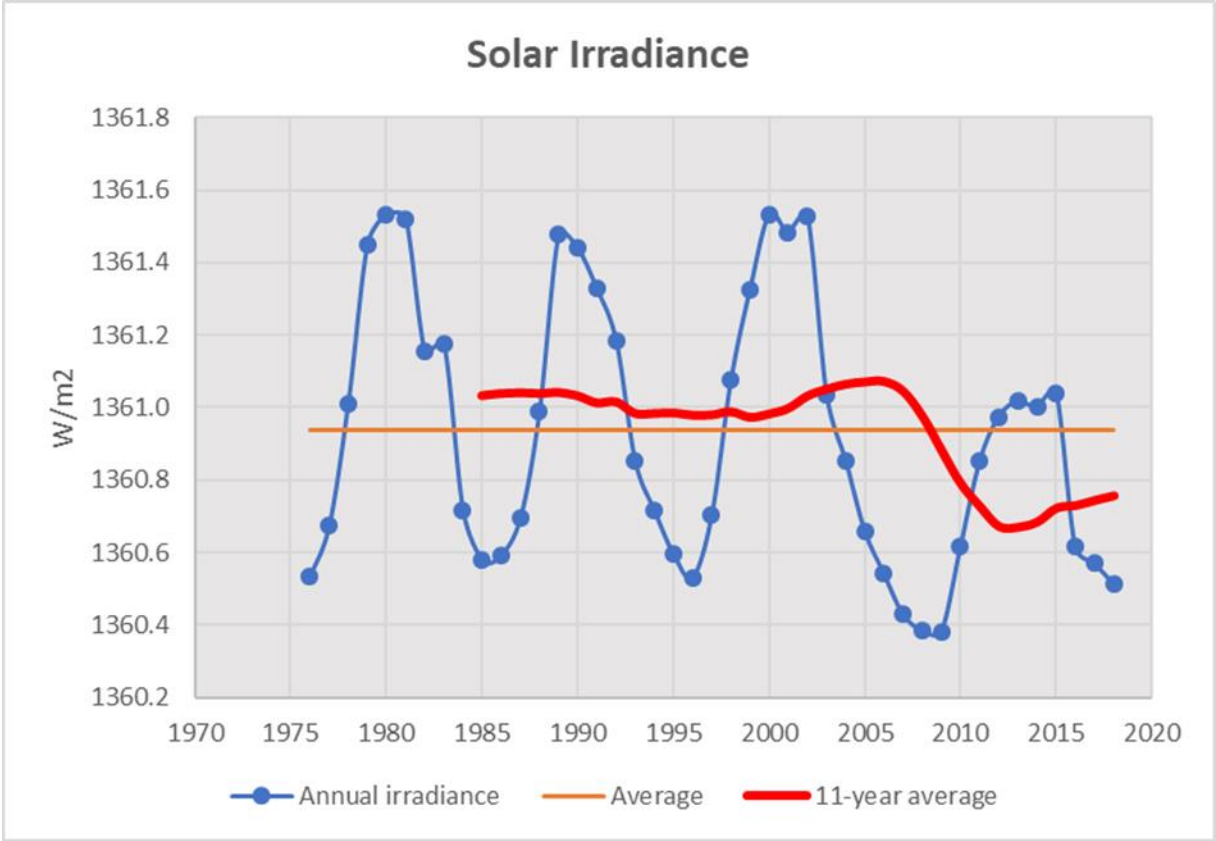
11-year average temperatures have risen 0.96 deg. C, The 11-year average temperature will eliminate 11-year cycle of solar spots

2. INFLUENCE OF THE SUN

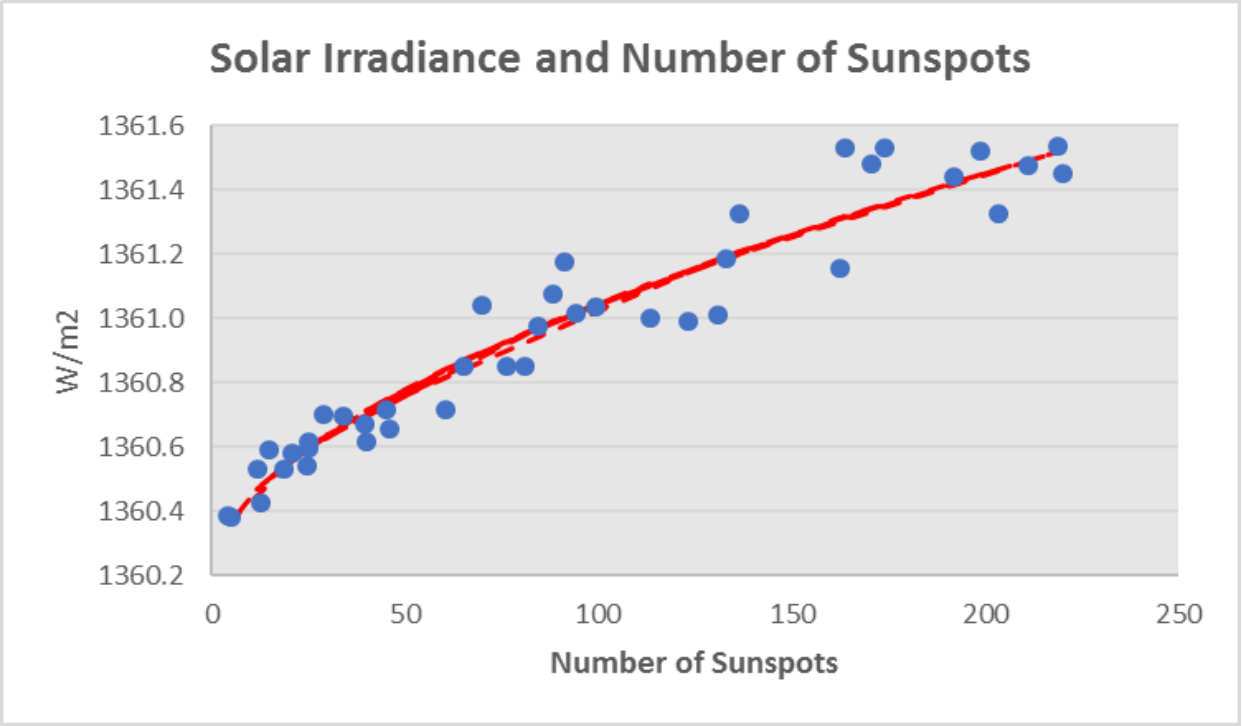
Number of sunspots



Solar Irradiance has bee measured since 1976

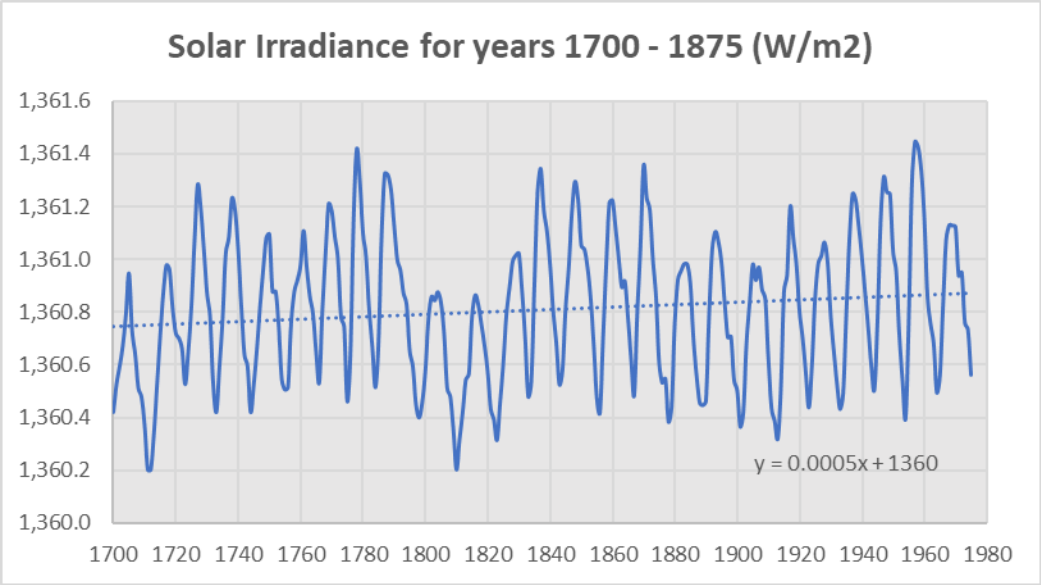


Total Solar Irradiance (TSI) can be calculated from the number of sunspots



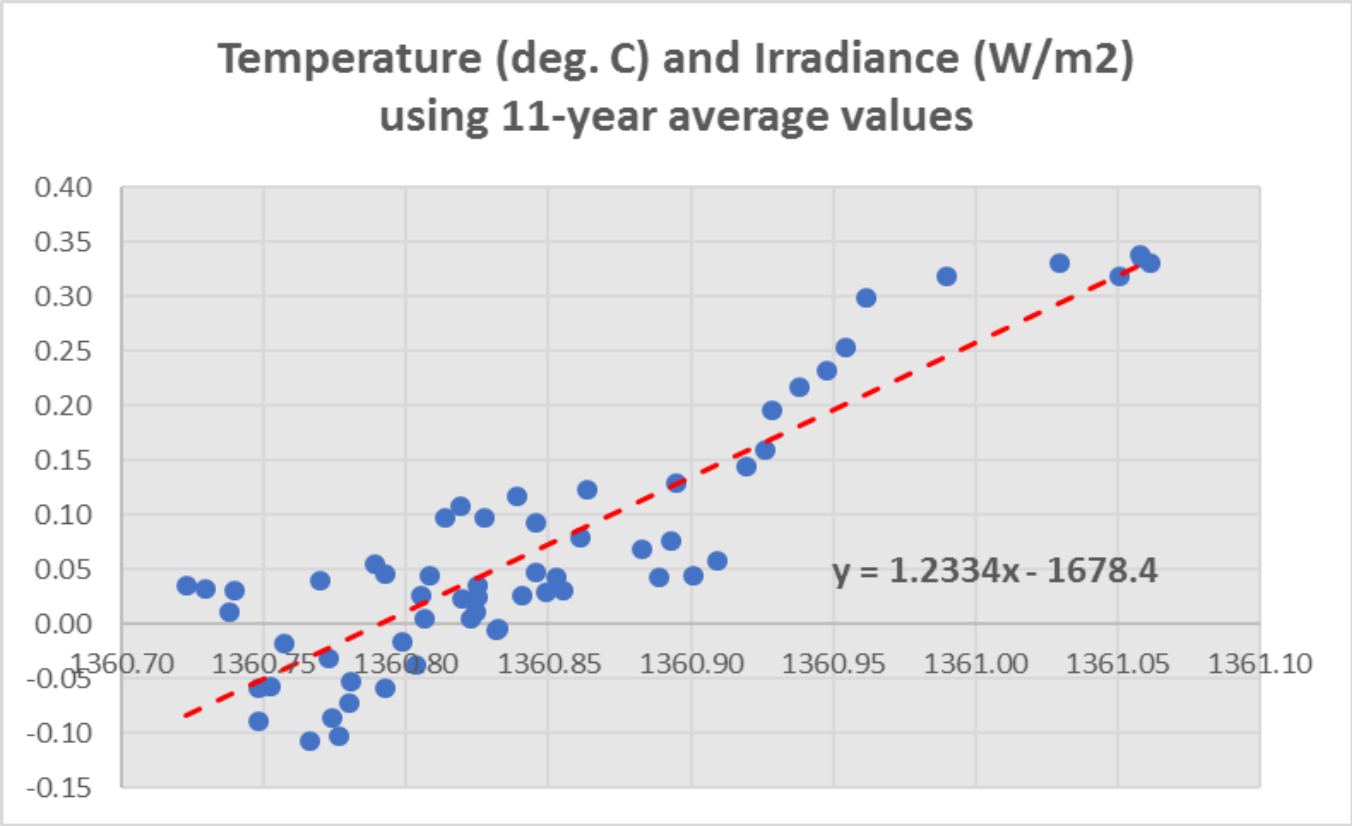
TSI = 1360.202+SQRT(SPOTS/175)+0.0009*SPOTS

TSI can be extrapolated to the years 1700 – 1975 by using sunspot numbers



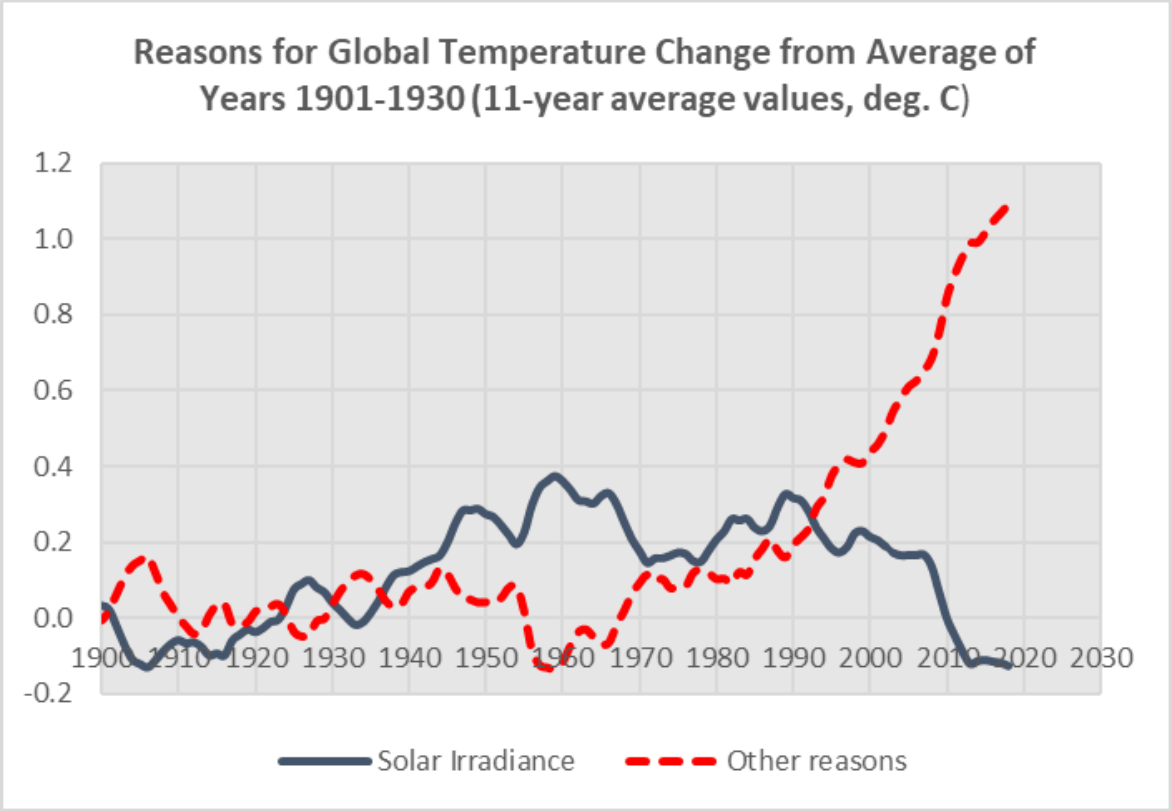
TSI = 1360.202+SQRT(SPOTS/175)+0.0009*SPOTS

Global warming is following total solar (TSI) irradiance with a linear relation



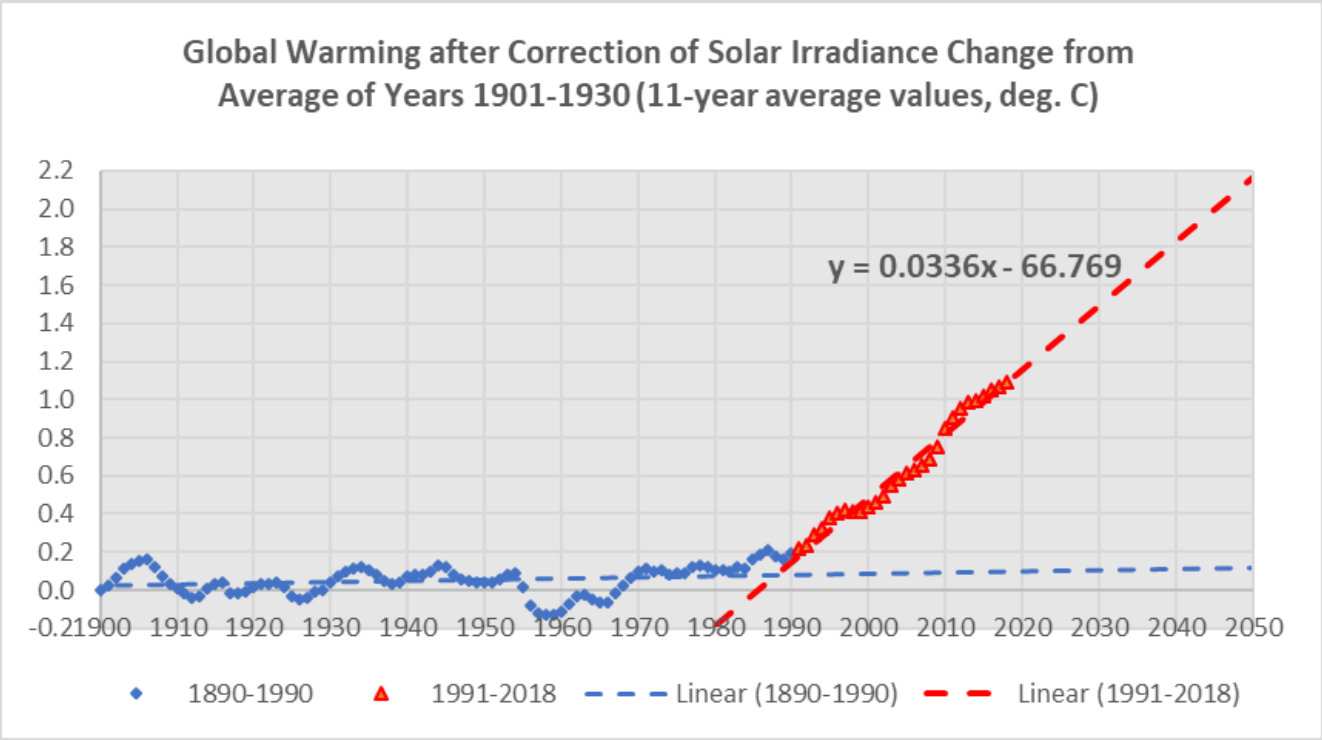
dT = 1.2334 x (TSI – 1360.79)

Reasons for Global Warming



Solar irradiance has been the main reason for warming until 1990

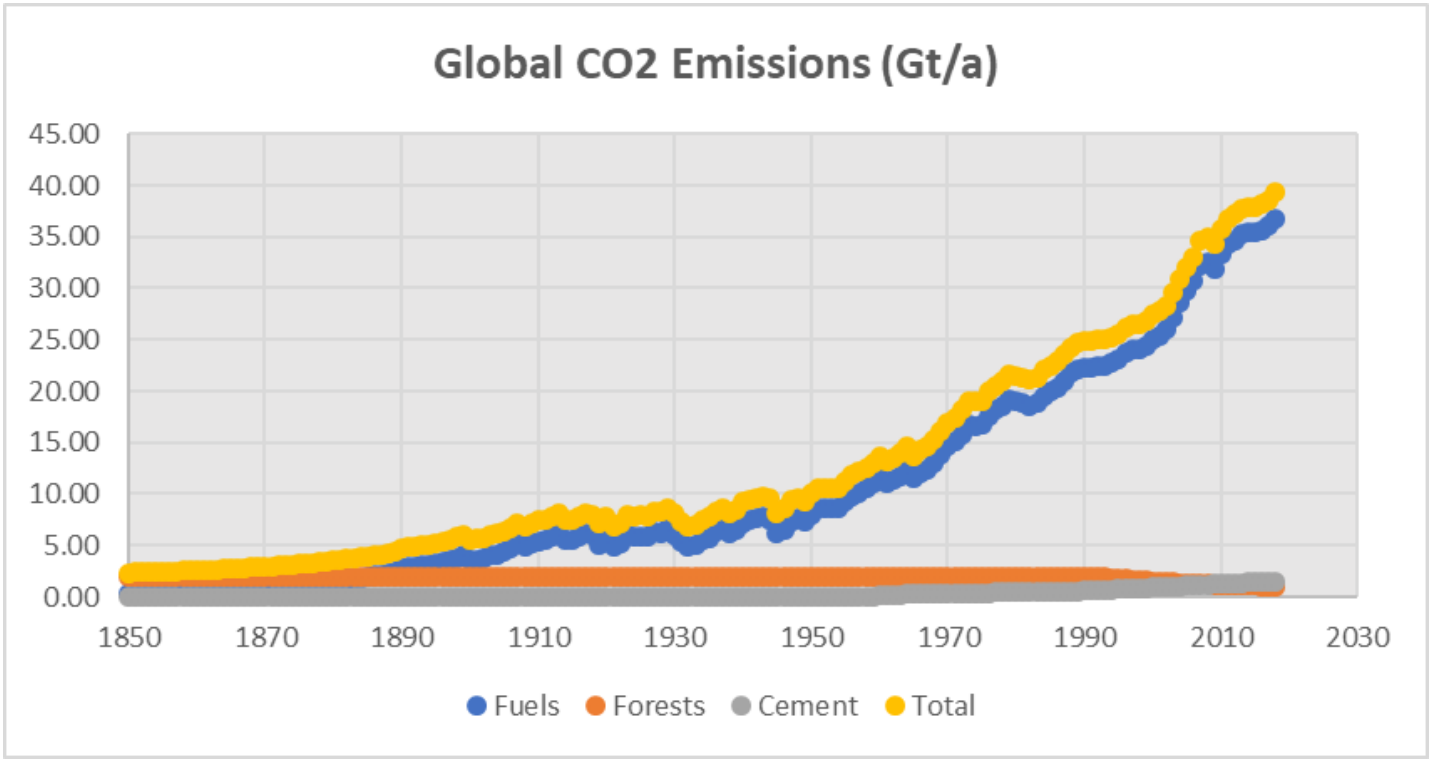
GW Trends after Solar Irradiance



With this trend the1.5 deg. C limit will be exceeded by 2030 and the 2.0 deg. C limit by 2045

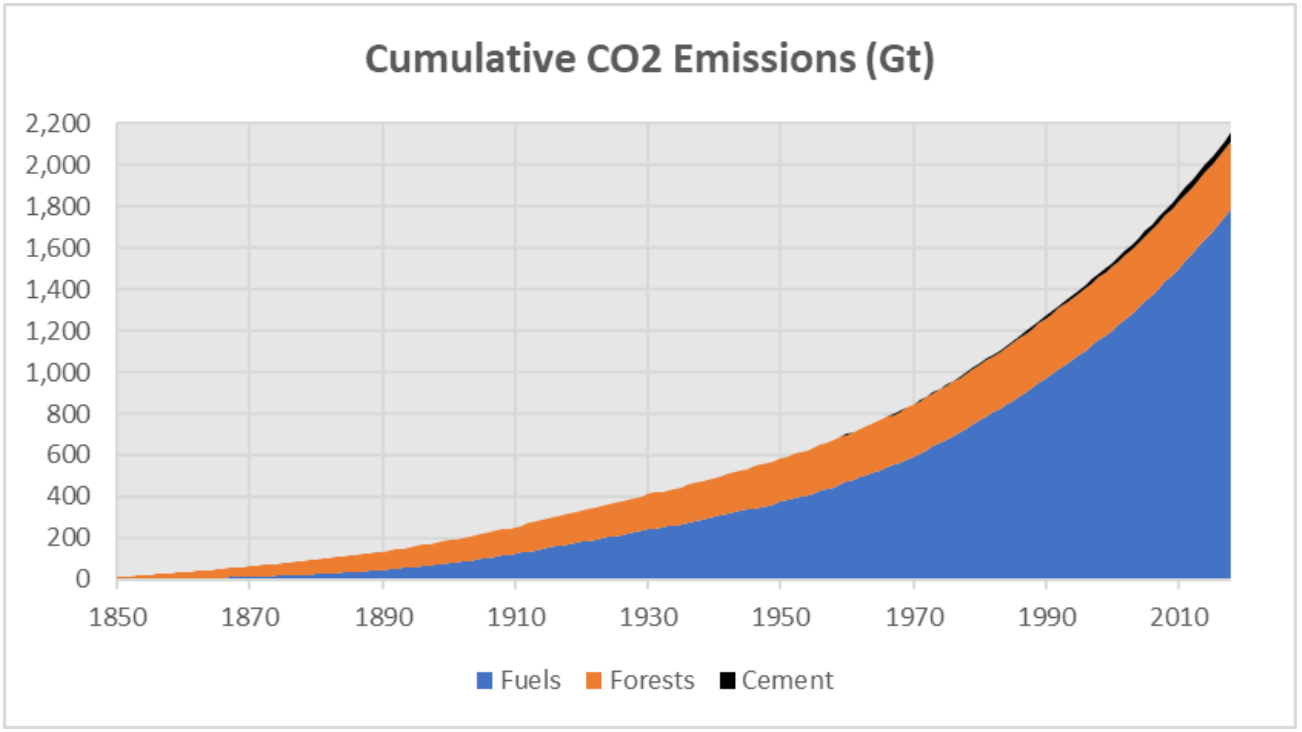
3. CO2 EMISSIONS AND CONCENTRATION

Emissions from Fuels, Forests and Cement Industry (GtCO2/a)

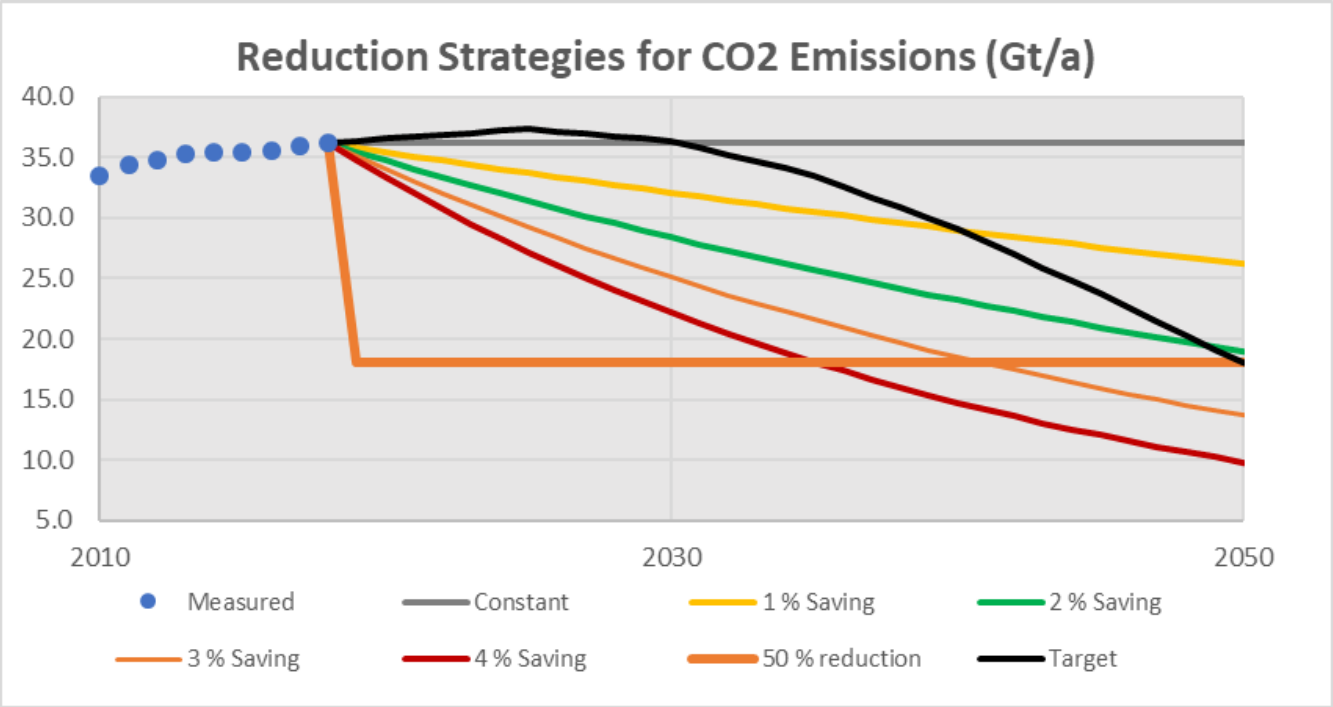


Forest emissions were larger than fuel emissions before 1880

Cumulative Emissions from Fuels, Forests and Cement Industry (GtCO2/a)

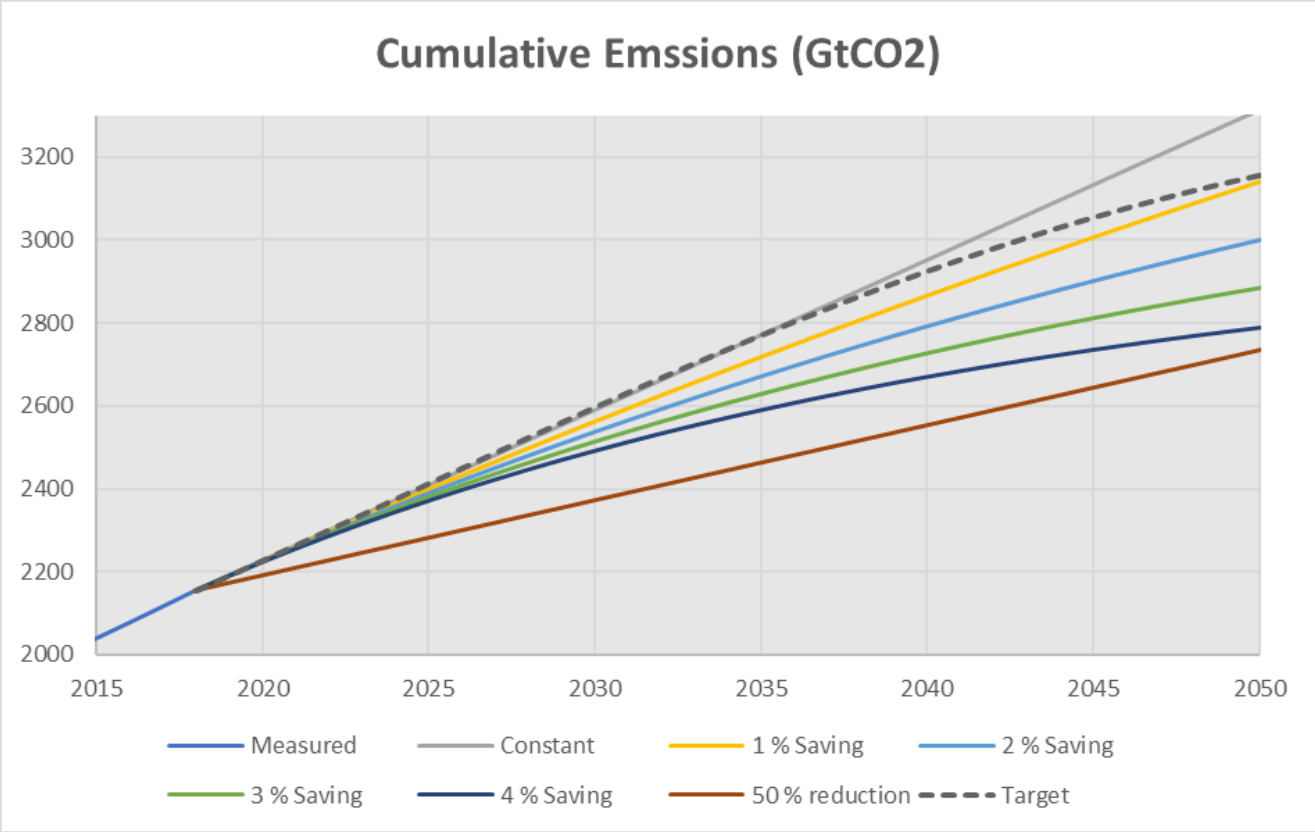


Emission Reduction Scenarios

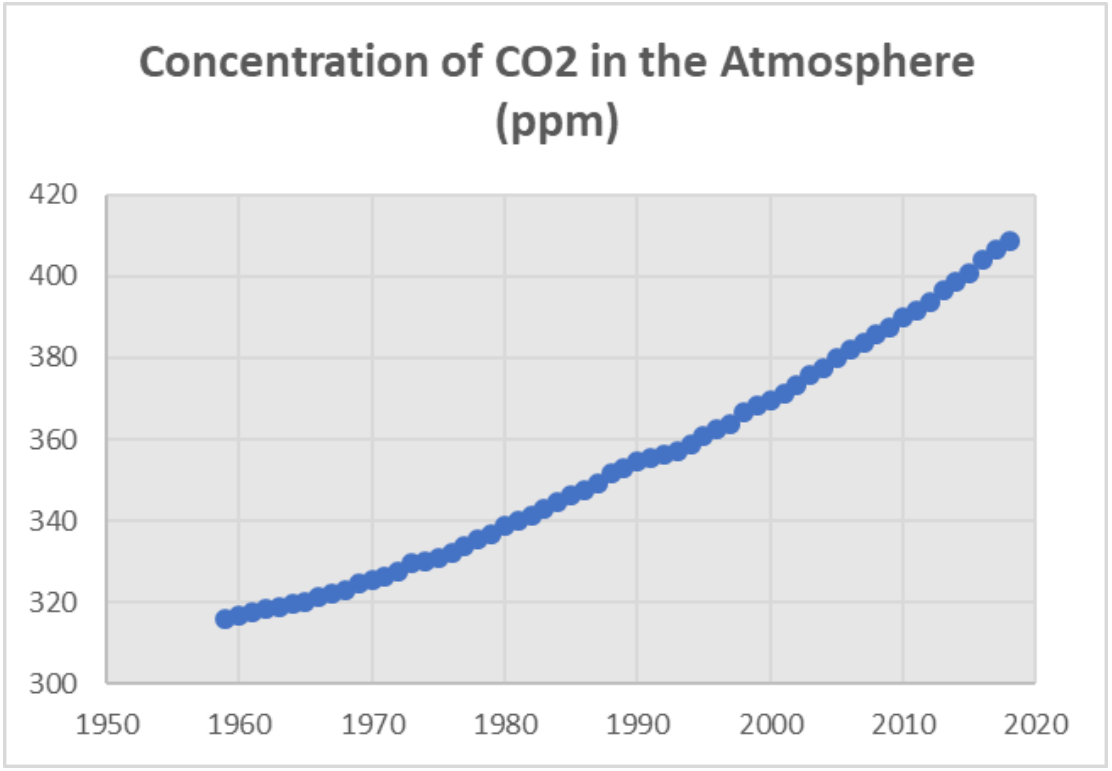


18 Gt emissions by 2050 can be achieved by 2 % saving annually, 50 % saving 2019 or with the target plan (black curve).

Cumulative emissions by 2050

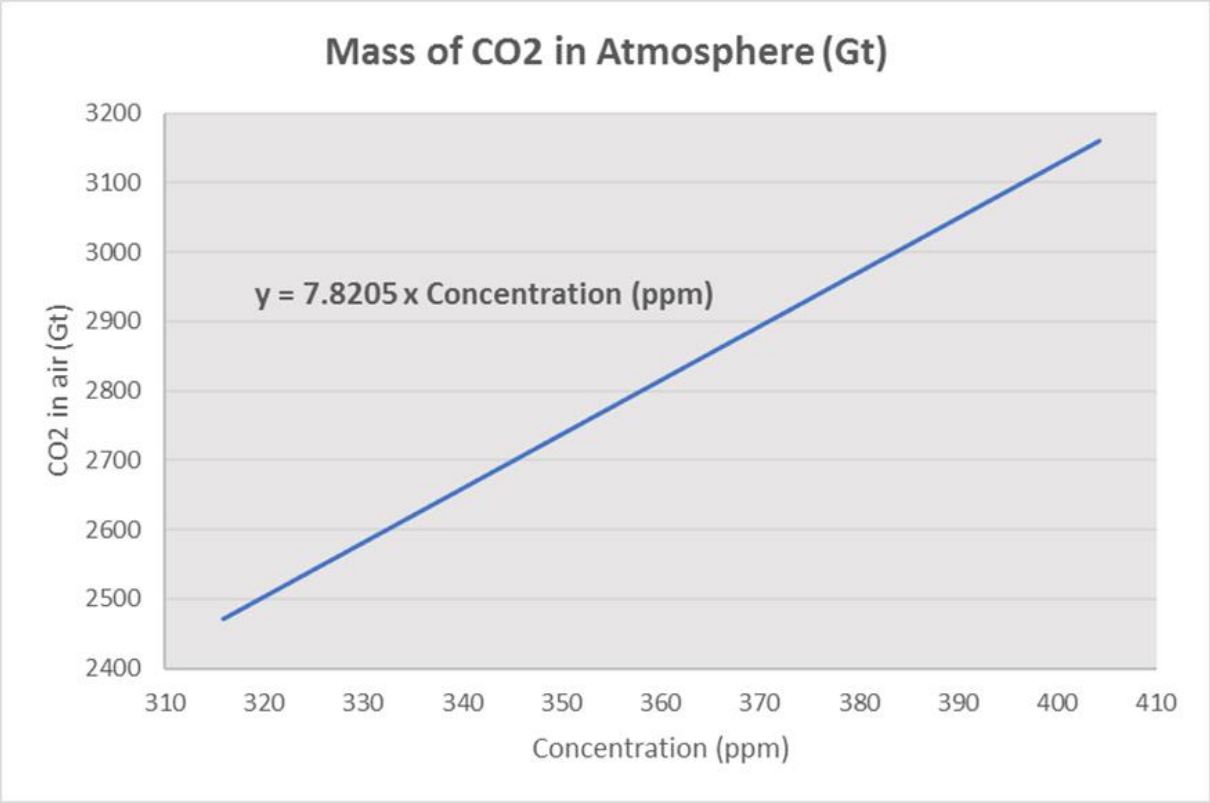


Annual CO2 Concentration



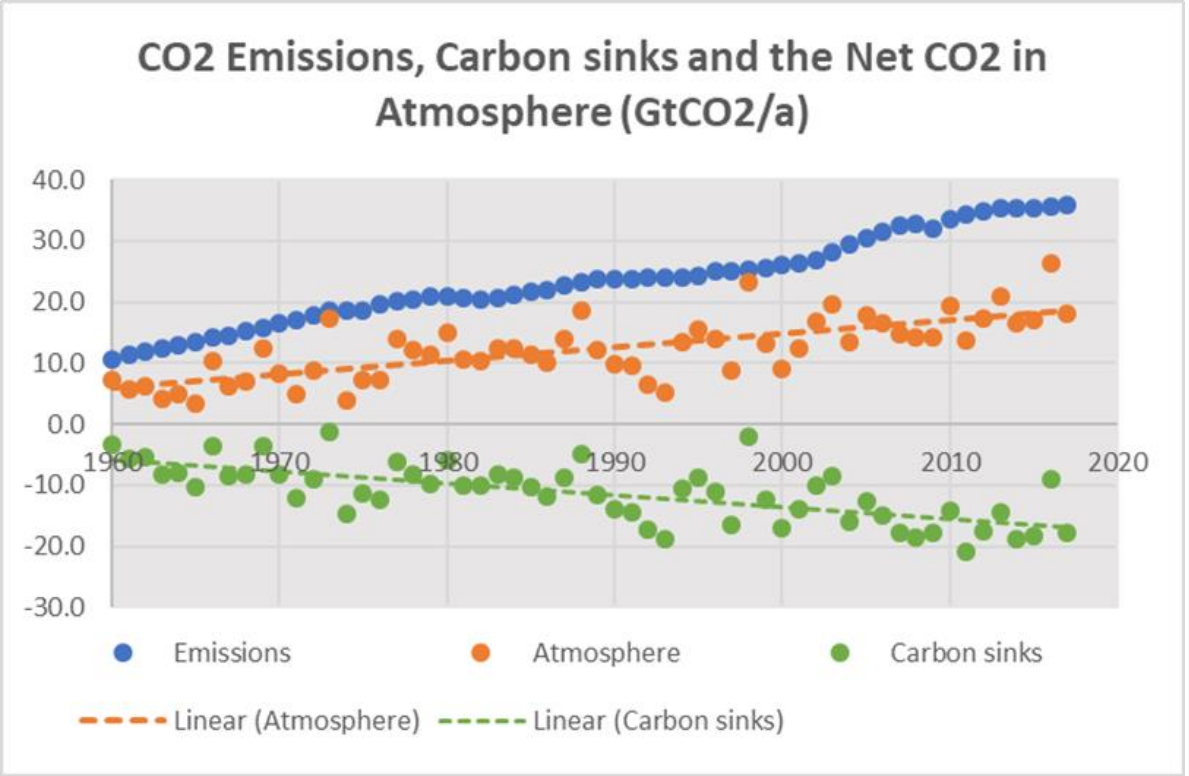
Charles David Keeling started measurements in 1958 in Hawaii. His first measurement result was 314 ppm. The first full year was 1959, when average concentration was 316.0 ppm, but in 2018 it was 408.5 ppm.

Mass of CO2 in Atmosphere can be calculated from CO2 concentration



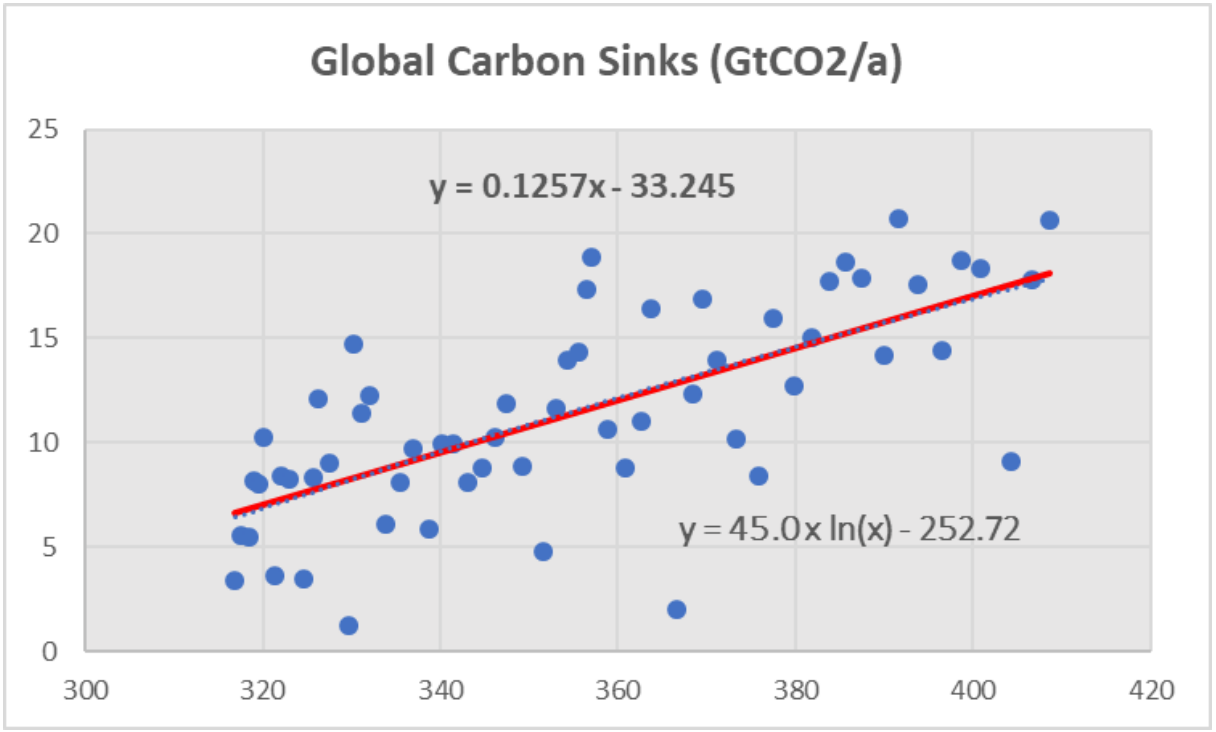
Formula: Ma = 7.8205 x concentration (ppm)

Carbon sinks are about 50 % of emissions



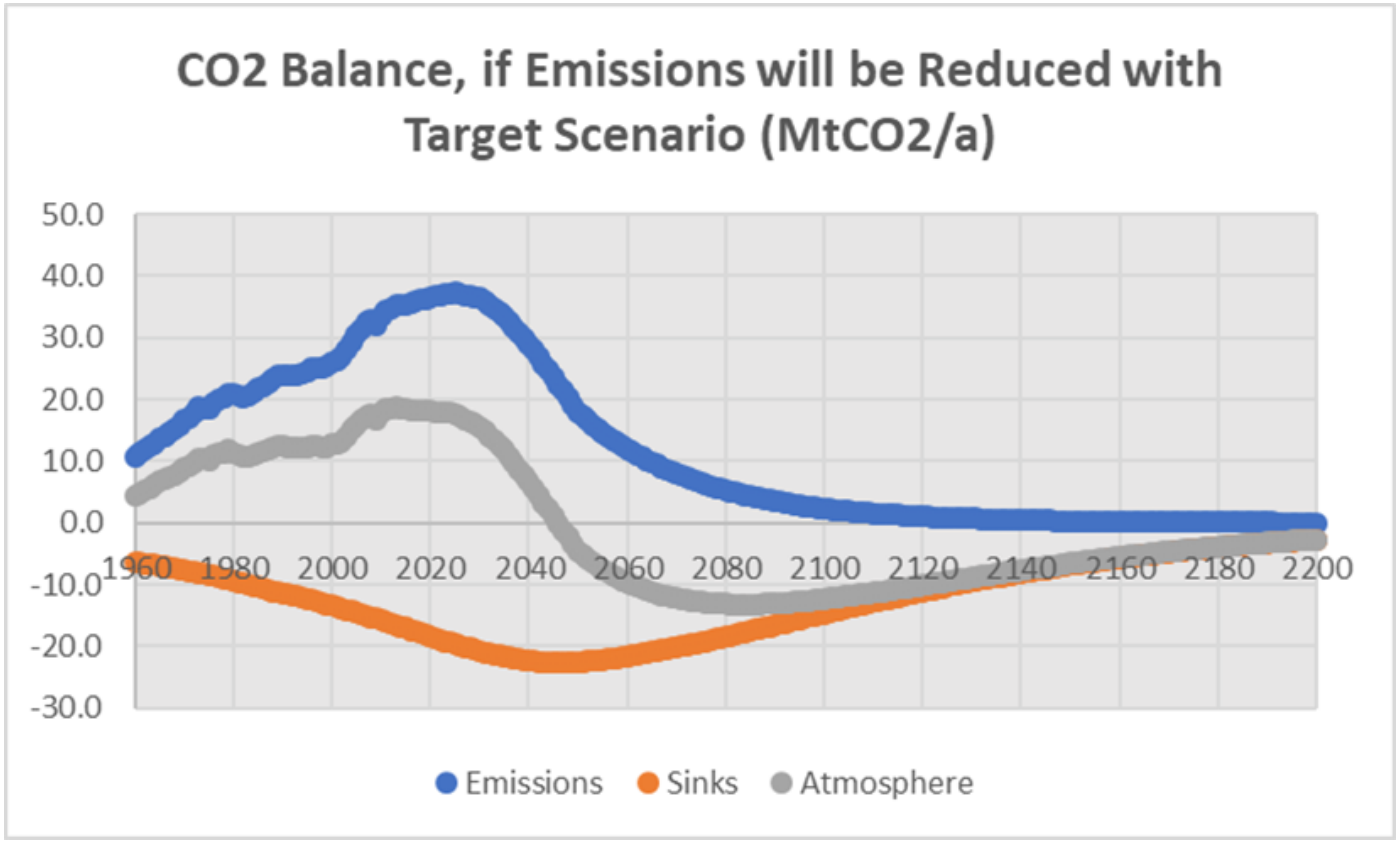
Increase of mass in air dMa = dMe (emissions) – dMs (sinks)

Carbon Sinks Depend on the CO2 Concentration in the Air

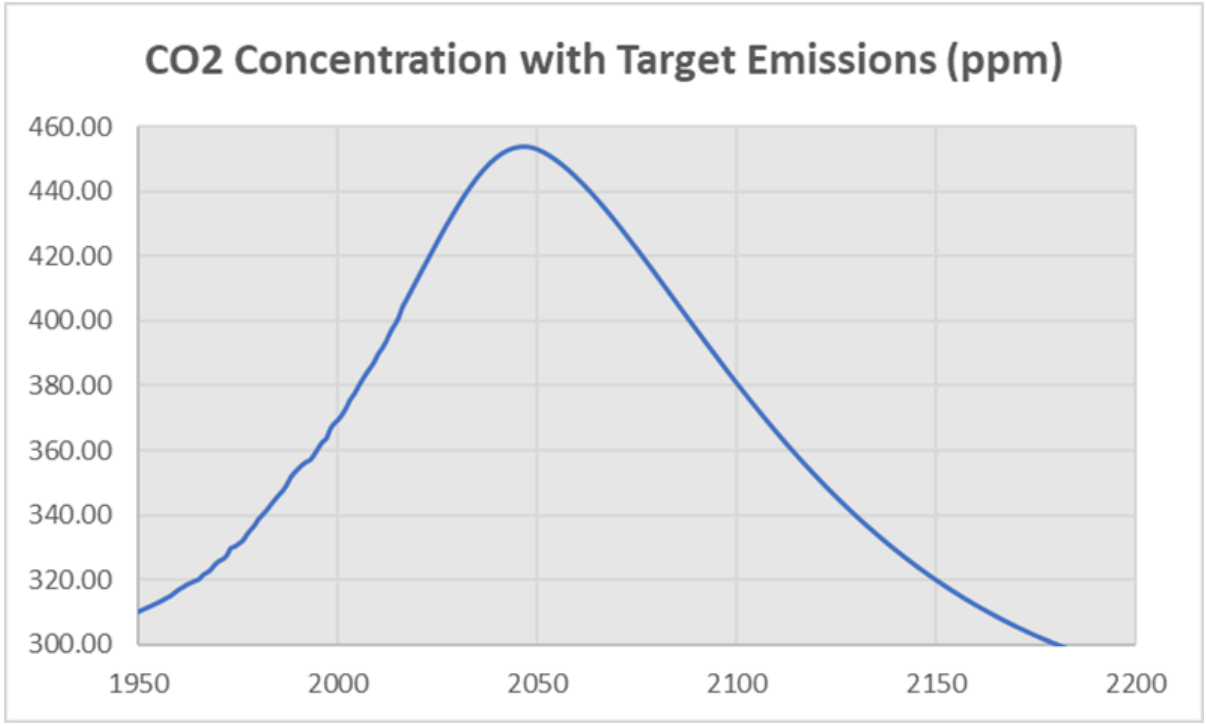


Logarithmic model: dMs = 46.0 x ln (Concentration) – 252.7

With Target Emission Plan, the Sinks will be Larger than Emissions by the year 2045

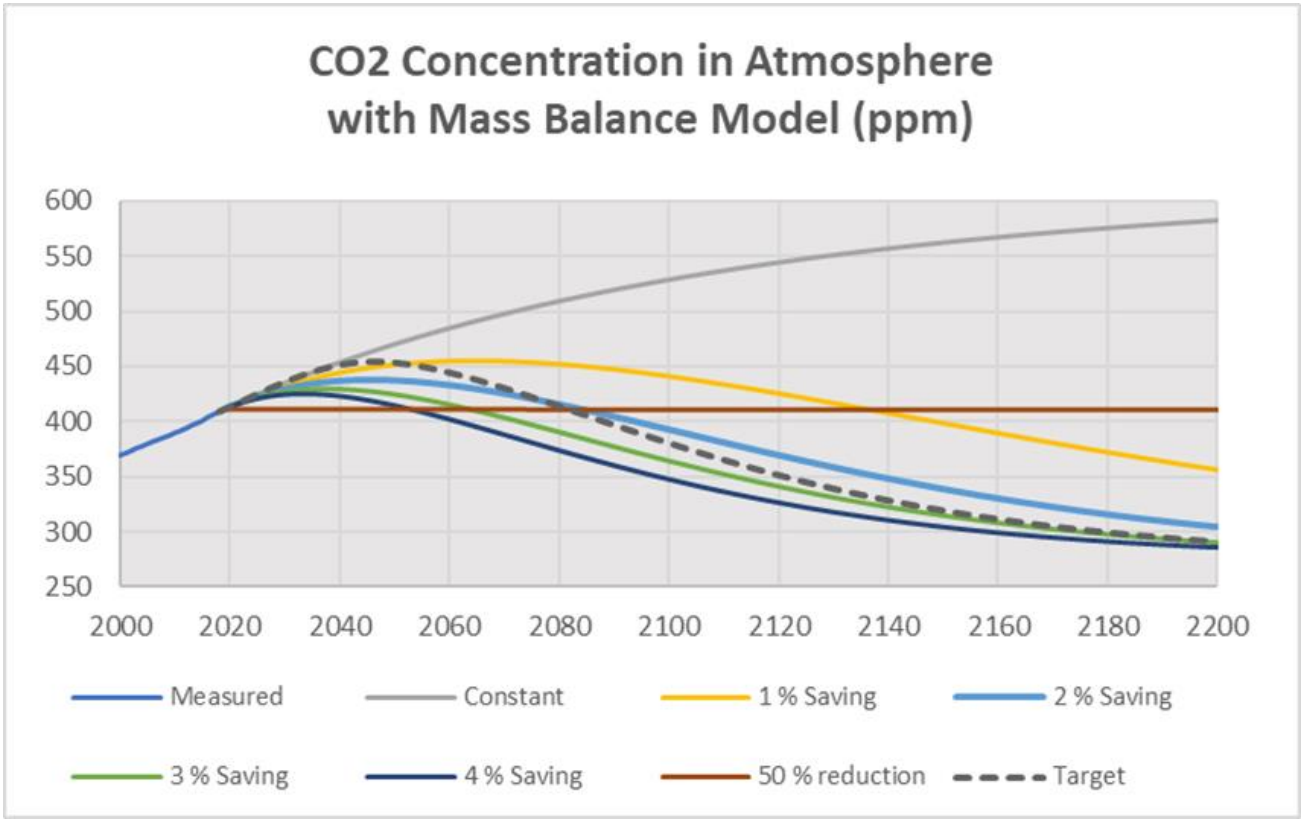


Concentration of CO2 in Atmosphere with Reduction with the Target Plan (ppm)



Concentration will stay below 450 ppm, if the emissions will be reduced with the target plan

Concentration of CO2 in Atmosphere with the Mass Balance Model (ppm)



Concentration will stay below 450 ppm, if the emissions will be reduced at least 2 %/a or with the target emissions

4. FORECASTING GLOBAL WARMING

Global Warming Model using TSI, CO2 and SO2 as variables

$$dT = 1.23 \times dTSI + 4.61 \times \ln(C/292) + 0.30 \times \ln(E/22.57)$$

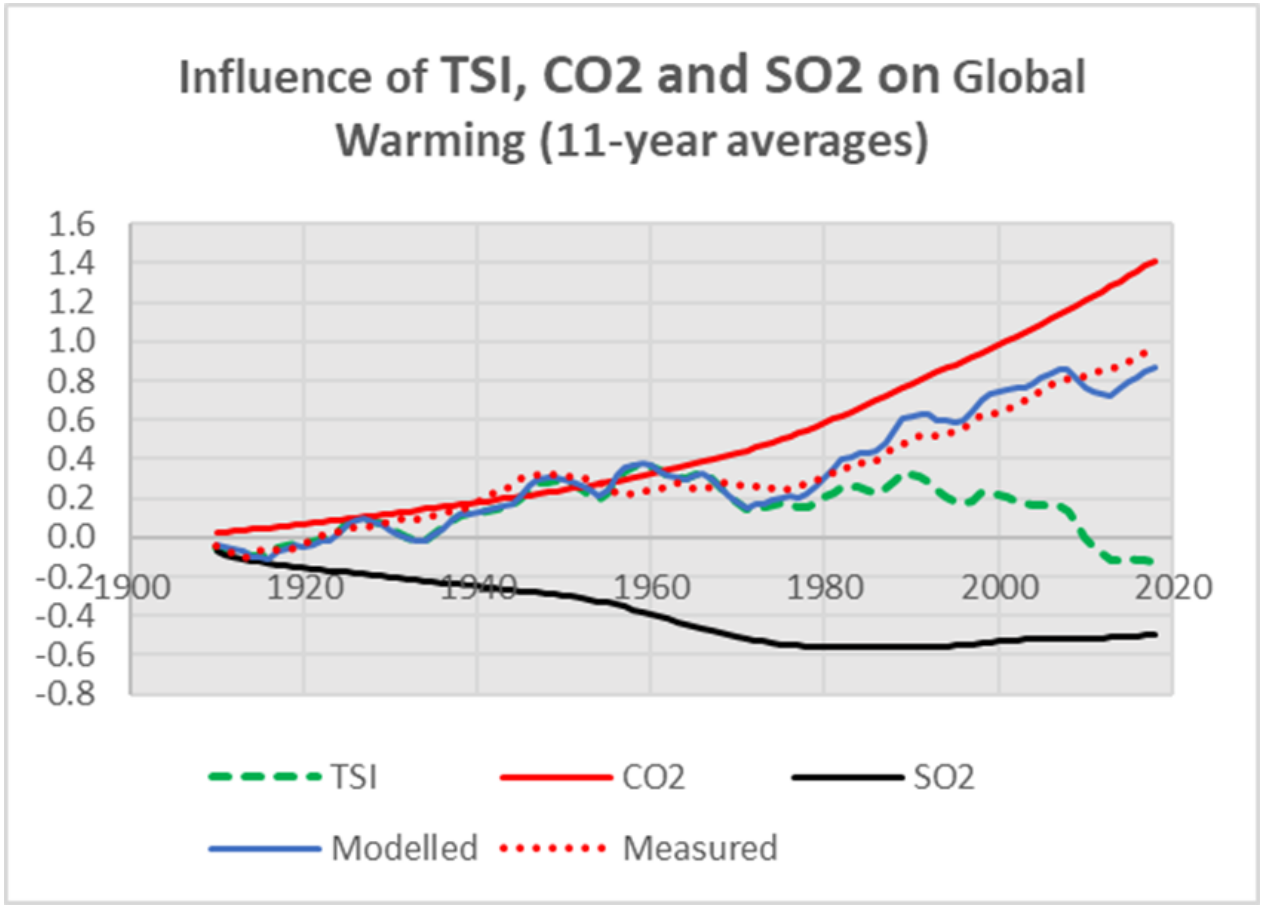
Where

dTSI = Change in Total Solar Irradiance

C= CO_2 concentration in the Atmosphere

E = SO_2 emissions (1000 tons)

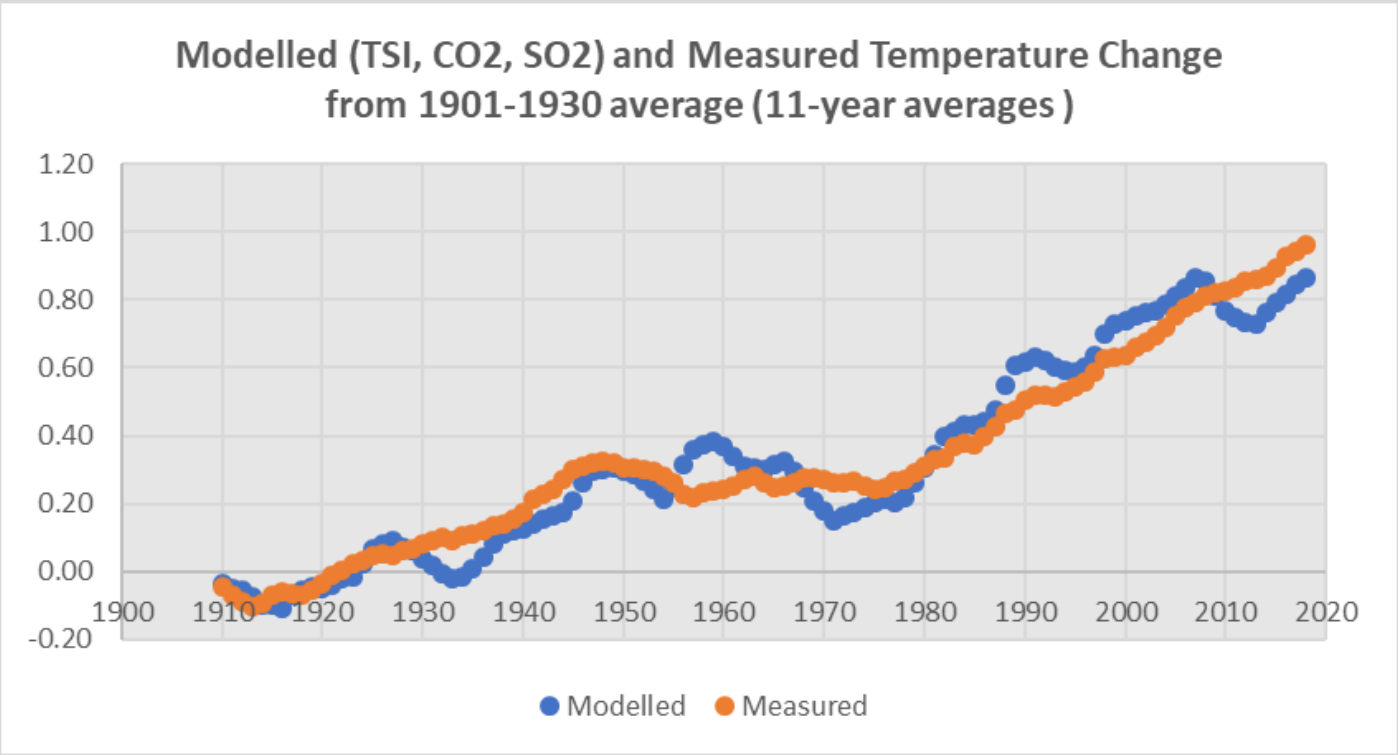
Modelling Global Warming by TSI, CO2 and SO2



1.4 deg.C(CO2) - 0.4 deg.C (SO2) - 0.1 deg. C(TSI) = + 0.9 deg. C

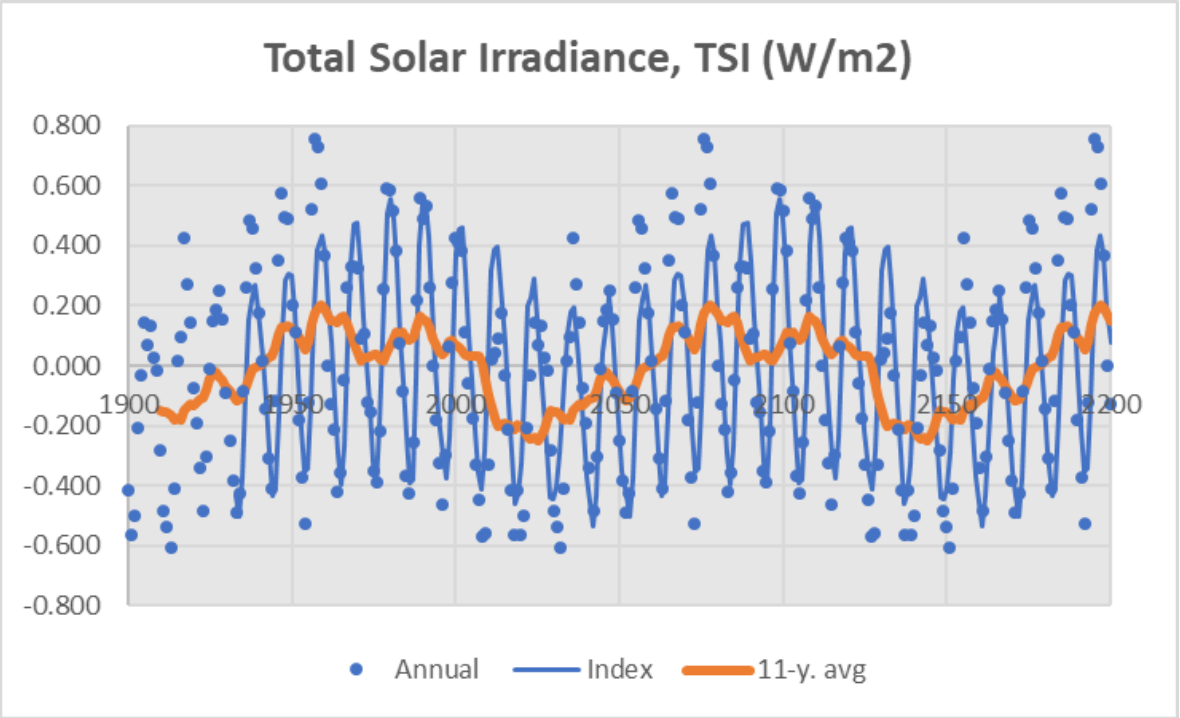
Modelling Global Warming by TSI, CO2 and SO2

dT = 1.23 x dTSI + 4.61 x ln(C/292) + 0.30 x ln(E/22.57)



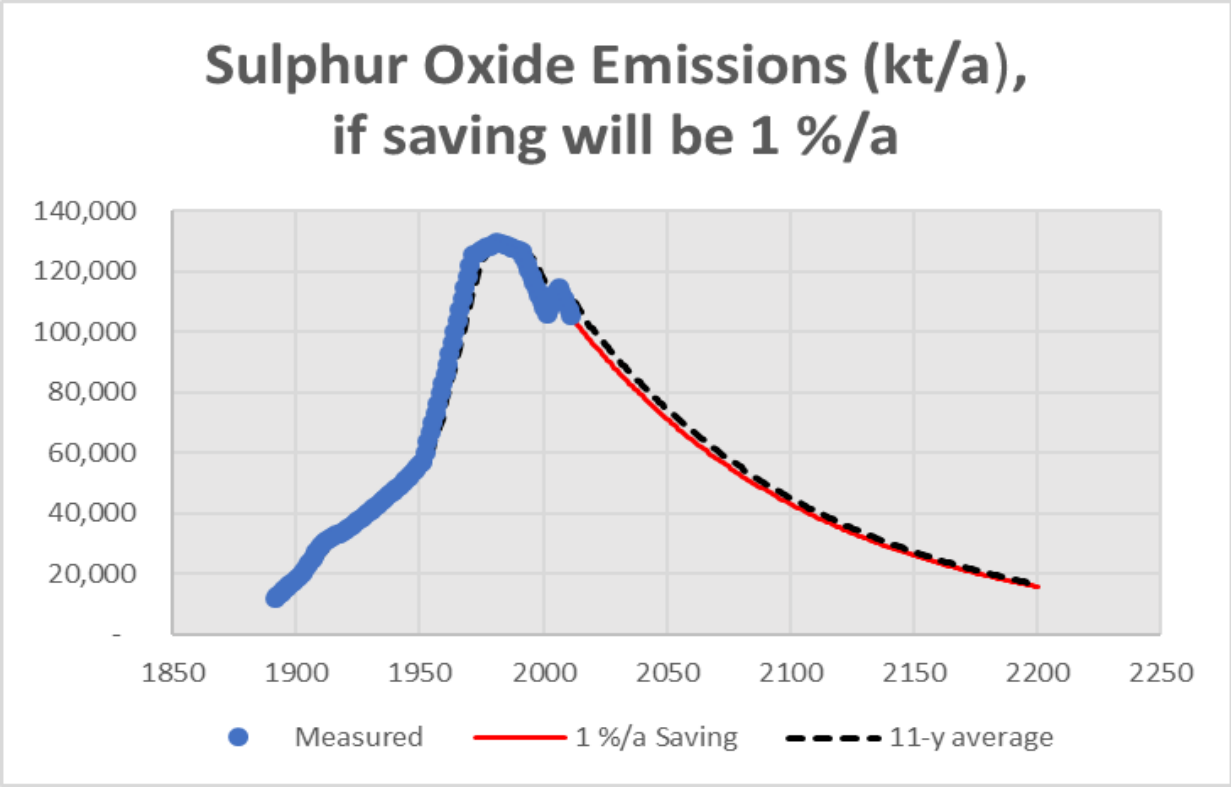
Standard deviation of the model temperatures from measured temperatures = 0.07 deg. C in the whole range 1911 - 2018

Assumption:
Future Total Solar Irradiance will Follow the 99-year cycle

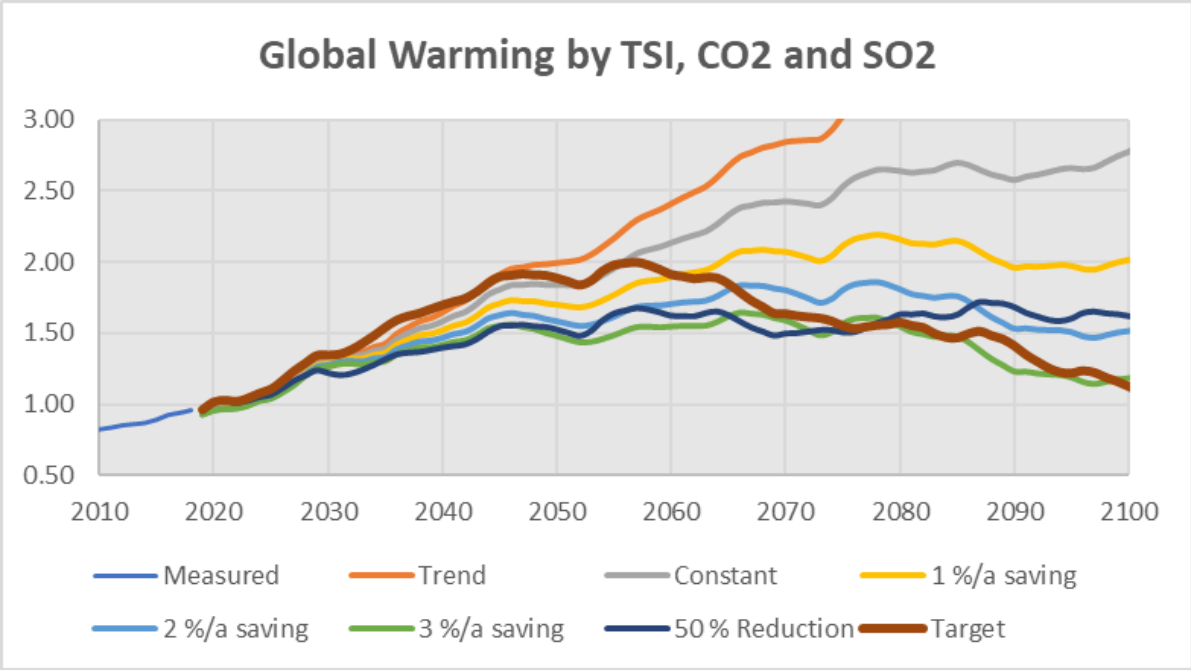


TSI(2019) = TSI(1920) etc.

Assumption:
SO2 emissions will decrease 1 %/a

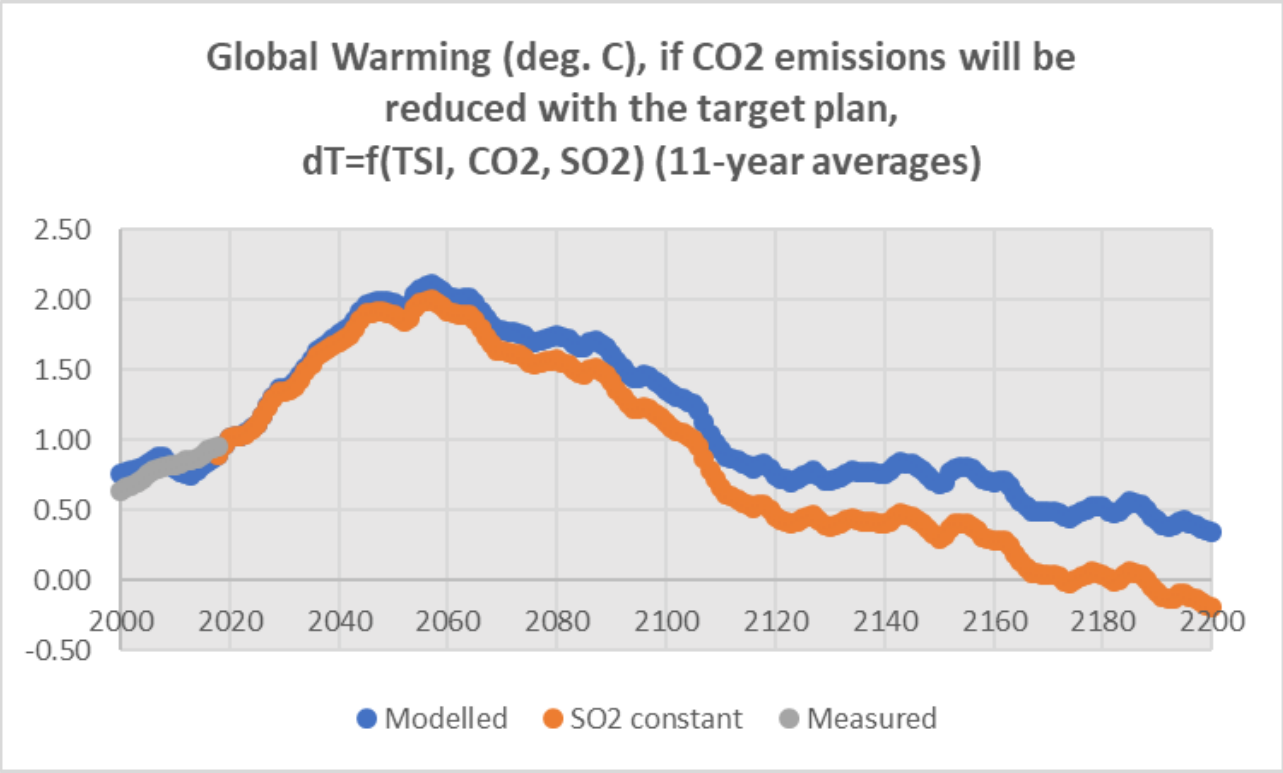


Global warming depending on CO2 saving strategies



dT = 2.0 deg. C, if CO2 emissions will be reduced with the target plan
dT = 1.9 deg. C, if CO2 emissions are reduced 2 % annually (Blue)

Global warming, if CO2 emissions will decrease with target plan and TSI will change as in years 1920-2018



Temperature peak at 2.0 deg. C by 2045-2050.

Global warming depending on CO2 saving strategies

	Global warming from years 1901 - 1930 (deg. C)						
Year	Trend	Constant	1 %/a	2%/a	3 %/a	-50%	Target
2018	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2030	1.3	1.3	1.3	1.3	1.3	1.2	1.3
2040	1.6	1.6	1.5	1.5	1.4	1.4	1.7
2050	2.0	1.8	1.7	1.6	1.5	1.5	1.9
2100	3.7	2.8	2.0	1.5	1.2	1.6	1.1
2200	3.9	3.6	1.4	0.7	0.5	1.9	-0.2
Max	4.2	3.7	2.2	1.9	1.6	2.0	2.0

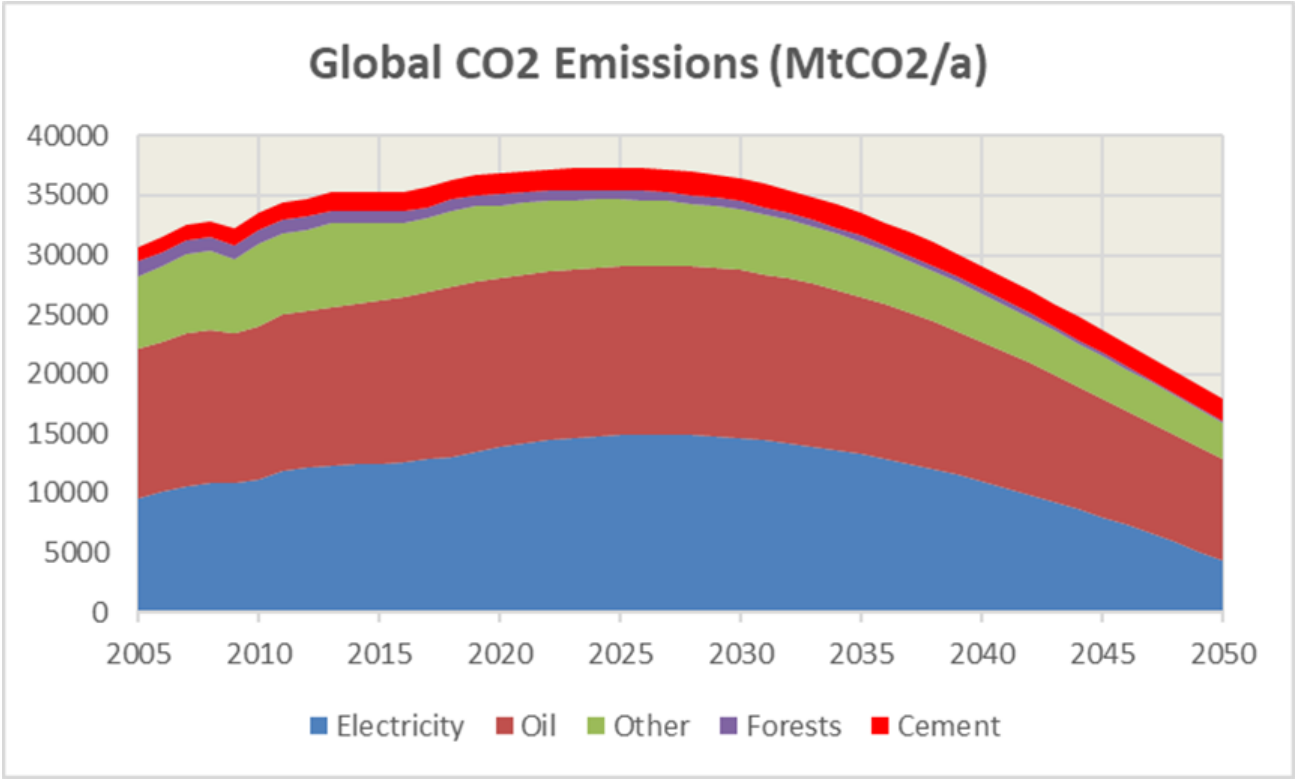
The 2.0-degree limit will not be exceeded, if CO2 emissions will be reduced 50 % today, 2 % annually or with the target plan.

The 1.5-degree limit will need 4 % reduction annually

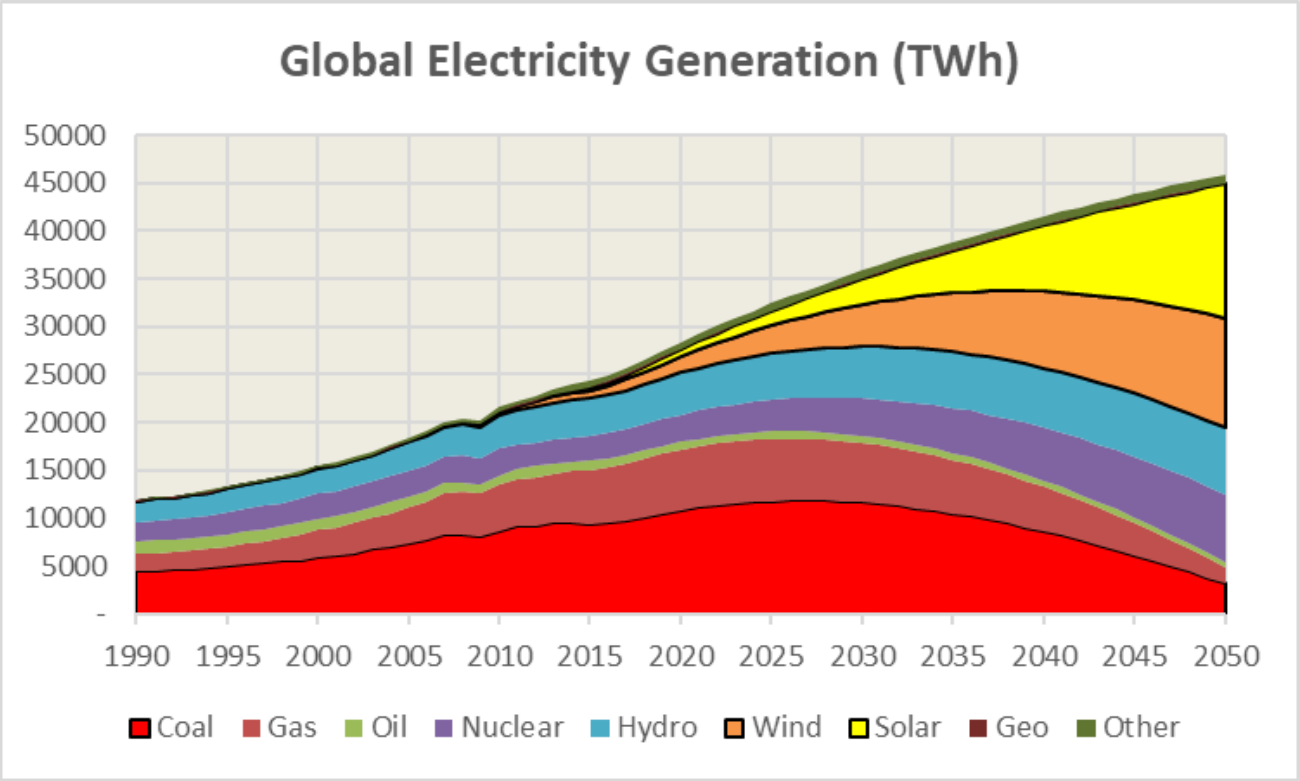
5. ACTION PLANS

Reduce global emissions to 18 Gt by 2050
Per capita target 1.8 tCO2/capita

Reduce CO2 Emissions to less than 18 Gt by 2050

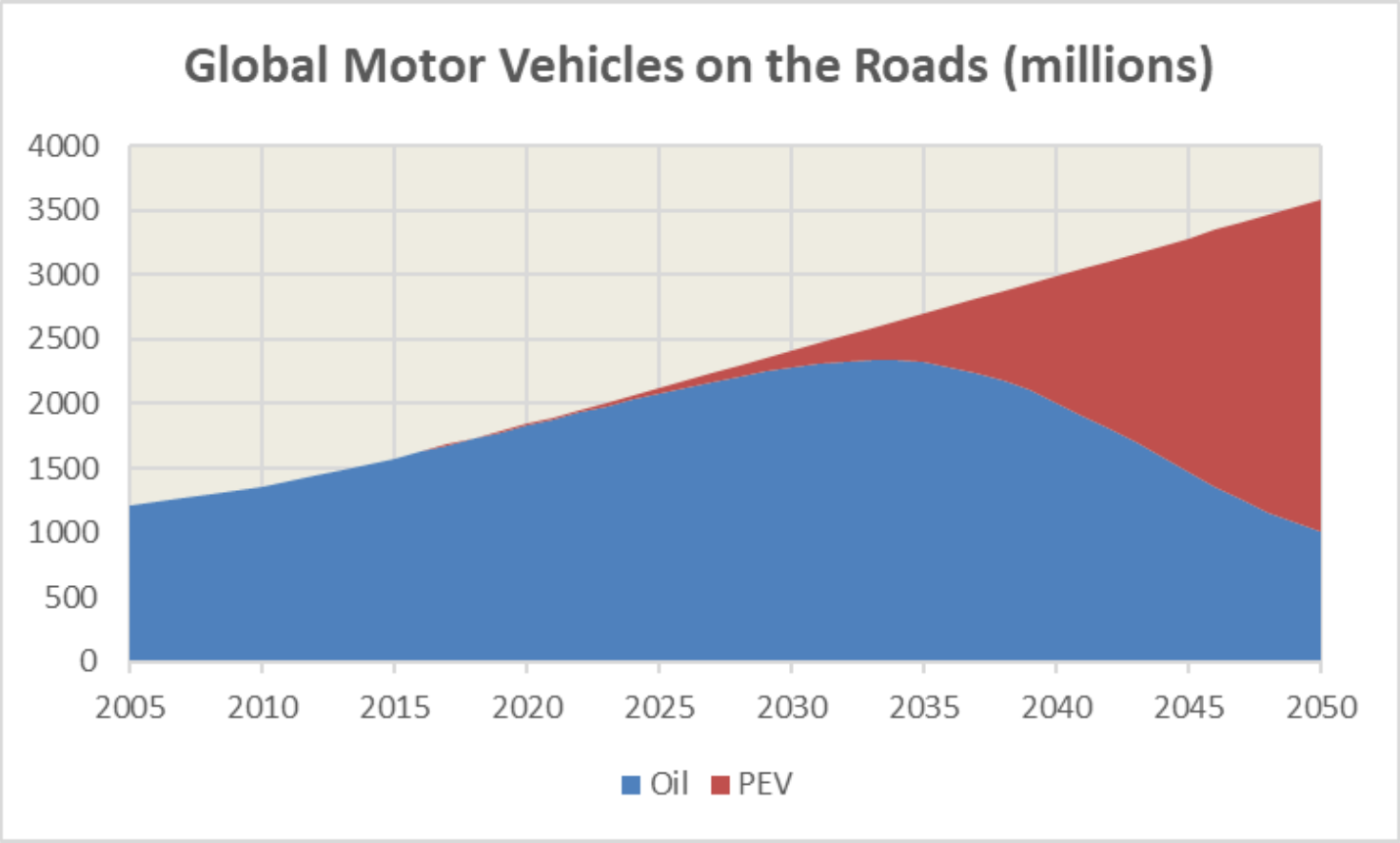


Decarbonize Electricity: Produced mainly by non-fossil sources by 2050



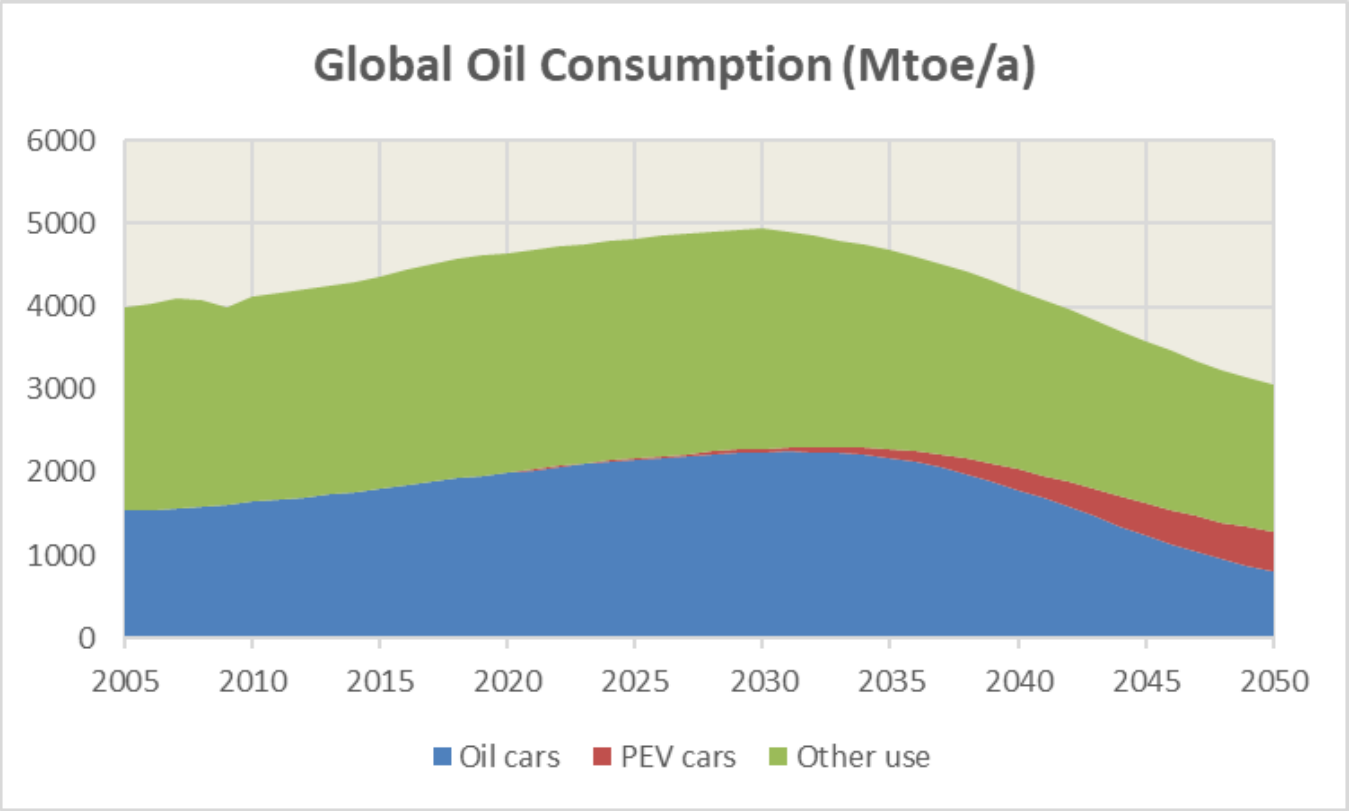
Solar and wind will generate 55 % of electricity in 2050
Fossil share should be decreased from 64 % in 2018 to 10 % by 2050

Decarbonize Traffic: 70 % of Vehicles will be powered by Electricity by 2050

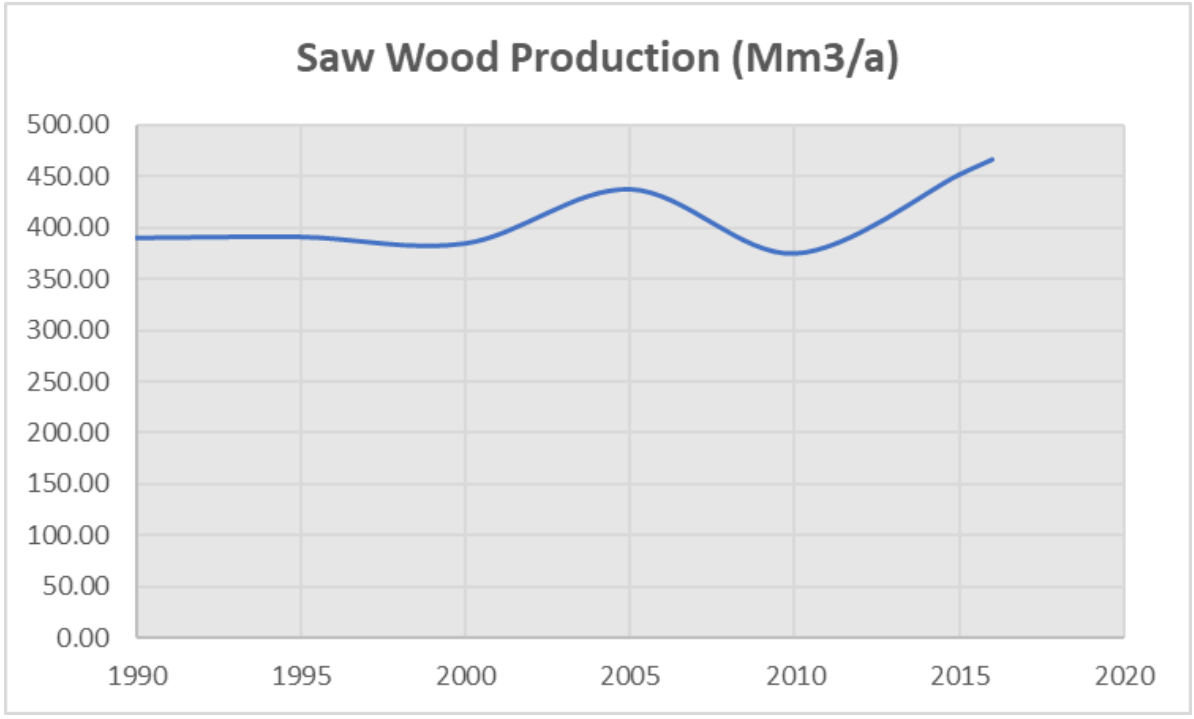


PEV = Plug-in Electrical Vehicles

Oil consumption will be peaking in the year 2030 at 5000 Mtoe/a



Build houses from wood instead from concrete



SUMMARY

- Paris target of less than 2.0 deg. C global warming can be achieved
- The CO2 emissions (36 Gt/a) should be reduced below carbon sinks (18 Gt/a) by 2050
- Target plan for each countries is to reduce CO2 emissions to less than 1.8 tCO2/capita by 2050