Greenhouse re-examined.

Earth's surface receives energy from the Sun, and its heating effect reduces with distance, described by the Stefan-Boltzmann relationship. At Earth's distance from the Sun, the average temperature is reckoned to be about -18°C as calculated from Stefan-Boltzmann, whereas the actual average temperature is about 33°C higher than that. A generally accepted assertion is that that 33°C difference is due to the Greenhouse Gas effect, ie the atmospheric gases that are able to absorb IR energy, known as "Greenhouse Gases", are responsible for that 33°C difference.

I haven't seen any substantiation of that assertion. *This section tests that assertion*.

The name **"Greenhouse Gas" (GG).**
It is recognised the name is not really appropriate for the heat captured in the atmosphere by such "Greenhouse" molecules as CO_2 or H_2O, but the name has certainly captured the attention! A *real greenhouse* is hotter than its surroundings due to the heated air within being prevented from escaping by its glass walls and roof, and the heat builds up. It's a blanketing effect. Of course, planets do not have roofs to prevent gases escaping – gravity does that fairly well.

However, *AGW has modified this definition subtly*. AGW's "Greenhouse Gas" effect, GG, operates by preventing Earth's IR, ie heat energy, from escaping without first interacting with and heating some molecules - the GG molecules - a small proportion of gases in the atmosphere, so that energy is prevented from escaping unscathed. It's a real effect (but its size has never been determined correctly). But this is now an incorrect definition; it suggests that the atmosphere would not be heated by Earth's heat without GG being present. **In fact, AGW could not exist without such a definition change. AGW essentially defines itself into existence!**

The Sun radiates enormous energy. It passes through Earth's atmosphere of numerous gases, dust and clouds to reach the actual surface. The incoming energy is mostly in the visible part of the electromagnetic spectrum; after all, the daytime sky is usually transparent - if there is no smoke, dust, etc. Some of this energy is absorbed by Earth to heat its surface but much is reflected away immediately into Space. Some of the surface energy is also radiated back into Space, mostly at the longer, infrared wavelengths. Some of this IR is absorbed by the GG, principally water vapour and carbon dioxide which represent only tiny percentages of the atmosphere. The principal atmospheric components are nitrogen, oxygen and argon, constituting about 99·94% of dry air, but they are not *defined* as GG as they do not absorb IR. Water vapour is a GG and can vary up to about 3%. Carbon dioxide is currently about 0·04% and rising.

All the above is true and accepted by all, but ***embarrassingly,*** *what has been forgotten is that radiation is but* ***one method of transferring energy****, the other two being* ***conduction and convection****, and it is principally using these processes that Earth heats its atmosphere.*

[Radiation does transfer energy by far the quickest – equilibrium is achieved in tiny fractions of a second – compared to convection and conduction which vary considerably depending on the circumstances. The Earth itself is a case in point. Its Core is thousands of degrees but the rate of heat conduction through the insulating Crust is so slow that equilibrium has still not been attained after billions of years. However, the atmosphere can equilibrate with the surface temperature within approximately a day. One can deduce this by observing desert temperatures; both air and soil temperatures soar during the day but both plunge during the night. The equilibration is slower near the coast – maybe weeks – due to the high thermal mass of the oceans' water, and so is somewhere between days and weeks.

However, process *speed* is not an issue; it's been active for millions of years. Even the alleged enhanced Greenhouse effect has been operating for decades.]

Earth's surface transfers heat to its surroundings. We are interested largely in Earth's heat transfer upwards to the atmosphere only.
[That transferred downwards to the Crust is minimal compared to that coming from the inner planet - as one can deduce from the heat in hot deep mines, eg in South Africa's diamond mines relative to that in shallow caves which are cool.]

This heat is transferred to and between the air molecules by conduction and convection, and in the case of the GG only, also by radiation. These molecules share their received extra energy with each other by colliding with each other (and additionally without colliding, by radiation between GG), so that all air molecules in a parcel reach the same temperature as each other at equilibrium.
[This is essentially a restatement of the "Zeroth Law" of Thermodynamics - a name given to a statement of commonsense - that when bodies are placed together, heat will flow from the hotter bodies to the cooler until they reach a common temperature.]

It would seem the conduction and convection effects on 100% of the air molecules would far outweigh the extra involvement of radiation in the tiny percentage of its "Greenhouse Gases". *However, that proposition is tested below.*

A mass of molecules changes its temperature when its heat energy changes, and the relationship between temperature and its heat content for that mass of molecules is expressed generally as

$$Q = m.\, C.\, \Delta T \qquad (2)$$

Q is the quantity of heat absorbed by the substance,
m is the mass of heated substance,
ΔT is the change in temperature,
C is the **Specific Heat,** a quantity characteristic of that particular substance, roughly constant over moderate temperature ranges. **[**J. $kg^{-1}.C^{-1}$]

Typical values of C for common liquids, gases and solids at 20°C are shown here.

Aluminium	900		Alcohol	2400
Basalt	1400		Mercury	140
Copper	390		Water, liquid 15°C	4186
Glass	840		, ice -5°C	2100
Marble	860		, steam 110°C	2010
Wood	1700		, vapour 20°C	1930

Air	1010		Methane	2220
Ar	520		N_2	1040
CO_2	840		O_2	919

[As shown by their Specific Heats, the *heat contents* for gases, liquids or solids are similar weight for weight, but gases' are much smaller, volume to volume - which is how they are perceived by touch.]

Gas specific heats are more complicated in that they vary depending on whether heat is added with the gas at a constant pressure or a constant volume, with $C_P > C_V$ always. Because temperatures are measured at Earth's surface, C_P measured at 1 atm pressure and around 20°C is appropriate here. Ironically, CO_2 is 80% as effective as a greenhouse gas as is air (and only 40% of water vapour's).

The significant point from the above equation is that it is irrelevant how the heat is added to the molecule. The temperature increase is determined not by the method it is received - whether by convection, conduction or radiation, because they do not appear in the equation - but only by

- the amount of heat energy it receives,
- by *how many molecules (ie pressure for gases)* there are,
- and by its characteristic Specific Heat, C.

To labour the point, when applied to the gas mixture that is air, the above equation becomes

$\Delta T = Q / (C_{CO2} \,.\, m_{CO2} + C_{air} \,.\, m_{air}) \approx Q / C_{air}\,(\,0{\cdot}0004 + 0{\cdot}9996\,)$ if $C_{CO2} \approx C_{air}$.

The heat content of any parcel of air is proportional to its mass (ie its pressure) and as all molecules in a parcel are at the same temperature, the amount of Earth's heat absorbed is proportional to the atmosphere's total pressure and not just to the tiny mass of the GG.

Remarks.

1. Even though it absorbs IR, CO_2 adds to temperature only by its percentage in the air, currently an insignificant 0·04%. *If* the greenhouse temperature effect is 33°C, the CO_2 total contribution will be 0·013°C!

2. Not previously regarded as such, the *real greenhouse molecules are the major air constituents, oxygen, nitrogen and argon* - simply because their much greater mass and percentage in the air produces the blanketing effect, whereas the GG such as carbon dioxide and water vapour effect very little atmospheric warming, in proportion to their small percentage.

3. The size of Earth's blanketing greenhouse effect is constant - because the number of molecules in the atmosphere is constant. (Burning of fuels does not change the number as for each molecule of CO_2 produced, an O_2 is removed. H_2O is also produced – that's but a drop in the ocean!)

4. Because the greenhouse effect is constant,

- there must be something else causing Vostok's changes in temperature (Fig 1),
- there must be something else changing Global Average Temperatures (Fig 2),
- the greenhouse effect must be many degrees less than 33°C.