#1.1 Heating Air

GLOBAL WARMING CAUSES Heating AirTable of Contents   Definitions 2To understand global warming, one must know what water does with heat 3 Boiling water becomes bigger, but its temperature and pressure do not change 4At a given temperature, moist air contains much most heat than dry air 5How clouds can contain millions of tons of water and not fall 6Why seaward mountain slopes are green, deserts form behind the mountains 7Why heat and humidity tend to stay in the air 8   Go to Site Menu Go to Section GuideGo to next item Steam Engine

Heating Air Definitions Note: This section is necessarily slightly technical. It is suggested that the reader take a few moments to review Abbreviations before continuing. Abbreviations were used because they greatly clarify and shorten the text. The reader should not be daunted by technical jargon; an intuitive grasp of Causes is adequate for what follows. Some readers might wish to review The Endgame Scenario first-and return here (Causes) for proof.

Some of the more commonly used abbreviations are: SW Sea-WaterDW Distilled/Drinking Water Q Heat kCal or JLQ Latent Heat SQ Sensible Heat P Pressure atmT Temperature 'CRV ReservoirW work or powerWmec mechanical work or powerWeleelectrical work or power

Φ atmospheric humidity g/kg dry air ρ density kg/m3To understand global warming, one must know what water does with heat. 1 litre of water by 1°C = 4.186kJ, J = Joule 1atm (atmosphere) is the average pressure of atmosphere at sea level = 0.10133MPa(MegaPascals)Warming one litre of liquid water (L.H2O) from 0'C to 100°C requires 100 kCal of heat (Q). Boiling that litre to steam (G.H2O) at 100°C, 1atm, requires another 539kCal, or 2257kJ (Evap hfg, Table I) of Q. The G.H2O has the same Temperature (T), Pressure (P) and weight as the L.H2O. But it is about 1600 times bigger. Boiling water becomes bigger, but its temperature and pressure do not change The heat added to the L.H2O between 0 and 100°C can be felt and measured with a thermometer. It is thus called sensible heat (SQ). The Q added to the 100°C water to boil it away is called "latent" because it is stored in the G.H2O and released again when the G.H2O condenses back to L.H2O. LQ is volume Q. LQ and SQ initially came from the same fire. They differ what the water does with them. Its T rises from 0 to 100°C; its volume increases during the 100°C L.H2O- G.H2O phase transition. Most substances expand as they are heated. The volume of mercury in a thermometer increases slightly as it is warmed. That is why the column lengthens or shortens to show T. Mercury expands when it boils to vapour- as water does. When L.H2O freezes to ice, it becomes bigger and colder at the same time- but its T does not change. The Q removed from L.H2O as it freezes is a sort of negative LQ. LQ absorption can be used for cooling. This can be observed after swimming on a day when a very hot, dry wind is blowing. One soon becomes so cold that one shivers. The hot dry wind absorbs LQ out of one's body as it dries the water off it. The body, and the hot wind, both have a lower T than before the wind absorbed the moisture and LQ necessary to do this. This effect is used to measure atmospheric humidity with wet and dry bulb thermometers. The wet bulb is relatively cooler when the air is drier. It is also used to keep water cool in hot, dry climates. The water is put in porous earthenware jars. Water seeping out through the pores sucks heat out of the jars as it evaporates. A sophisticated variant of the same idea is used in absorption chillers. If a warm (e.g. 40°C) dry wind blows over a colder (20°C) sea, both the sea and the wind are T cooled, while the wind absorbs LQ (586 kCal per kg L.H2O evaporated) out of the sea. More LQ is absorbed per kg atmospheric humidity (Φ) evaporating from (20°C) water (586 kCal per kg L.H2O evaporated) than from water boiling at 100°C (539 kCal per kg L.H2O boiled). Cold, dry air is heavy, hot, wet air is light A Φ-saturated wind blowing over a sea with the same T neither absorbs, nor loses, Q or Φ from it. If Φ saturated air is above a colder sea, L.H2O condenses out of the air onto the sea- some of the LQ usually remains in the air. The energy which binds salt to pure L.H2O in sea water is on the order of 1 kCal per kg L.H2O. A warm, dry wind must spend an extra kCal for ever kg L.H2O it evaporates. Air saturated with Φ condenses more easily onto salty than onto fresh water as it gets that kCal/kg backIf dry air and the sea below it both have the same T, then Φ, together with its LQ, can evaporate out of the sea into the air without changing the T of either -if the sea's T is kept constant by solar energy falling onto it. The solar heating of the sea water is then equal to the LQ in Φ evaporating off it. If dry, and saturated, air have the same P and T, the dry air is heavier. This is shown in Table 2. At 1atm (bar) and 20°C, the density of saturated wet air, r sat, is 1.188 kg/m3, r of dry air is 1.198 kg/m3. Φ evaporating off of the ocean thus tends to mix with surrounding cooler, dryer air and rise up through it in invisible bubbles and plumes. The rising moist air expands and cools as it rises to greater heights. How clouds can contain millions of tons of water and not fall When the moist air rises, it expands and cools. At a certain height it becomes so cold that Φ in it becomes super-saturated and condenses to cloud. Clouds consist of innumerable minute L.H2O droplets. Condensation occurs at the same height for all cloud bubbles and plumes. That is why one often sees towering flat-bottomed clouds over calm oceans on sunny days (Fig.005). The bottoms are all at the same height.Condensation releases LQ into the air between the droplets. This LQ becomes SQ that keeps the air warm and light-weight so that it bouys the cloud droplets up. Though the cloud may contain thousands of tons of water- it floats rather than falling down. The SQ that prevents the cloud from falling was initially solar heat added to sea water. It was then converted into LQ in Φ that rose up into the sky and condensed to droplet L.H2O there. The L.H2O was pumped up from sea to sky invisibly, highly efficiently, with no noise or pollution. At a given temperature, moist air contains much most heat than dry airTable 2 was computed with the Stueve algorithm. It shows, for instance, that if dry air is heated from 10 to 30°C at 1 bar, its enthalpy (Hq dryw) increases from 10.2 to 30.6 kJ per kg of dry air. That is an increase of 20.4 kJ/kg. Its density, ρ, falls from 1.24 to 1.16 kg/ m3. Cold, dry air is heavy. If the T and P of air remain constant at 30°C, 1 bar, while its Φ is raised from of 0 (dry) to 24.4 g/ kg dry air (saturated), its enthalpy rises from 30.6 to 94.2 kJ/kg, its ρ falls from 1.16kg/m3 to 1.14 kg/m3. The enthalpy of air increases more as its Φ is raised from 0 to saturation at constant T than when it is heated from 10 to 30°C. Warm, moist air is light-weight. Table 2 shows that if air T is held constant while its P is increased, it becomes saturated at lower Φ values. If P is raised, or T lowered, in saturated air, then L.H_2O condenses out in it, first as cloud, then as rain,. How latent heat can become sensible heat The Stueve algorithm can be used to calculate what happens if a parcel of Φ-saturated air moves from sea level over Italy, up a few thousand m over the Alps and then falls back down almost to sea level over the Swiss lowlands (Fig.007). It expands and loses P and T as it rises up the Italian side of the Alps. The cooling works faster than the pressure loss so that cloud forms, and then rain falls. The LQ remains in the cloud. When the cloud parcel falls back down on the Swiss side of the Alps, it warms as is recompressed back to almost its sea level P. This compression heats the cloud parcel so that the droplets in it dry to clear air. The bottom of the cloud is higher over the Swiss side of the Alps than that at which rain began to condense out of it on the Italian side. This is because the LQ that remained in the parcel when rain fell out of it became SQ as that parcel was recompressed. That is how hot, dry 'Foehn' winds develop. A good Foehn can thaw (thawing LQ) warm (SQ), and evaporate (evaporate (LQ) 40cm snow off exposed slopes in a day in the middle of winter. The Foehn effect can create deserts. If a country has a coastal mountain range over which moist sea winds normally blow inland, rain falls out over its seaward slope, its leeward slope and hinterland are hot and dry. Why heat and humidity tend to stay in the airWhen sun shines on a forest, the trees in it fix solar energy, CO_2 and H_2O into wood cellulose. If the wood is burnt, the solar energy is released as Q while the CO_2 and G.H_2O are returned to the air in smoke. This also happens when organic materials rot. Dead leaves fall on the ground in autumn. In winter, they rot to nutrients and L.H_2O that seep down into the soil while CO_2 is released into the air. Q is also returned to the environment. A compost heap can become so warm that steam rises out of it- rotting rags can catch fire. This effect reduces winter cold in forested regions. In spring and summer plants again bind H_2O, CO_2 and Q into their bodies. If forests are cleared or burnt, and not replanted, Q, CO_2 and G.H_2O discharged into the air tend to remain there. The phenomenon has been accelerating since the Industrial Revolution. Fossil fuels contain chemically stored solar energy, CO_2 and L.H_2O. Air gets hotter and drier when fossil fuels are burnt in it. It can thus absorb more Φ from the environment than it received from combustion gasses. Combustion exhaust gasses have a larger P x V (V = volume) enthalpy component than the inlet air did as well as more LQ and SQ. The enthalpy difference is added to the atmosphere. It does not only become hotter, it also becomes bigger and wetter. At a given P, warmer, wetter air is lighter (smaller ρ) than dry air. If its P is reduced or its T increased, it can absorb more Φ before it saturates. This effect is cumulative. As more fossil fuels are burnt, the earth's atmosphere becomes thicker, warmer and lighter. Some of the Φ added to the air does not rain out again because warmer air can contain more Φ before it becomes saturated. More of the Q added to it by burning fossil fuels remains in the atmosphere as LQ- and this does not rain out (Foehn effect). The atmosphere may trap a little heat (greenhouse effect); it radiates almost no heat into outer space.Other conditions equal, and according to the first, energy constance, Law Of Thermodynamics, most of the new Q added to the atmosphere when fossil or nuclear fuels are burnt remains permanently in the atmosphere.   Go to Site MenuGo to Section GuideGo to next item Steam Engine