Solar Energy Absorption

In the excellent article "Atmospheric effects of pollutants" by Hobbs *et al.* (8 Mar., p. 909), there is a misstatement concerning the absorption of solar energy in the atmosphere. In the section "Radiation balance" the authors state: "The infrared radiation is a minor part of the incoming solar power . . . ," and then go on to discuss atmospheric heating by absorption of solar radiation without considering absorption by H_2O, CO_2 or other species with infrared absorption bands. In fact, the infrared radiation is not a minor part of the incoming solar power. Above the atmosphere, only 50 percent of the solar energy is at wavelengths less than 0.71 micrometer, which is approximately where the infrared begins. The wavelengths below which 60, 70, 80, 90, and 98 percent of the solar energy is found are 0.84, 1.0, 1.2, 1.6, and 3.0 μm, respectively. There are important absorption bands for H_2O at 0.72, 0.81, 0.94, 1.1, 1.38, 1.87, 2.7, and 3.2 μm; for CO_2 at 1.6, 2.0, and 2.7 μm; and for O_2 at 0.78 and 1.27 μm. The water bands are the most important by far. The literature has been well summarized by Robinson (*1*).

The atmospheric absorption of H_2O, CO_2, and O_2 is almost entirely responsible for the reduction of solar energy flux from 2.00 calories per square centimeter per second at the top of the atmosphere to 1.40 at sea level. The direct heating of the atmosphere from this absorption can hardly be neglected.

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References

1. N. Robinson, *Solar Radiation* (Elsevier, New York, 1966), pp. 47–110.

Merriam correctly points out that we excessively deprecated the influence of solar infrared radiation on the heat budget of the atmosphere. To complement his values for the integrated solar radiance as a function of wavelength, we add an approximate budget for the interaction of solar radiation with the earth (*1*): for every 100 watts of incoming power, 24 are reflected by clouds, 7 are scattered back to space by the earth's atmosphere, and 4 are reflected back to space by the planet's surface (subtotal 35); 22.5 watts reach the surface directly, 14.5 more after diffuse scattering from clouds, and 10.5 more after diffuse molecular scattering (subtotal 47.5); of the residue (subtotal 17.5), about 6 are absorbed by the atmosphere in the ultraviolet and 11.5 in the infrared. In our article, we carelessly "misspoke" our intention of stating that this last number is a minor part of the total power incident on the planet. It is, of course, a larger part of the nonreflected solar power, about 18 percent.

The main purpose of our article was to estimate the influences of potential pollutants upon the atmosphere. For a hypothetical pollutant that is very active in the infrared to absorb 10^{-3} of that 18 percent, its global concentration would have to exceed about 10 parts per million. The arguments in our article suggest that other deleterious effects would likely be observed at lesser concentrations.

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References

1. M. Neilburger, J. G. Edinger, W. D. Bonner, *Understanding Our Atmospheric Environment* (Freeman, San Francisco, 1973), p. 65.

Osmotic Power Plant

I have for years used the osmotic pump fallacy to illustrate the workings of the second law of thermodynamics, and hope that none of my students see the article "The osmotic pump" by Levenspiel and de Nevers (18 Jan., p. 157) and have dust thrown into their intellectual gears. Those familiar with oceanography know that the nonequilibrium states which do obtain over short distances do not admit of practical energy-producing processes.

If one wants to engage in speculation and still be quite consistent with the laws of thermodynamics, one should calculate the amount of energy produced by having the mixing of the Hudson River with the Atlantic Ocean in New York Harbor take place under those conditions which approach reversibility and which are attainable by the use of modern ion-exchange membrane technology. A simple calculation will show that such a membrane plant would make electricity sufficient to supply all of the needs of New York City and much of the hinterland. It would