The vertical has been a popular antenna since the dawn of radio. Indeed, a quarter-wavelength antenna fed against a good ground system is credited to Marconi himself. This configuration relies on the ground image of the vertical element to electrically form the other half of a dipole. Over the years, the need for a good ground system seems to have been forgotten by more than a few amateurs and engineers alike. "Elevated verticals" for the lower HF bands, especially 80 and 160 meters, have been in vogue recently. Elevated verticals can reduce losses. But, they're not magic, either. In this short article, we explore what might make them attractive or not.

Let's look at the evolution of the elevated vertical from an electromagnetic standpoint and see what its limitations are. The left half of Figure 1 is a cartoon of the fields around a dipole. On the right, we have a similar cartoon of the antenna bent at the feedpoint. The field lines are not perfect. And, I left many of them out to improve clarity. However, the point should be quite obvious: the electric field lines from the antenna on the right spend a considerable distance going through the ground, especially in the high flux region near the base of the vertical.

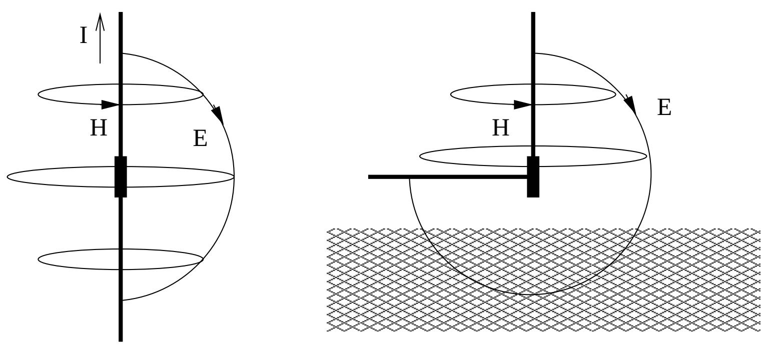

Figure 1: Evolution from dipole to elevated vertical with one radial

Consider now Equations 1 and 2. They are both statements of the time-average Poynting theorem. The terms correspond directly to one another. This is a conservation theorem, a matter of accounting. It says that power sourced must be equal (and opposite) the sum of power radiated and power dissipated. Notice that the dissipation term (P_{dis}) relates to integral (sum) of the electric field intensity squared times the conductivity in the region of interest. Since the ground has a small finite conductivity, some dissipation will occur in the ground. If you put an antenna in free space ($\sigma = 0$), the dissipation term will vanish. Therefore, all supplied[1] power will be radiated. The amount of electric field in the earth can be reduced to varying degrees by elevating the antenna

[1] *Supplied* refers to the power that actually makes it into the antenna element after mismatches and matching network losses.

higher, adding more *radial* wires parallel to the ground, or both.

$$\frac{1}{2}\Re\left(\oint_S \mathbf{E}\times\mathbf{H}^*\cdot d\mathbf{s}\right)+\frac{1}{2}\int_V \sigma|\mathbf{E}|^2 dv+\frac{1}{2}\Re\left(\int_V \mathbf{J}^*\cdot\mathbf{E}dv\right)=0 \tag{1}$$

$$P_{\text{rad}}+P_{\text{dis}}+P_{src}=0 \tag{2}$$

In reality, the losses due to dissipation in the ground are difficult to quantify without using a computer modeling program or making actual field-strength measurements. However, qualitatively speaking, we can now use our understanding of the *science* to start making some engineering decisions about ground systems for vertical antenna systems. If you can only have a small (4, 8, 16, etc) number of radials, elevated radials will reduce your losses over putting the same number directly on the ground. Another advantageous use of elevated radials is over an existing burried radial field for another antenna, for example, an 80-meter 4-square suspended on caternaries from your 160-meter vertical. Although, the screening effectiveness of the 160-meter radial field may prove inadequate on 80 meters. On the other hand, if you can install as many radials as you want, the complexity and expense of installing dozens of $\lambda/2$ or $\lambda/4$ elevated radials eventually exceeds that of simply plowing them into the ground.

For each ground characteristic, the trade-off point between elevate and bury is different. For extremely poor ground ($\sigma \approx 0$), it doesn't really matter too much whether you elevate or bury. If the electric field gradient due to the radial field is approximately equal to or exceeds the electric field gradient due to the skin depth of the earth, burial is the way to go. Otherwise, you'll get lower losses by elevating.

I hope this was a good introduction to the science of elevated verticals and the associated engineering trade-offs. If I wanted maximum performance from minimum effort, I would install lots of burried radials.