8.2 (a) Given the peak value H_0 of the magnetic field, inside the line, the azimuthal magnetic field is then given by $H = H_0\, a/r$, and using the relation $\vec{B} = \pm\sqrt{\mu\varepsilon}\,\hat{z}\times\vec{E}$, the radial electric field is $E = \sqrt{\frac{\mu}{\varepsilon}}\,H = \sqrt{\frac{\mu}{\varepsilon}}\,H_0\frac{a}{r}$. Then, the transmitted power becomes $\frac{1}{2}EH$, and

$$P = \frac{1}{2}\int EH\,da = \frac{1}{2}\sqrt{\frac{\mu}{\varepsilon}}\,H_0^2\int_0^{2\pi}d\phi\int_a^b\frac{a^2}{r^2}\,r\,dr = \sqrt{\frac{\mu}{\varepsilon}}\,\pi a^2 H_0^2\log\left(\frac{b}{a}\right).$$

(b) Using Eq. (8.58),

$$-\frac{dP}{dz} = \frac{1}{2\sigma\delta}\oint|\vec{n}\times\vec{H}_{\parallel}|^2\,dl = \frac{1}{2\sigma\delta}\left(\int_0^{2\pi}H_0^2\cdot a\,d\phi + \int_0^{2\pi}H_0^2\frac{a^2}{b^2}\cdot b\,d\phi\right)$$

$$= \frac{\pi a^2}{\sigma\delta}H_0^2\left(\frac{1}{a}+\frac{1}{b}\right),$$

and $$\gamma = -\frac{1}{2P}\frac{dP}{dz} = \frac{1}{2\sigma\delta}\sqrt{\frac{\varepsilon}{\mu}}\frac{\left(\frac{1}{a}+\frac{1}{b}\right)}{\log\left(\frac{b}{a}\right)}.$$

(c) The voltage between the cylinder is $V = \int_a^b E\,dr = \sqrt{\frac{\mu}{\varepsilon}}\,H_0 a\log\left(\frac{b}{a}\right)$, and the current in one of the cylinders is $I = \oint K\cdot dl = 2\pi a\cdot H_0$. Therefore, $Z_0 = \frac{V}{I} = \frac{1}{2\pi}\sqrt{\frac{\mu}{\varepsilon}}\log\left(\frac{b}{a}\right)$.

(d) The Joule heating is given by $|dP/dz| = \frac{1}{2}I^2R$, which leads to

$$R = \frac{2}{I^2}\left|\frac{dP}{dz}\right| = \frac{1}{2\pi\sigma\delta}\left(\frac{1}{a}+\frac{1}{b}\right).$$

For the inductance, the energy in the wire is

$$W_{wire} = \frac{\mu}{2}\int|H|^2da = \frac{\mu}{2}\cdot2\pi\int_a^b H_0^2\frac{a^2}{r^2}\,r\,dr = \pi a^2\mu H_0^2\log\left(\frac{b}{a}\right)$$

In the cylinders,

$$W_{cyl} = \frac{\mu_c}{2}\left(2\pi a\cdot\int_0^{+\infty}H_0^2e^{-2\xi/\delta}d\xi + 2\pi b\cdot\int_0^{+\infty}H_0^2\frac{a^2}{b^2}e^{-2\xi/\delta}d\xi\right)$$

$$= \frac{\mu_c\delta}{2}\,\pi a^2H_0^2\left(\frac{1}{a}+\frac{1}{b}\right)$$

Then $$L = \frac{2}{I^2}\left(W_{wire}+W_{cyl}\right) = \frac{\mu}{2\pi}\log\left(\frac{b}{a}\right) + \frac{\mu_c\delta}{4\pi}\left(\frac{1}{a}+\frac{1}{b}\right).$$

Here, the integration is performed as if we have a surface current.