To use per-unit calculations, first define our nominal or base quantities

$$S_n = S_b \ [VA]$$
$$V_n = V_b \ [V]$$
$$I_n = I_b \ [A]$$
$$Z_b = \frac{V_n^2}{S_n} \ (\Omega)$$

Per unit impedances are defined normalized to the base impedance

$$Z_{pu} \ [\%] = \frac{Z \ (\Omega)}{Z_b \ (\Omega)}$$
$$X_{pu} \ [\%] = \frac{X \ (\Omega)}{Z_b \ (\Omega)}$$
$$R_{pu} \ [\%] = \frac{R \ (\Omega)}{Z_b \ (\Omega)}$$

Impedance is defined as usual in the cartesian plane with resistance (real axis) and reactance (imaginary axis)

$$Z = R + jX$$
$$Z_{pu} = R_{pu} + jX_{pu}$$

X over R (***XoR***) is a commonly defined parameter that defines the ratio of ***X*** to ***R***, either in absolute or per unit

$$XoR = \frac{X_{pu}}{R_{pu}}, X_{pu} = XoR \cdot R_{pu}$$

XoR and per unit impedance can be used to work out per unit resistance and reactance

$$|Z_{pu}|^2 = |R_{pu}|^2 + |X_{pu}|^2$$
$$|Z_{pu}|^2 = |R_{pu}|^2 + (|R_{pu}| \cdot XoR)^2$$
$$|Z_{pu}|^2 = |R_{pu}|^2(1 + XoR^2)$$
$$R_{pu} = \frac{Z_{pu}}{\sqrt{1 + XoR^2}}$$

A baseline loss can be found from an efficiency at an operating point ***S***

$$\eta = \frac{P_o}{P_i}$$
$$P_i = P_o + P_{loss}$$
$$P_{loss} = P_i - P_o$$
$$P_{loss} = \frac{P_o}{\eta} - P_o$$
$$P_{loss} = P_o\left(\frac{1}{\eta} - 1\right)$$

Loss due to current can be determined using per unit values

$$P_{loadloss} = I^2 R$$

$$R = R_{pu} Z_b$$
$$Z_b = \frac{V_n^2}{S_n}$$
$$I = \frac{S}{V}$$
$$P_{loadloss} = \frac{S^2}{V^2} R_{pu} \frac{V_n^2}{S_n}$$
$$P_{loadloss} = \frac{V_n^2 S^2}{V^2 S_n} R_{pu}$$

This general equation is used when calculating load-based loss later, but given a nominal operating point $V = V_n$.

$$P_{loadloss}|_{V=V_n} = \frac{S^2}{S_n} R_{pu}$$

And since S is typically given as a percentage of S_n, load factor F, the equation simplifies further to

$$P_{loadloss} = F^2 S_n R_{pu}$$

We then find $P_{noloadloss}$ to use for future loss calculations

$$P_{noloadloss} = P_{loss} - P_{loadloss}$$