Linear Collider Exercises

1.1 LEP had already an energy loss of 3 GeV per turn for a beam energy of 100 GeV.
Imagine you would want to build a storage ring to collide electrons and positrons at a centre-of-mass energy of 1 TeV (E_{beam} = 500 GeV).
How big would this storage ring be if

a) You could re-use the LEP RF system and replace the same energy loss, namely 3 GeV/turn?
b) You could allow for the same relative energy loss as in LEP?
c) You imagine the extreme case that you could fill the whole ring with accelerating cavities and could replace an energy loss of 100% (i.e. 500 GeV) per turn?

d) What is the scaling of the radius with energy in case c) ?
e) What gradient (accelerating field per unit length) would you need in case c) (Neglecting all other elements like bending and quadrupole magnets)?
f) Apart from the large size, why don't we build such a machine?

1.2 Taking the approximation given for δ_{BS}, calculate the normalized vertical emittance and beam size at the collision point for the following parameters for a linear collider:

$L = 7.2 \cdot 10^{34}\,\mathrm{cm}^{-2}\mathrm{s}^{-1}$

$P = 320\,\mathrm{MW}$

$\eta = 12.6\%$

$\delta_{BS} = 16\%$

$H_D = 1.7$

$E_{cm} = 3\,\mathrm{TeV}$

$\beta_y = 0.09\,\mathrm{mm}$

1.3 For a given beam power and centre-of-mass energy, show that the luminosity scaling for a round beam ($\sigma_x = \sigma_y = \sigma$) can be expressed as

$$L \propto \frac{\sigma_z}{N}\delta_{BS}$$

Comment on this result.