Basic problem:
The total cost of abatement is given by

$$TC = (3+r)q^2$$

where q is abatement and r is a parameter unknown to the regulator. However, it is known that, with equal probability, $r = 0$ or $r = 4$. Without any further information, the regulator would use the expected value of r, which is $r = 2$
Without abatement, firms emit 2 units. Therefore, with abatement, $e = 2 - q$ or $q = 2 - e$

1. Write the cost function in terms of e

$$\begin{aligned} TC &= (3+r)q^2 \\ TC &= (3+r)(2-e)^2 \end{aligned}$$

   For the given values of r

$$\begin{aligned} r = 0 \quad & TC = 3(2-e)^2 \\ r = 2 \quad & TC = 5(2-e)^2 \\ r = 4 \quad & TC = 7(2-e)^2 \end{aligned}$$

2. Marginal Savings

$$\begin{aligned} MC &= \frac{dTC}{de} = (3+r)\overbrace{[2(2-e)(-1)]}^{Chain\ Rule} \\ MC &= (3+r)\,(2e-4) \\ MS &= -MC = (3+r)\,(4-2e) \end{aligned}$$

   for $r = 2$

$$MS = 20 - 10e$$

   and $MD = 4e$. Regulator would solve

$$\begin{aligned} MD &= MS \\ 4e &= 20 - 10e \\ 14e &= 20 \\ e &= 1.43 \end{aligned}$$
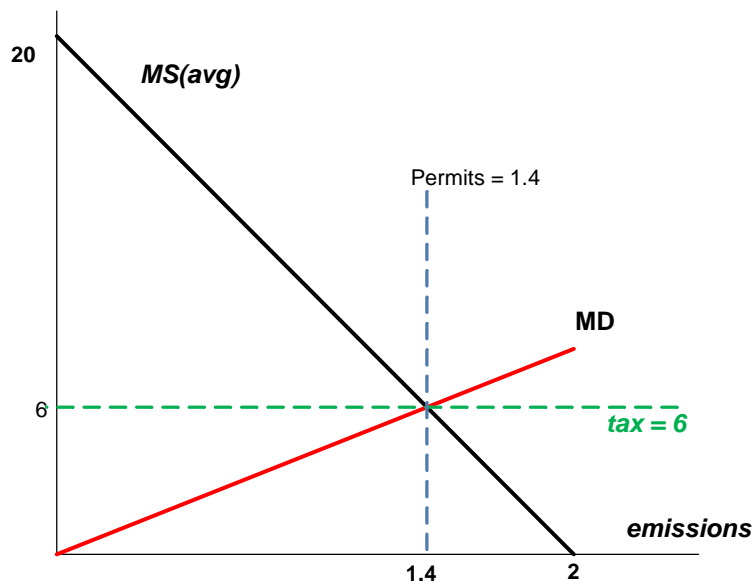
   Graphically, the solution is in Figure 1

3. If the regulator uses $r = 2$ and, in fact, $r = 4$, then the true marginal savings is

$$MS_{High} = 28 - 14e$$

   The optimal emissions would be found where

$$\begin{aligned} 28 - 14e &= 4e \\ e &= 28/18 = 1.56 \end{aligned}$$

$$MS = 28 - 14\,(1.55) = 6.3$$

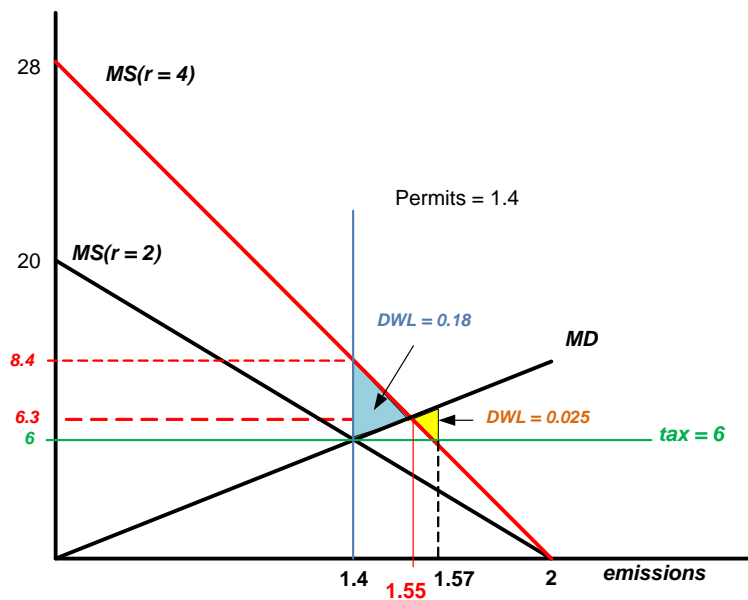The deadweight loss of Permits is $DWL = 0.18$ and the deadweight loss of a tax is $DWL = 0.025$. See figure 2

figure 2