

# Stock Externalities

Sometimes, the damage to society comes not directly from the emissions *flow*, but rather from the ***accumulated stock*** of a pollutant.

A good example is global warming. It is the *stock of accumulated greenhouse gases (GHGs) in the atmosphere* that ultimately causes harm. Furthermore, the *dissipation rate* for accumulated GHGs is very low.

- **stock externality** Accumulated result of action by a producer or consumer which, though not accounted for in the market price, affects other producers or consumers.

Necessary to estimate the ***net (benefits - costs) present value (NPV)*** of the pollution created.

# Stock Buildup and Its Impact



Stock will accumulate, some fraction of the stock,  $\delta$ , will **dissipate** each year.

Assume the stock starts at zero, in the first year, the stock of pollutant ( $S$ ) will be just the amount of that year's **emissions** ( $E$ ):

$$S_1 = E_1$$

In the second year, the stock of pollutant will equal the emissions of that year plus the nondissipated stock from the first year

$$S_2 = E_2 + (1 - \delta)S_1$$

and so on. In general, the stock in any year  $t$  is given by the emissions generated that year plus the nondissipated stock from the previous year:

$$S_t = E_t + (1 - \delta)S_{t-1}$$

If emissions are at a constant annual rate  $E$ , then after  $N$  years, the stock of pollutant will be:

$$S_N = E[1 + (1 - \delta) + (1 - \delta)^2 + \dots + (1 - \delta)^{N-1}]$$

As  $N$  becomes infinitely large, the **stock** will approach the **long-run** equilibrium level  $E/\delta$ .

# NUMERICAL EXAMPLE

Dissipation rate of 2%

Per unit env. damage of 0.001 \$ billion

Per unit cost of reducing emissions 0.015 \$ billion

TABLE 18.1		BUILDUP IN THE STOCK OF POLLUTANT				
YEAR	$E$	$S_t$	DAMAGE (\$ BILLION)	Cost of $E = 0$ (\$ BILLION)	NET BENEFIT (\$ BILLION)	
2010	100	100	0.100	1.5	- 1.400	
2011	100	198	0.198	1.5	-1 .302	
2012	100	296	0.296	1.5	-1 .204	
...	...	...	...	...	...	
2110	100	4.337	4.337	1.5	2.837	
...	...	...	...	...	...	
$\infty$	100	5,000	5.000	1.5	3.500	

Table 18.1 shows the annual **cost** of reducing emissions from 100 units to **zero**, the annual **benefit** from averting damage, and the annual **net benefit** (the annual benefit net of the cost of eliminating emissions).

To determine whether a policy of zero emissions makes sense, we must calculate the net present value of the flow of the annual net benefits. Denoting the **discount rate** by  $R$ , the NPV is:

$$NPV = \frac{(-1.5 + 0.198)}{1 + R} + \frac{(-1.5 + 0.296)}{(1 + R)^2} + \dots + \frac{(-1.5 + 4.337)}{(1 + R)^{99}}$$

**TABLE 18.2** NPV OF “ZERO EMISSIONS” POLICY

		Discount Rate, R				
		.01	.02	.04	.06	.08
Dissipation Rate, $\delta$	.01	108.81	54.07	12.20	-0.03	-4.08
	.02	65.93	31.20	4.49	-3.25	-5.69
	.04	15.48	3.26	-5.70	-7.82	-8.81

Note: Entries in table are NPVs in \$billions. Entries for  $\delta = .02$  correspond to net benefit numbers in Table 18.1.

Table 18.2 shows how the NPV of a “zero emissions” policy depends on the dissipation rate,  $\delta$ , and on R.

If  $\delta$  is **lower**, the accumulated stock of pollutants will reach higher levels and cause greater economic damage; therefore, the **future benefits of present emission reductions will be larger**.

If R is **higher**, the present value of **future net benefits will be lower**, since future benefits are discounted more heavily (“are worth less today”).