Example: Lifecycle Cost of Power Plants

Building a 1 GW power plant around 2011 (earlier fuel prices)

Two options: coal or gas
Expected life: **1-40**
Two types of cost: construction (once) and fuel (annual)
$r = 5\%$

Cost	Coal	Gas
Construction, year 0	$2.8 B	$1.0 B
Annual fuel, years 1-40	$127 M	$161 M

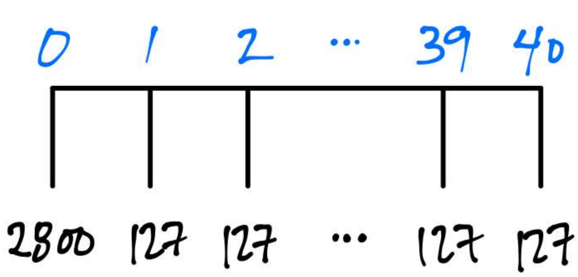
What's the PV cost over the life cycle of each plant?

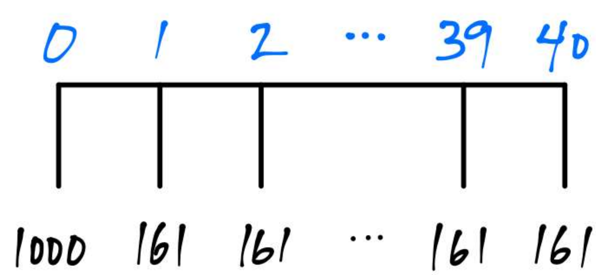
- Known as the *total cost of ownership* (TCO)

Analysis:

Cash flow, in M$:

Coal	Gas





Splitting into construction and fuel:

Construction, M$:

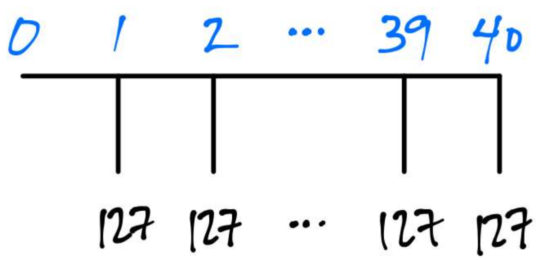
Coal	Gas

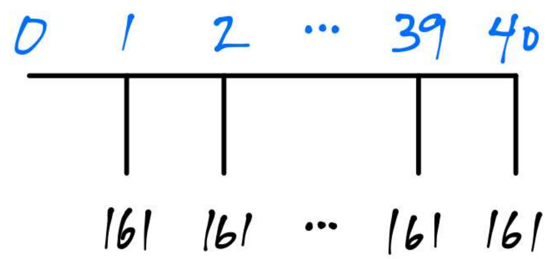
$PV = \$2.8\ B$

$PV = \$1\ B$

Fuel, M$:

Coal	Gas





$$PV = \frac{127}{0.05}\left(1 - \frac{1}{(1.05)^{40}}\right)$$

$$PV = \$2.2\ B$$

$$PV = \frac{161}{0.05}\left(1 - \frac{1}{(1.05)^{40}}\right)$$

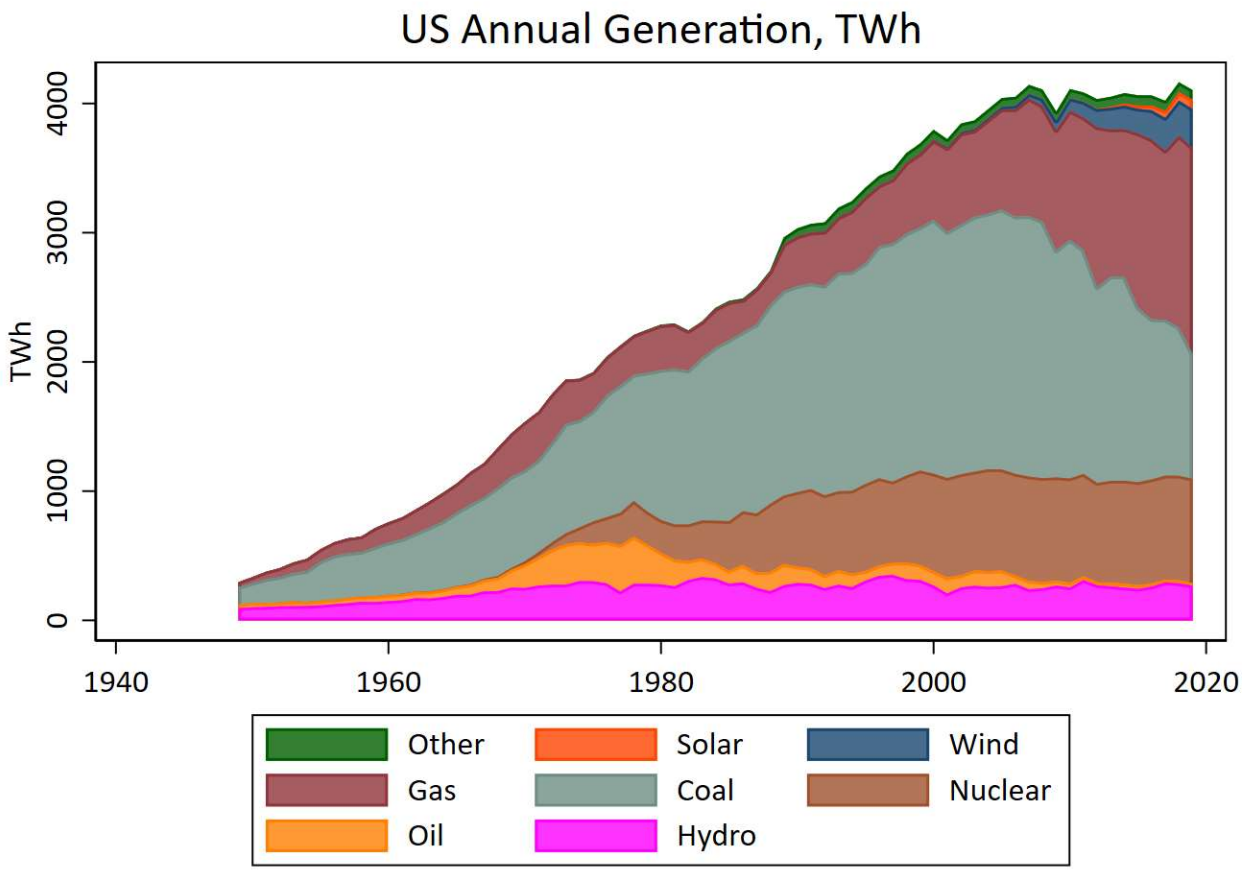
$$PV = \$2.8\ B$$

Combining costs:

Cost	Coal	Gas
Construction	\$2.8 B	\$1.0 B
Fuel	\$2.2 B	\$2.8 B
Total	\$5.0 B	\$3.8 B

- Gas was far cheaper even with the fuel cost premium
- Industry stopped building coal plants more than a decade ago

FYI: gas and renewables have rapidly replaced coal generation



Example: Climate Change Policy

Net PV of an energy tax to reduce CO2 emissions

Tax details from CD case in Exercise 7:
Implemented in year 1 and continued indefinitely
CV = $135 B/year
Revenue = $120 B/year

Avoided damages:
Begin in year 41 and continue indefinitely
$500 B/year

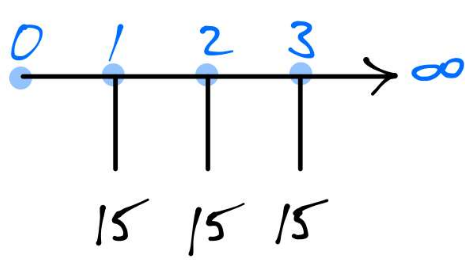
NPV at r = 4%, 5%, and 6%?

Analysis:

Net welfare cost per year:

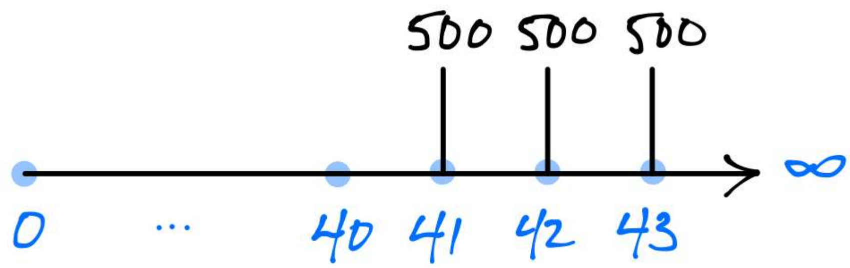
Tax $\Delta SS = -\$135\ B + \$120\ B = -\$15\ B$

Cost cash flow:



$$PV_C = \frac{\$15\ B}{r}$$

Benefit cash flow:



Year 40 lump sum equivalent:

$$PV_{40} = \frac{\$500\ B}{r}$$

PV in year 0:

$$PV_B = \frac{PV_{40}}{(1+r)^{40}}$$

Net PV:

$$NPV = PV_B - PV_C$$

Use Excel to calculate the three cases

Quick preview of spreadsheet:

Global Warming Example

Annual CV of the Energy Tax	$ 135	cv
Annual Revenue from the Tax	$ 120	rev
Annual Damage from Warming (billion)	$ 500	benefit
Years Until Damage Begins	$ 40	delay
Annual Net Cost of the Tax	$ 15	cost = cv - rev

	Interest Rate			
	4%	5%	6%	
PV of costs in year 0	$ 375	$ 300	$ 250	pvc = cost/r
PV of benefits in year 40	$ 12,500	$ 10,000	$ 8,333	lrb = benefit/r
PV of benefits in year 0	$ 2,604	$ 1,420	$ 810	pvb = lrb/(1+r)^delay
NPV of benefits - costs in year 0	$ 2,229	$ 1,120	$ 560	net = pvb - pvc

Tips for using Excel effectively:

- Name cells
- Make input cells distinct
- Include visible versions of formulas
- Format for printing
- Use white space
- Break calculations into steps

Example: Sewer Upgrade

Upgrade combined sewer system to avoid overflows

Construction cost:

$50 M paid at 0

Benefit:

Saves **$5 M/year** in fines and damage from **year 6 on forever**

Finance by issuing a bond:

1. Investors would buy bond from the city for **$50 M in 0**
2. City would make coupon payments of **$3 M/year in 1-20**
3. City would repay the **$50 M principal in year 20**

Evaluation:

Does the overall project have a positive NPV?

City uses r = 5% in NPV calculations

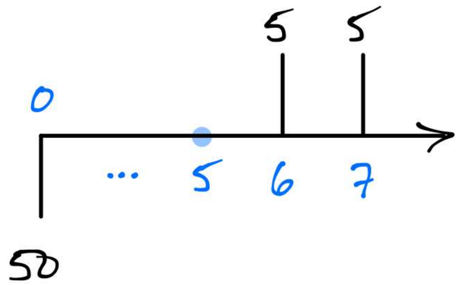
Analysis:

Two logically separate components:

1. **Physical upgrade**: construction, avoided fines and damage
2. **Bond**: cash in at 0, payments out in 1-20

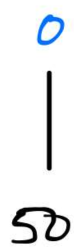
Analyze individually

Physical upgrade:



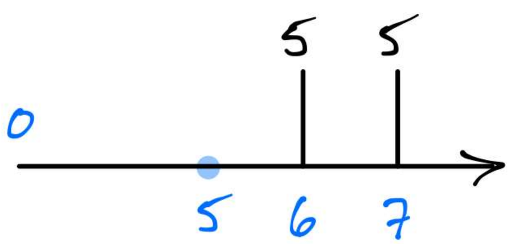
NPV of the physical upgrade?

Cost:



$$PV_C = 50M$$

Benefits:



$$PV_B = \frac{\frac{5\ M}{0.05}}{(1.05)^5}$$

$$PV_B = 78\ M$$

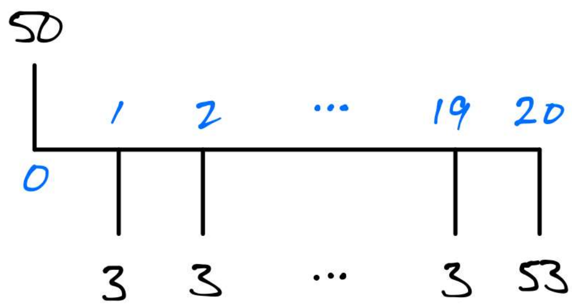
NPV of upgrade:

$$NPV_{up} = PV_B - PV_C$$

$$NPV_{up} = \$78\ M - \$50\ M$$

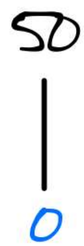
$$NPV_{up} = \$28\ M$$

Bond:



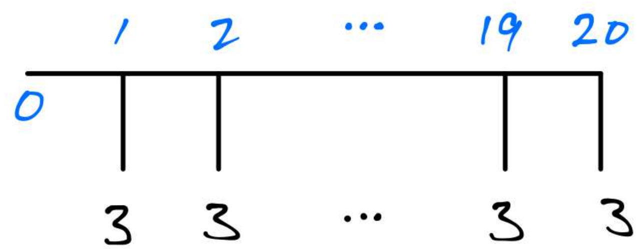
NPV of the bond?

Benefits:



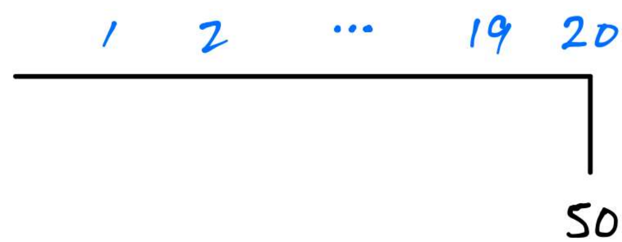
$$PV_B = 50\ M$$

Cost: coupons



$$PV_C^C = \frac{3M}{0.05}\left(1 - \frac{1}{1.05^{20}}\right) = 37\ M$$

Cost: principal:



$$PV_C^P = \frac{50\ M}{1.05^{20}} = 19\ M$$

NPV of bond:

$$NPV_{bond} = PV_B - PV_C^C - PV_C^P$$

$$NPV_{bond} \;=\; \$50\ M \;-\; \$37\ M \;-\; \$19\ M$$

$$NPV_{bond} = \;-\$6\ M$$

Overall project:

$$NPV_{total} = NPV_{up} + NPV_{bond}$$

$$NPV_{total} = \$28M - \$6M$$

$$NPV_{total} = \$22M$$

Positive NPV:

- Gains are more than enough to compensate losers
- Project is efficient: a potential Pareto improvement