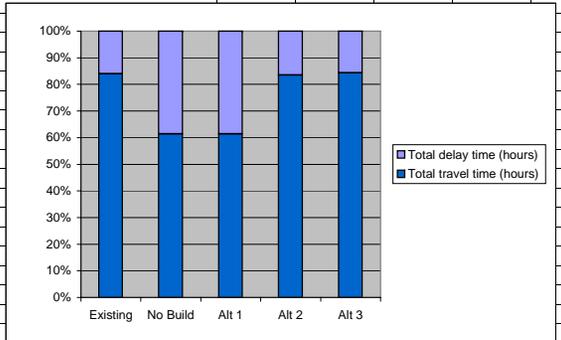
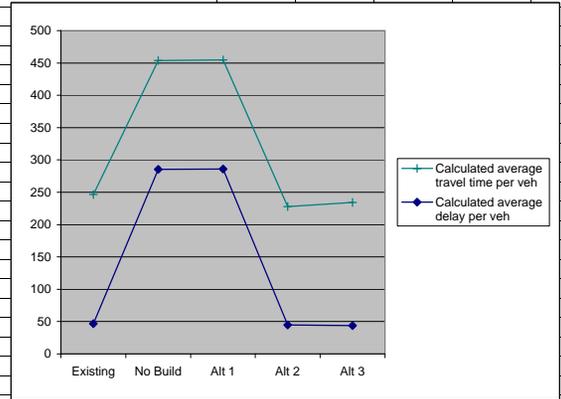


VISSIM RESULTS						
	Existing	No Build	Alt 1	Alt 2	Alt 3	
Vissim Results						
Number of vehicles in network	1,486	3,407	3,283	2,013	1,889	
Number of vehicles that left network	21,432	23,713	23,529	28,469	27,677	
Total vehicles	22,918	27,120	26,812	30,482	29,566	
Total Inputted traffic volume (ConnDOT)		28,210	28,210	28,510	27,620	
Total path distance (mi)	56,462	62,085	61,154	75,413	75,798	VMT
Adjusted VMT		64581	64343	69792	72321	
Average Trip Length		2.29	2.28	2.47	2.56	
Total travel time (hours)	1,569	3,417	3,385	1,930	1,924	VHT
Average speed (mph)	36.0	18.2	31.5	1486.0	1492.5	
Total delay time (hours)	298.2	2148.8	2130.2	380.5	358.3	
Average delay time per vehicle (sec)	46.8	285.2	18.6	1768.3	1790.5	
Total stopped delay (hours)	2.2	283.2	311.6	3.4	0.8	
Average stopped delay per vehicle (sec)	0.3	37.6	41.8	0.4	0.1	
Number of stops	7079	366703	378018	9775	2044	
Average number of stops per vehicle	0.3	13.5	14.1	0.3	0.1	
Checks						
Calculated average speed	36.0	18.2	18.1	39.1	39.4	Distance / Travel time (line 5 / line 6)
Calculated average delay per veh	46.8	285.2	286.0	44.9	43.6	Delay / Vehicles (line 8 in sec / line 4 + line 3)
Calculated average stops per veh	0.3	13.5	14.1	0.3	0.1	Stops / Vehicles (line 12 / line 4 + line 3)
Calculated average travel time per veh	246	454	454	228	234	
Accident runs						
4.5 hour simulation of accident						
Network Performance						
Wed Jan 03 10	14	49	2007			
Simulation time from 0.0 to 16200.0.						

	No Build	NB w/ 30 min accident	Alt 3	Alt 3 w/ 30 min accident		
Number of vehicles in the network, All Vehicle Types	873	901		764	759	
Number of vehicles that have left the network, All Veh	86656	85682		91041	91046	
Total Path Distance, All Vehicle Types (ft)	234087	231307		248113	248016	
Total travel time, All Vehicle Types (h)	9703	10342		5765	5823	
Average speed, All Vehicle Types (m)	24	22		43	43	
Total delay time, All Vehicle Types (h)	4927	5617		743	790	
Average delay time per vehicle, All Vehicle Types (ft)	203	234		29	31	
Total stopped delay, All Vehicle Types (h)	552	919		2	6	
Average stopped delay per vehicle, All Vehicle Types	23	38		0	0	
Number of Stops, All Vehicle Types	757383	924316		4199	11886	
Average number of stops per vehicles, All Vehicle Typ	9	11		0	0	

		639			58	
				3938		
				4519		
Evaluation table						
Off Peak Analysis						
Network Performance						
Thu Jan 04 14	5	22	2007			
Simulation time from 1800.0 to 5400.0.						

		No Build	Alt 1	Alt 2	Alt 3	
Number of vehicles in the network, All Vehicle Types		1274	1191	1110	1116	
Number of vehicles that have left the network, All Vehicle Types		18256	18332	18458	18085	
Total Path Distance, All Vehicle Types		49700	49768	48895	49663	
Total travel time, All Vehicle Types		1228	1232	1102	1151	
Average speed, All Vehicle Types		40	40	44	43	
Total delay time, All Vehicle Types		201	203	95	124	
Average delay time per vehicle, All Vehicle Types		37	37	18	23	
Total stopped delay, All Vehicle Types		0	1	0	0	
Average stopped delay per vehicle, All Vehicle Types		0	0	0	0	
Number of Stops, All Vehicle Types		873	1259	339	299	
Average number of stops per vehicles, All Vehicle Types		0	0	0	0	



HIGHWAY EMISSIONS FACTORS (g/mi)						
Model Year 2023						
1.10231E-06						
Mode	Speed	CO	NO _x	PM ₁₀	SO _x	VOC
Auto	5	2.57	0.23	0.12	0.01	0.31
	6	2.53	0.23	0.11	0.01	0.29
	7	2.48	0.22	0.10	0.01	0.28
	8	2.43	0.21	0.10	0.01	0.27
	9	2.38	0.21	0.09	0.01	0.26
	10	2.33	0.20	0.08	0.01	0.24
	11	2.29	0.20	0.08	0.01	0.23
	12	2.25	0.19	0.07	0.01	0.23
	13	2.20	0.19	0.07	0.01	0.22
	14	2.16	0.18	0.07	0.01	0.21
	15	2.12	0.18	0.06	0.01	0.20
	16	2.09	0.18	0.06	0.01	0.20
	17	2.05	0.17	0.06	0.01	0.20
	18	2.02	0.17	0.06	0.01	0.19
	19	1.99	0.17	0.05	0.01	0.19
	20	1.95	0.16	0.05	0.01	0.18
	21	1.92	0.16	0.05	0.01	0.18
	22	1.90	0.16	0.05	0.01	0.18
	23	1.87	0.16	0.05	0.01	0.17
	24	1.84	0.15	0.04	0.01	0.17
	25	1.81	0.15	0.04	0.00	0.17
	26	1.79	0.15	0.04	0.00	0.17
	27	1.77	0.15	0.04	0.00	0.16
	28	1.74	0.15	0.04	0.00	0.16
	29	1.72	0.14	0.04	0.00	0.16
	30	1.70	0.14	0.04	0.00	0.16
	31	1.68	0.14	0.04	0.00	0.16
	32	1.66	0.14	0.04	0.00	0.16
	33	1.64	0.14	0.04	0.00	0.16
	34	1.62	0.14	0.04	0.00	0.16
	35	1.60	0.14	0.04	0.00	0.15
	36	1.58	0.13	0.04	0.00	0.15
	37	1.57	0.13	0.03	0.00	0.15
	38	1.55	0.13	0.03	0.00	0.15
	39	1.54	0.13	0.03	0.00	0.15
	40	1.52	0.13	0.03	0.00	0.15
	41	1.51	0.13	0.03	0.00	0.15
	42	1.49	0.13	0.03	0.00	0.15
	43	1.48	0.13	0.03	0.00	0.15
	44	1.47	0.13	0.03	0.00	0.15
	45	1.45	0.13	0.03	0.00	0.15
	46	1.44	0.13	0.03	0.00	0.15
	47	1.43	0.13	0.03	0.00	0.15
	48	1.42	0.13	0.03	0.00	0.15
	49	1.41	0.13	0.03	0.00	0.15
	50	1.41	0.13	0.03	0.00	0.15
	51	1.40	0.13	0.03	0.00	0.15
	52	1.39	0.13	0.03	0.00	0.15
	53	1.38	0.13	0.03	0.00	0.15
	54	1.38	0.13	0.03	0.00	0.15
	55	1.37	0.13	0.03	0.00	0.15
	56	1.37	0.13	0.03	0.00	0.15
	57	1.37	0.14	0.03	0.00	0.15
	58	1.36	0.14	0.03	0.00	0.15
	59	1.36	0.14	0.03	0.00	0.15
	60	1.36	0.14	0.03	0.00	0.15
	61	1.36	0.14	0.03	0.00	0.15
	62	1.36	0.14	0.03	0.00	0.16
	63	1.36	0.14	0.03	0.00	0.16
	64	1.37	0.14	0.03	0.00	0.16
	65	1.37	0.15	0.03	0.00	0.16

Source: California Air Resources Board EMFAC2002, V2.2 Burden Area Planning

HEALTH COST OF TRANSPORTATION EMISSIONS						
(\$/ton)						
Area	Proj Loc	CO	NO _x	PM ₁₀	SO _x	VOC
LA/South Coas	1	\$121	\$48,983	\$401,257	\$150,757	\$3,045
CA Urban Area	2	\$63	\$14,339	\$115,859	\$57,867	\$1,002
CA Rural Area	3	\$57	\$10,659	\$82,612	\$41,750	\$787

Source: McCubbin and Delucchi, 1996

**Table 5
Useful Life (years)**

Preliminary Engineering	0
Right of Way	
Land	100
Buildings	0 - 100 ^(a)
Major Structures	60
Grading & Drainage	50
Sub-Base and Base	40
Surface	25

(a) Buildings that are acquired and demolished have a useful life of zero years. Buildings that are not demolished have a useful life of 100 years.

Table 4 Example Total Highway User Benefit Tallying Spreadsheet

Year	PRESENT VALUE OF USER BENEFITS ^(c)			Present Value of Total User Benefits ^(c)	
	VMT Benefits ^(a)	VHT Benefits ^(a)	Accident Reduction Savings ^{(b) (c)}		
2011	1	\$5,373,985	\$22,348,044	\$4,079,014	\$ 31,801,043
2012	2	\$5,222,834	\$24,238,203	\$3,774,352	\$ 33,233,189
2013	3	\$5,075,548	\$26,049,598	\$3,485,831	\$ 34,610,775
2014	4	\$4,932,800	\$27,790,302	\$3,212,120	\$ 35,935,022
2015	5	\$4,793,880	\$29,460,334	\$2,953,122	\$ 37,207,136
2016	6	\$4,658,872	\$31,061,888	\$2,707,967	\$ 38,428,308
2017	7	\$4,527,467	\$32,598,229	\$2,476,018	\$ 39,599,712
2018	8	\$4,399,957	\$34,065,893	\$2,258,858	\$ 40,722,508
2019	9	\$4,276,038	\$35,472,493	\$2,049,300	\$ 41,797,832
2020	10	\$4,155,809	\$36,817,818	\$1,853,388	\$ 42,826,813
2021	11	\$4,038,572	\$38,103,804	\$1,668,382	\$ 43,810,559
2022	12	\$3,924,831	\$39,331,558	\$1,493,770	\$ 44,750,159
2023	13	\$3,814,294	\$40,503,338	\$1,329,059	\$ 45,646,690
2024	14	\$3,706,889	\$41,620,560	\$1,173,779	\$ 46,501,208
2025	15	\$3,602,470	\$42,684,802	\$1,027,482	\$ 47,314,754
2026	16	\$3,501,011	\$43,697,803	\$889,737	\$ 48,088,352
2027	17	\$3,402,410	\$44,660,465	\$760,133	\$ 48,823,008
2028	18	\$3,306,586	\$45,574,849	\$638,277	\$ 49,519,712
2029	19	\$3,213,460	\$46,442,185	\$523,794	\$ 50,179,438
2030	20	\$3,122,957	\$47,263,862	\$416,323	\$ 50,803,142
2011-2030		\$83,049,848	\$729,781,406	\$38,768,303	\$ 851,599,358

- (a) All daily VMT and VHT data was derived using a transportation forecast model of this region.
- (b) Statewide crash data for each facility type was gathered from Mn/DOT sources for a three year period from 1999-2001. This data was used to find a crash rate per 100 million vehicle miles and severity distribution. These two factors were used to estimate crash data benefits for 2011 and 2030 (Positive benefits are obtained because the Alternative shifted VMT to facilities with lower crash rates and severity distribution as compared to the Base Case).
- (c) Present value of savings during the life of the project in terms of 2004 dollars.

Table 6 Calculate Total Present Cost for the Base Case and Alternative(s)

Year	PRESENT VALUE OF COSTS ^(d)				Present Value of Net Annual Costs ^{(e) (f) (g)}			
	Capital Cost ^(h)		Maintenance Cost ^(h)			Remaining Capital Value ⁽ⁱ⁾		
	Base Case	Alternative	Base Case	Alternative	Base Case	Alternative		
2008	-	\$0	\$94,115,754	\$0	\$0	\$0	\$94,115,754	
2009	-	\$0	\$90,933,096	\$0	\$0	\$0	\$90,933,096	
2010	-	\$0	\$87,859,064	\$0	\$0	\$0	\$87,859,064	
2011	1	\$0	\$0	\$391,887	\$218,226	\$0	-\$173,662	
2012	2	\$0	\$0	\$378,635	\$210,845	\$0	-\$167,789	
2013	3	\$0	\$0	\$384,120	\$203,716	\$0	-\$180,404	
2014	4	\$0	\$0	\$353,460	\$196,827	\$0	-\$156,633	
2015	5	\$0	\$0	\$341,507	\$190,171	\$0	-\$151,336	
2016	6	\$0	\$0	\$329,959	\$183,740	\$0	-\$146,218	
2017	7	\$0	\$0	\$470,084	\$177,527	\$0	-\$292,557	
2018	8	\$0	\$0	\$448,041	\$171,523	\$0	-\$276,518	
2019	9	\$0	\$0	\$297,604	\$165,723	\$0	-\$131,881	
2020	10	\$7,497,177	\$0	\$37,080	\$160,119	\$0	-\$7,374,138	
2021	11	\$7,243,649	\$0	\$27,075	\$154,704	\$0	-\$7,116,019	
2022	12	\$0	\$0	\$268,421	\$149,473	\$0	-\$118,949	
2023	13	\$0	\$0	\$259,344	\$144,418	\$0	-\$114,926	
2024	14	\$0	\$0	\$250,574	\$139,534	\$0	-\$111,040	
2025	15	\$0	\$0	\$242,101	\$134,816	\$0	-\$107,285	
2026	16	\$0	\$0	\$503,821	\$130,257	\$0	-\$373,564	
2027	17	\$0	\$0	\$226,004	\$125,852	\$0	-\$100,152	
2028	18	\$0	\$0	\$218,361	\$121,595	\$0	-\$96,765	
2029	19	\$0	\$0	\$364,368	\$117,484	\$0	-\$246,883	
2030	20	\$0	\$0	\$203,842	\$113,511	\$9,673,099	-\$91,944,562	
2011-2030		\$14,740,826	\$272,906,915	\$5,996,285	\$3,210,064	\$9,673,099	\$91,944,562	\$ 173,108,493

- (a) Assumes construction in 2020-2021 for Base Case and 2008-2010 for Alt. Initial capital costs were brought back to 2004 to determine present value.
- (b) Annual costs consist of roadway and bridge maintenance. For the Base Condition, major maintenance costs are added to routine maintenance costs in scheduled years (Minnesota only).
- (c) Assumes base year for remaining capital value as 2030. Remaining value in constant dollars was brought back from 2030 to 2004 to determine present value.
- (d) Present value of costs during the life of the project in terms of 2004 dollars.
- (e) Net cost is the difference between the Base Case and the Alternative.
- (f) Remaining capital value was considered a reduction of cost in this analysis and was subtracted from construction and maintenance costs to obtain a net cost.

TRAVEL TIME BENEFITS								
			Constants	Existing	No Build	Alt 1	Alt 2	Alt 3
Travel Time								
VHT Estimates (Based on a 12 hour day)								
Peak Period								
	Peak Hour VHT (hours) - from VISSIM			1569	3417	3385	1930	1924
	Difference in VHT from No Build					-32	-1486	-1493
	Length of peak period (hrs)			5	10	10	5	5
	Peak Period VHT saved (hours)					-315	-7430	-7463
Off-Peak Period								
	Off-Peak Hour VHT (hours) - from VISSIM				1228	1232	1102	1151
	Difference in VHT from No Build					4	-127	-77
	Length of Off-Peak Period			11	6	6	11	11
	Off Peak Period VHT saved					25	-1392	-851
Daily (12 Hour) Period								
	Daily VHT				41535	41245	21772	22281
	Daily Savings					-290	-19,763	-19,254
Value of Time								
	Average Peak hour VOT for Autos (\$/hr)	\$	12.37					
	Average Vehicle Occupancy	\$	1.20	Assumption?				
	Average Peak VOT for Trucks (\$/hr)	\$	27.83					
	Percent Trucks		5.0%					
	Number of Working days per year		260					
Calculations								
	Auto Benefits					\$1,064,874	\$72,461,569	\$70,594,688
	Truck Benefits					\$105,078	\$7,150,241	\$6,966,024
	Total Travel Time Benefits					\$1,169,952	\$79,611,811	\$77,560,712

SAFETY BENEFITS							
		0 Existing	No Build	Alt 1	Alt 2	Alt 3	
Accident Reduction Benefits							
Daily Volume (sum CDOT daily network inputs)			301200	301200	301200	301200	From ConnDOT Daily counts
Daily VMT			689,534	686,990	745,170	772,180	Line 3 x calculated average trip length
Peak Hour VMT			64,581	64,343	69,792	72,321	From VISSIM
# Fatalities per year		1					
Fatality Rate (acc/million veh mi)			0.0040	0.0040	0.0030	0.0030	Reduction based on TRB research (23.7%)
Fatality Cost	\$	3,262,459	\$3,262,459	\$3,262,459	\$2,489,256	\$2,489,256	
	Savings			\$0	\$773,203	\$773,203	
# Injuries per year	\$	108					
Injury Rate			0.4291	0.4291	0.3274	0.3274	Reduction based on TRB research (23.7%)
Injury Cost	\$	85,716	\$9,257,322	\$9,257,322	\$7,063,337	\$7,063,337	
	Savings			\$0	\$2,193,985	\$2,193,985	
# PDO per year	\$	388					
PDO Rate			1.5416	1.5416	1.1763	1.1763	Reduction based on TRB research (23.7%)
PDO Cost	\$	7,198	\$2,792,816	\$2,792,816	\$2,130,919	\$2,130,919	
	Savings			\$0	\$661,897	\$661,897	
	Total Savings			\$0	\$3,629,085	\$3,629,085	
VHT Reduction Benefits							
VHT due to accidents (hours)			639	639	58	58	
Accident rate reduction factor			1.00	0.95	0.76	0.76	Reduction based on TRB research (23.7%)
			1.6370	1.5552	1.2490	1.2490	
I-84 accidents/year			287.5	287.5	287.5	287.5	412 accidents on I-84 per year - evenly split by direction
Annual VHT due to accident			183,644	174,462	12,627	12,627	163 accidents on I-84 mainline
Annual Savings				-9,182	-171,018	-171,018	249 accidents on I-84 ramps
Average Peak hour VOT for Autos (\$/hr)	\$	12.37					
Average Vehicle Occupancy	\$	1.15					
Average Peak VOT for Trucks (\$/hr)	\$	27.83					
Percent Trucks		5.0%					
Auto Benefits				\$124,091	\$2,311,171	\$2,311,171	
Truck Benefits				\$12,777	\$237,973	\$237,973	
Total Travel Time Benefits				\$136,868	\$2,549,144	\$2,549,144	
Total Safety Benefits				\$136,868	\$6,178,230	\$6,178,230	

OPERATING COST BENEFITS												
	Constants	Existing	No Build	Alt 1	Alt 2	Alt 3						
Vehicle Operating Costs												
Daily Volume (sum CDOT daily network inputs)			301,200	301,200	301,200	301,200	From ConnDOT Daily counts					
Daily VMT			689,534	686,990	745,170	772,180	Line 3 x calculated average trip length					
Peak Hour VMT		56,462	62,085	61,154	75,413	75,798						
Length of peak period (hrs)		5	10	10	5	5						
Length of Off-Peak Period		11	6	6	11	11						
Peak Average Speed (mph)		36.0	18.2	18.1	39.1	39.4						
Off Peak Average Speed (mph)		45.0	45.0	45.0	45.0	45.0						
Peak Fuel Consumption (gal/mi) - Autos		0.045	0.076	0.076	0.043	0.043	Per Cal-BC Table					
Off Peak Fuel Consumption - Autos		0.041	0.041	0.041	0.041	0.041						
Peak Fuel Consumption (gal/mi) - Trucks		0.154	0.174	0.174	0.152	0.152						
Off Peak Fuel Consumption - Trucks		0.151	0.151	0.151	0.151	0.151						
Fuel Price (\$/gal)	\$	2.55					Per Cal-BC : What is fuel price in CT?					
Non-Fuel Cost Per Mile - Autos	\$	0.17					Per Cal-BC : What is non-fuel cost in CT?					
Non-Fuel Cost Per Mile - Trucks	\$	0.30										
Percent Trucks		5.0%										
Number of Working days per year		260										
Fuel Cost - Auto			\$45,946,102	\$45,456,630	\$27,317,872	\$28,051,965	Fuel Cost = VMT x Fuel Consumption x Fuel Price					
Fuel Cost - Truck			\$6,731,994	\$6,670,130	\$5,265,730	\$5,409,046						
Non-Fuel Cost - Auto			\$30,961,982	\$30,511,014	\$11,323,364	\$11,421,622	Non-Fuel Cost = VMT x Cost Per Mile					
Non-Fuel Cost - Truck			\$3,953,649	\$3,898,925	\$2,300,040	\$2,325,460						
Peak Hour Vehicle Operating Cost			\$87,593,727	\$75,967,644	\$46,207,006	\$47,208,093	Cost = Fuel Cost + Non-Fuel Cost					
Peak Hour Vehicle Operating Cost Savings vs No Build				\$11,626,083	\$41,386,721	\$40,385,634						

SALVAGE

Alternatives Estimate of Remaining Capital Value I-84 Interchange Project January 2007

	(input)	
Total Analysis Period (years)		20
Construction Timeframe (years)		5
Net Analysis Period		15
Assumed Discount Rate		1.00%

Cost Element	Estimated Current Cost (2005-2006)	Useful Life (yrs.)	
Alternative 1			
Right-of-Way	\$24,000,000	100	\$20,400,000
Structures	\$27,580,800	60	\$20,685,600
Grading/Drainage	\$239,763	50	\$167,834
Sub-base and Base	\$2,593	40	\$1,621
Surface	\$35,344,106	25	\$14,137,643
TOTAL	\$87,167,262		\$55,392,697
Alternative 2			
Right-of-Way	\$92,000,000	100	\$78,200,000
Structures	\$526,646,568	60	\$394,984,926
Grading/Drainage	\$101,259,800	50	\$70,881,860
Sub-base and Base	\$4,355,774	40	\$2,722,359
Surface	\$23,870,053	25	\$9,548,021
TOTAL	\$748,132,195		\$556,337,166
Alternative 3			
Right-of-Way	\$110,000,000	100	\$93,500,000
Structures	\$506,543,533	60	\$379,907,650
Grading/Drainage	\$106,972,200	50	\$74,880,540
Sub-base and Base	\$4,602,508	40	\$2,876,567
Surface	\$25,201,614	25	\$10,080,645
TOTAL	\$753,319,854		\$561,245,402

ALT 1

GENERIC BENEFIT-COST MODEL

This model can be modified to include any number of benefits and costs and any number of years. The discount rate can also be changed. The example below shows how it can be used to calculate net present value and the benefit-cost ratio.

The examples further below show how to calculate the internal rate of return, cost-effectiveness and payback period.

Discount rate = 7%

Year	Benefits					Costs			Discount Factor	Discounted Total Benefits	Discounted Total Costs			
	Travel Time	Safety	Operating	Emission	Total Benefits	Capital	Maintenance	Total Costs						
0	2007				\$0	\$0	\$0	\$0	1.00	\$0	\$0			
1	2008				\$0	\$0	\$0	\$0	0.94	\$0	\$0			
2	2009				\$0	\$0	\$0	\$0	0.88	\$0	\$0			
3	2010				\$0	\$0	\$0	\$0	0.83	\$0	\$0			
4	2011				\$0	\$0	\$0	\$0	0.78	\$0	\$0			
5	2012				\$0	\$0	\$0	\$0	0.73	\$0	\$0			
6	2013				\$0	\$0	\$0	\$0	0.69	\$0	\$0			
7	2014				\$0	\$0	\$0	\$0	0.64	\$0	\$0			
8	2015				\$0	\$0	\$0	\$0	0.60	\$0	\$0			
9	2016				\$0	\$0	\$0	\$0	0.57	\$0	\$0			
10	2017				\$0	\$0	\$0	\$0	0.53	\$0	\$0			
11	2018				\$0	\$0	\$0	\$0	0.50	\$0	\$0			
12	2019				\$0	\$0	\$0	\$0	0.47	\$0	\$0			
13	2020				\$0	\$0	\$0	\$0	0.44	\$0	\$0			
14	2021				\$0	\$0	\$0	\$0	0.41	\$0	\$0			
15	2022				\$0	\$0	\$0	\$0	0.39	\$0	\$0			
16	2023				\$0	\$0	\$0	\$0	0.37	\$0	\$0			
17	2024				\$0	\$0	\$0	\$0	0.34	\$0	\$0			
18	2025				\$0	\$76,847,102	\$37,561	\$76,884,663	0.32	\$0	\$24,748,380			
19	2026				\$0	\$76,847,102	\$37,561	\$76,884,663	0.30	\$0	\$23,237,916			
20	2027				\$0	\$76,847,102	\$37,561	\$76,884,663	0.28	\$0	\$21,819,639			
21	2028				\$0	\$76,847,102	\$37,561	\$76,884,663	0.27	\$0	\$20,487,924			
22	2029				\$0	\$76,847,102	\$37,561	\$76,884,663	0.25	\$0	\$19,237,487	Benefit reduction over time	0.01	
23	2030	\$1,169,952	\$136,868	\$11,626,083	\$28,257	\$12,961,159	\$0	\$37,561	0.23	\$3,045,109	\$8,825	0	1.00	1.00
24	2031	\$1,158,368	\$135,513	\$11,510,973	\$27,977	\$12,832,831	\$0	\$37,561	0.22	\$2,830,948	\$8,286	1	1.01	0.99
25	2032	\$1,146,900	\$134,171	\$11,397,003	\$27,700	\$12,705,773	\$0	\$37,561	0.21	\$2,631,849	\$7,780	2	1.02	0.98
26	2033	\$1,135,544	\$132,842	\$11,284,162	\$27,426	\$12,579,974	\$0	\$37,561	0.19	\$2,446,752	\$7,305	3	1.03	0.97
27	2034	\$1,124,301	\$131,527	\$11,172,437	\$27,154	\$12,455,419	\$0	\$37,561	0.18	\$2,274,673	\$6,860	4	1.04	0.96
28	2035	\$1,113,169	\$130,225	\$11,061,819	\$26,885	\$12,332,099	\$0	\$37,561	0.17	\$2,114,696	\$6,441	5	1.05	0.95
29	2036	\$1,102,148	\$128,936	\$10,952,296	\$26,619	\$12,209,999	\$0	\$37,561	0.16	\$1,965,970	\$6,048	6	1.06	0.94
30	2037	\$1,091,236	\$127,659	\$10,843,857	\$26,355	\$12,089,107	\$0	\$37,561	0.15	\$1,827,705	\$5,679	7	1.07	0.93
31	2038	\$1,080,431	\$126,395	\$10,736,493	\$26,095	\$11,969,413	\$0	\$37,561	0.14	\$1,699,163	\$5,332	8	1.08	0.92
32	2039	\$1,069,734	\$125,144	\$10,630,191	\$25,836	\$11,850,904	\$0	\$37,561	0.13	\$1,579,662	\$5,007	9	1.09	0.91
33	2040	\$1,059,142	\$123,905	\$10,524,941	\$25,580	\$11,733,569	\$0	\$37,561	0.13	\$1,468,565	\$4,701	10	1.10	0.91
34	2041	\$1,048,656	\$122,678	\$10,420,734	\$25,327	\$11,617,395	\$0	\$37,561	0.12	\$1,365,281	\$4,414	11	1.12	0.90
35	2042	\$1,038,273	\$121,463	\$10,317,558	\$25,076	\$11,502,371	\$0	\$37,561	0.11	\$1,269,261	\$4,145	12	1.13	0.89
36	2043	\$1,027,993	\$120,261	\$10,215,404	\$24,828	\$11,388,486	\$0	\$37,561	0.10	\$1,179,995	\$3,892	13	1.14	0.88
37	2044	\$1,017,815	\$119,070	\$10,114,262	\$24,582	\$11,275,729	\$0	\$37,561	0.10	\$1,097,006	\$3,654	14	1.15	0.87
38	2045	\$1,007,738	\$117,891	\$10,014,120	\$24,339	\$11,164,088	-\$55,392,697	-\$55,392,697	0.09	\$1,019,854	-\$5,060,197	15	1.16	0.86
Totals		\$17,391,401	\$2,034,546	\$172,822,333	\$420,036	\$192,668,316	\$328,842,815	\$751,220	\$329,594,035		\$29,816,489	\$104,559,518		

Benefit/cost ratio = 0.29
Net present value = -\$74,743,029

Internal Rate of Return

Use the same spreadsheet but adjust the discount rate until the total discounted benefits equal the total discounted costs. This discount rate will be the internal rate of return

Discount rate = 36.83%

Year	Benefits			Costs			Discount Factor	Discounted Total Benefits	Discounted Total Costs
	Benefit 1	Benefit 2	Total Benefits	Cost 1	Cost 2	Total Costs			
0	\$50,000	\$1,000	\$51,000	\$100,000	\$7,500	\$107,500	1.00	\$51,000	\$107,500
1	\$50,000	\$1,000	\$51,000	\$50,000	\$5,000	\$55,000	0.73	\$37,273	\$40,196
2	\$50,000	\$1,000	\$51,000	\$1,000	\$2,000	\$3,000	0.53	\$27,240	\$1,602
3	\$50,000	\$1,000	\$51,000	\$1,000	\$0	\$1,000	0.39	\$19,908	\$390
4	\$50,000	\$1,000	\$51,000	\$1,000	\$0	\$1,000	0.29	\$14,549	\$285
Totals		\$250,000	\$5,000	\$255,000	\$153,000	\$14,500		\$149,970	\$149,974

Result

Internal rate of return = 37%

Cost-effectiveness

To determine the cost to obtain a given benefit, use only the cost portion of the spreadsheet. Enter the given benefit in cell H54.

Discount rate = 3%

Total discounted benefit = \$100,000 units of benefit (can be in dollars, tons of emissions removed, or any other metric)

Year	Costs			Discount Factor	Discounted Total
	Cost 1	Cost 2	Total Costs		
0	\$50,000	\$1,000	\$51,000	1.00	\$51,000
1	\$50,000	\$1,000	\$51,000	0.97	\$49,515
2	\$50,000	\$1,000	\$51,000	0.94	\$48,072
3	\$50,000	\$1,000	\$51,000	0.92	\$46,672
4	\$50,000	\$1,000	\$51,000	0.89	\$45,313
Totals		\$250,000	\$5,000		\$240,572

Result

Cost-effectiveness = + F63/H54 = \$2.41 per unit of benefit

To determine the benefit from the investment of a given cost, use only the benefit portion of the spreadsheet. Enter the given cost in cell H54.

Discount rate = 3%

Total discounted cost = \$200,000

Year	Benefits (any type of unit)			Discount Factor	Discounted Total Costs
	Benefit 1	Benefit 2	Total Benefits		
0	\$100,000	\$7,500	\$107,500	1.00	\$107,500
1	\$50,000	\$5,000	\$55,000	0.97	\$53,398
2	\$1,000	\$2,000	\$3,000	0.94	\$2,828
3	\$1,000	\$0	\$1,000	0.92	\$915
4	\$1,000	\$0	\$1,000	0.89	\$888
Totals		\$153,000	\$14,500		\$165,529

Result

Cost-effectiveness = F82/H73 = 0.83 units of benefit per dollar

Payback Period

The payback period is the number of years until the total benefits exceed the total costs

Discount rate = 3%

Year	Benefits			Costs			Discount Factor	Discounted Total Benefits	Discounted Total Costs	Payback Period Cumulative Benefits minus Costs
	Benefit 1	Benefit 2	Total Benefits	Cost 1	Cost 2	Total Costs				
0	\$50,000	\$1,000	\$51,000	\$100,000	\$7,500	\$107,500	1.00	\$51,000	\$107,500	-\$56,500
1	\$50,000	\$1,000	\$51,000	\$50,000	\$5,000	\$55,000	0.97	\$49,515	\$53,398	-\$60,383
2	\$50,000	\$1,000	\$51,000	\$1,000	\$2,000	\$3,000	0.94	\$48,072	\$2,828	-\$15,139
3	\$50,000	\$1,000	\$51,000	\$1,000	\$0	\$1,000	0.92	\$46,672	\$915	\$30,618
4	\$50,000	\$1,000	\$51,000	\$1,000	\$0	\$1,000	0.89	\$45,313	\$888	\$75,043
Totals		\$250,000	\$5,000	\$255,000	\$153,000	\$14,500		\$240,572	\$165,529	

Result The payback period is between 2 and 3 years

ALT 2

GENERIC BENEFIT-COST MODEL

This model can be modified to include any number of benefits and costs and any number of years. The discount rate can also be changed. The example below shows how it can be used to calculate net present value and the benefit-cost ratio.

The examples further below show how to calculate the internal rate of return, cost-effectiveness and payback period.

Discount rate = 7%

Year	Benefits					Costs			Discount Factor	Discounted Total Benefits	Discounted Total Costs														
	Travel Time	Safety	Operating	Emission	Total Benefits	Capital	Maintenance	Total Costs																	
0	2007				\$0	\$0	-\$793,393	-\$793,393	1.00	\$0	-\$793,393														
1	2008				\$0	\$0	-\$1,221,508	-\$1,221,508	0.94	\$0	-\$1,146,956														
2	2009				\$0	\$0	-\$1,707,109	-\$1,707,109	0.88	\$0	-\$1,505,088														
3	2010				\$0	\$0	-\$2,244,053	-\$2,244,053	0.83	\$0	-\$1,857,737														
4	2011				\$0	\$0	-\$2,827,830	-\$2,827,830	0.78	\$0	-\$2,198,138														
5	2012				\$0	\$0	-\$3,454,946	-\$3,454,946	0.73	\$0	-\$2,521,699														
6	2013				\$0	\$0	-\$4,122,589	-\$4,122,589	0.69	\$0	-\$2,825,351														
7	2014				\$0	\$0	-\$4,828,433	-\$4,828,433	0.64	\$0	-\$3,107,127														
8	2015				\$0	\$0	-\$5,570,514	-\$5,570,514	0.60	\$0	-\$3,365,878														
9	2016				\$0	\$0	-\$6,347,140	-\$6,347,140	0.57	\$0	-\$3,601,071														
10	2017				\$0	\$0	-\$7,156,839	-\$7,156,839	0.53	\$0	-\$3,812,635														
11	2018				\$0	\$0	-\$7,998,311	-\$7,998,311	0.50	\$0	-\$4,000,853														
12	2019				\$0	\$0	-\$8,870,398	-\$8,870,398	0.47	\$0	-\$4,166,274														
13	2020				\$0	\$0	-\$9,772,062	-\$9,772,062	0.44	\$0	-\$4,309,643														
14	2021				\$0	\$0	-\$10,702,362	-\$10,702,362	0.41	\$0	-\$4,431,851														
15	2022				\$0	\$0	-\$11,660,441	-\$11,660,441	0.39	\$0	-\$4,533,889														
16	2023				\$0	\$0	-\$12,645,518	-\$12,645,518	0.37	\$0	-\$4,616,820														
17	2024				\$0	\$0	-\$13,656,872	-\$13,656,872	0.34	\$0	-\$4,681,747														
18	2025				\$0	\$292,853,476	\$30,191	\$292,883,667	0.32	\$0	\$94,276,231														
19	2026				\$0	\$292,853,476	\$30,191	\$292,883,667	0.30	\$0	\$88,522,283														
20	2027				\$0	\$292,853,476	\$30,191	\$292,883,667	0.28	\$0	\$83,119,515														
21	2028				\$0	\$292,853,476	\$30,191	\$292,883,667	0.27	\$0	\$78,046,493														
22	2029				\$0	\$292,853,476	\$30,191	\$292,883,667	0.25	\$0	\$73,283,092	Benefit reduction over time	0.01												
23	2030	\$79,611,811	\$6,178,230	\$41,386,721	\$936,800	\$128,113,562	\$0	\$30,191	\$30,191	0.23	\$30,099,143	\$7,093	0	1.00	1.00										
24	2031	\$78,823,575	\$6,117,059	\$40,976,952	\$927,525	\$126,845,111	\$0	\$30,191	\$30,191	0.22	\$27,982,283	\$6,660	1	1.01	0.99										
25	2032	\$78,043,143	\$6,056,494	\$40,571,239	\$918,342	\$125,589,219	\$0	\$30,191	\$30,191	0.21	\$26,014,301	\$6,254	2	1.02	0.98										
26	2033	\$77,270,439	\$5,996,529	\$40,169,544	\$909,249	\$124,345,761	\$0	\$30,191	\$30,191	0.19	\$24,184,727	\$5,872	3	1.03	0.97										
27	2034	\$76,505,385	\$5,937,157	\$39,771,826	\$900,247	\$123,114,615	\$0	\$30,191	\$30,191	0.18	\$22,483,825	\$5,514	4	1.04	0.96										
28	2035	\$75,747,906	\$5,878,374	\$39,378,045	\$891,334	\$121,895,658	\$0	\$30,191	\$30,191	0.17	\$20,902,548	\$5,177	5	1.05	0.95										
29	2036	\$74,997,927	\$5,820,172	\$38,988,164	\$882,508	\$120,688,771	\$0	\$30,191	\$30,191	0.16	\$19,432,480	\$4,861	6	1.06	0.94										
30	2037	\$74,255,373	\$5,762,546	\$38,602,142	\$873,771	\$119,493,832	\$0	\$30,191	\$30,191	0.15	\$18,065,802	\$4,564	7	1.07	0.93										
31	2038	\$73,520,171	\$5,705,491	\$38,219,943	\$865,120	\$118,310,725	\$0	\$30,191	\$30,191	0.14	\$16,795,242	\$4,286	8	1.08	0.92										
32	2039	\$72,792,249	\$5,649,001	\$37,841,527	\$856,554	\$117,139,332	\$0	\$30,191	\$30,191	0.13	\$15,614,040	\$4,024	9	1.09	0.91										
33	2040	\$72,071,534	\$5,593,071	\$37,466,859	\$848,073	\$115,979,536	\$0	\$30,191	\$30,191	0.13	\$14,515,912	\$3,779	10	1.10	0.91										
34	2041	\$71,357,954	\$5,537,694	\$37,095,900	\$839,677	\$114,831,224	\$0	\$30,191	\$30,191	0.12	\$13,495,014	\$3,548	11	1.12	0.90										
35	2042	\$70,651,440	\$5,482,865	\$36,728,614	\$831,363	\$113,694,281	\$0	\$30,191	\$30,191	0.11	\$12,545,915	\$3,332	12	1.13	0.89										
36	2043	\$69,951,920	\$5,428,579	\$36,364,964	\$823,132	\$112,568,595	\$0	\$30,191	\$30,191	0.10	\$11,663,566	\$3,128	13	1.14	0.88										
37	2044	\$69,259,327	\$5,374,831	\$36,004,915	\$814,982	\$111,454,055	\$0	\$30,191	\$30,191	0.10	\$10,843,273	\$2,937	14	1.15	0.87										
38	2045	\$68,573,591	\$5,321,615	\$35,648,431	\$806,913	\$110,350,549	-\$556,337,166	\$30,191	-\$556,306,975	0.09	\$10,080,670	-\$50,819,386	15	1.16	0.86										
Totals													\$1,183,433,745	\$91,839,709	\$615,215,785	\$13,925,589	\$1,904,414,828	\$907,930,214	-\$114,946,307	\$792,983,907		\$294,718,742	\$309,023,110		

Benefit/cost ratio = 0.95
 Net present value = -\$14,304,368

Internal Rate of Return

Use the same spreadsheet but adjust the discount rate until the total discounted benefits equal the total discounted costs. This discount rate will be the internal rate of return

Discount rate = 36.83%

Year	Benefits				Costs			Discount Factor	Discounted Total Benefits	Discounted Total Costs							
	Benefit 1	Benefit 2	Total Benefits	Cost 1	Cost 2	Total Costs											
0	\$50,000	\$1,000	\$51,000	\$100,000	\$7,500	\$107,500	1.00	\$51,000	\$107,500								
1	\$50,000	\$1,000	\$51,000	\$50,000	\$5,000	\$55,000	0.73	\$37,273	\$40,196								
2	\$50,000	\$1,000	\$51,000	\$1,000	\$2,000	\$3,000	0.53	\$27,240	\$1,602								
3	\$50,000	\$1,000	\$51,000	\$1,000	\$0	\$1,000	0.39	\$19,908	\$390								
4	\$50,000	\$1,000	\$51,000	\$1,000	\$0	\$1,000	0.29	\$14,549	\$285								
Totals										\$250,000	\$5,000	\$255,000	\$153,000	\$14,500	\$167,500	\$149,970	\$149,974

Result

Internal rate of return = 37%

Cost-effectiveness

To determine the cost to obtain a given benefit, use only the cost portion of the spreadsheet. Enter the given benefit in cell H54.

Discount rate = 3%

Total discounted benefit = \$100,000 units of benefit (can be in dollars, tons of emissions removed, or any other metric)

Year	Costs			Discount Factor	Discounted Total Benefits				
	Cost 1	Cost 2	Total Costs						
0	\$50,000	\$1,000	\$51,000	1.00	\$51,000				
1	\$50,000	\$1,000	\$51,000	0.97	\$49,515				
2	\$50,000	\$1,000	\$51,000	0.94	\$48,072				
3	\$50,000	\$1,000	\$51,000	0.92	\$46,672				
4	\$50,000	\$1,000	\$51,000	0.89	\$45,313				
Totals					\$250,000	\$5,000	\$255,000		\$240,572

Result

Cost-effectiveness = + F63/H54 = \$2.41 per unit of benefit

To determine the benefit from the investment of a given cost, use only the benefit portion of the spreadsheet. Enter the given cost in cell H54.

Discount rate = 3%

Total discounted cost = \$200,000

Year	Benefits (any type of unit)			Discount Factor	Discounted Total Costs				
	Benefit 1	Benefit 2	Total Benefits						
0	\$100,000	\$7,500	\$107,500	1.00	\$107,500				
1	\$50,000	\$5,000	\$55,000	0.97	\$53,398				
2	\$1,000	\$2,000	\$3,000	0.94	\$2,828				
3	\$1,000	\$0	\$1,000	0.92	\$915				
4	\$1,000	\$0	\$1,000	0.89	\$888				
Totals					\$153,000	\$14,500	\$167,500		\$165,529

Result

Cost-effectiveness = F82/H73 = 0.83 units of benefit per dollar

Payback Period

The payback period is the number of years until the total benefits exceed the total costs

Discount rate = 3%

Year	Benefits				Costs			Discount Factor	Discounted Total Benefits	Discounted Total Costs	Payback Period									
	Benefit 1	Benefit 2	Total Benefits	Cost 1	Cost 2	Total Costs														
0	\$50,000	\$1,000	\$51,000	\$100,000	\$7,500	\$107,500	1.00	\$51,000	\$107,500	-\$56,500										
1	\$50,000	\$1,000	\$51,000	\$50,000	\$5,000	\$55,000	0.97	\$49,515	\$53,398	-\$60,383										
2	\$50,000	\$1,000	\$51,000	\$1,000	\$2,000	\$3,000	0.94	\$48,072	\$2,828	-\$15,139										
3	\$50,000	\$1,000	\$51,000	\$1,000	\$0	\$1,000	0.92	\$46,672	\$915	\$30,618										
4	\$50,000	\$1,000	\$51,000	\$1,000	\$0	\$1,000	0.89	\$45,313	\$888	\$75,043										
Totals											\$250,000	\$5,000	\$255,000	\$153,000	\$14,500	\$167,500		\$240,572	\$165,529	

Result The payback period is between 2 and 3 years

ALT 3

GENERIC BENEFIT-COST MODEL

This model can be modified to include any number of benefits and costs and any number of years. The discount rate can also be changed. The example below shows how it can be used to calculate net present value and the benefit-cost ratio.

The examples further below show how to calculate the internal rate of return, cost-effectiveness and payback period.

Discount rate = 7%

Year	Benefits					Costs			Discount Factor	Discounted Total Benefits	Discounted Total Costs																								
	Travel Time	Safety	Operating	Emission	Total Benefits	Capital	Maintenance	Total Costs																											
0	2007				\$0	\$0	-\$852,097	-\$852,097	1.00	\$0	-\$852,097																								
1	2008				\$0	\$0	-\$1,311,889	-\$1,311,889	0.94	\$0	-\$1,231,820																								
2	2009				\$0	\$0	-\$1,833,420	-\$1,833,420	0.88	\$0	-\$1,616,452																								
3	2010				\$0	\$0	-\$2,410,093	-\$2,410,093	0.83	\$0	-\$1,995,194																								
4	2011				\$0	\$0	-\$3,037,065	-\$3,037,065	0.78	\$0	-\$2,360,781																								
5	2012				\$0	\$0	-\$3,710,582	-\$3,710,582	0.73	\$0	-\$2,708,282																								
6	2013				\$0	\$0	-\$4,427,624	-\$4,427,624	0.69	\$0	-\$3,034,402																								
7	2014				\$0	\$0	-\$5,185,695	-\$5,185,695	0.64	\$0	-\$3,337,027																								
8	2015				\$0	\$0	-\$5,982,684	-\$5,982,684	0.60	\$0	-\$3,614,924																								
9	2016				\$0	\$0	-\$6,816,774	-\$6,816,774	0.57	\$0	-\$3,867,519																								
10	2017				\$0	\$0	-\$7,686,383	-\$7,686,383	0.53	\$0	-\$4,094,737																								
11	2018				\$0	\$0	-\$8,590,117	-\$8,590,117	0.50	\$0	-\$4,296,882																								
12	2019				\$0	\$0	-\$9,526,731	-\$9,526,731	0.47	\$0	-\$4,474,542																								
13	2020				\$0	\$0	-\$10,495,110	-\$10,495,110	0.44	\$0	-\$4,628,519																								
14	2021				\$0	\$0	-\$11,494,243	-\$11,494,243	0.41	\$0	-\$4,759,769																								
15	2022				\$0	\$0	-\$12,523,213	-\$12,523,213	0.39	\$0	-\$4,869,357																								
16	2023				\$0	\$0	-\$13,581,177	-\$13,581,177	0.37	\$0	-\$4,958,424																								
17	2024				\$0	\$0	-\$14,667,362	-\$14,667,362	0.34	\$0	-\$5,028,155																								
18	2025				\$0	\$282,759,867	\$65,347	\$282,825,214	0.32	\$0	\$91,038,519																								
19	2026				\$0	\$282,759,867	\$65,347	\$282,825,214	0.30	\$0	\$85,482,178																								
20	2027				\$0	\$282,759,867	\$65,347	\$282,825,214	0.28	\$0	\$80,264,955																								
21	2028				\$0	\$282,759,867	\$65,347	\$282,825,214	0.27	\$0	\$75,366,155																								
22	2029				\$0	\$282,759,867	\$65,347	\$282,825,214	0.25	\$0	\$70,766,343																								
23	2030	\$77,560,712	\$6,178,230	\$40,385,634	\$886,611	\$125,011,187	\$0	\$65,347	0.23	\$29,370,267	\$15,353	Benefit reduction over time	0	1.00	1.00																				
24	2031	\$76,792,785	\$6,117,059	\$39,985,776	\$877,832	\$123,773,452	\$0	\$65,347	0.22	\$27,304,669	\$14,416	1	1.01	0.99																					
25	2032	\$76,032,460	\$6,056,494	\$39,589,877	\$869,141	\$122,547,972	\$0	\$65,347	0.21	\$25,384,343	\$13,536	2	1.02	0.98																					
26	2033	\$75,279,663	\$5,996,529	\$39,197,898	\$860,536	\$121,334,626	\$0	\$65,347	0.19	\$23,599,074	\$12,710	3	1.03	0.97																					
27	2034	\$74,534,320	\$5,937,157	\$38,809,800	\$852,016	\$120,133,293	\$0	\$65,347	0.18	\$21,939,361	\$11,934	4	1.04	0.96																					
28	2035	\$73,796,357	\$5,878,374	\$38,425,545	\$843,580	\$118,943,855	\$0	\$65,347	0.17	\$20,396,375	\$11,206	5	1.05	0.95																					
29	2036	\$73,065,700	\$5,820,172	\$38,045,094	\$835,227	\$117,766,193	\$0	\$65,347	0.16	\$18,961,907	\$10,522	6	1.06	0.94																					
30	2037	\$72,342,277	\$5,762,546	\$37,668,410	\$826,958	\$116,600,191	\$0	\$65,347	0.15	\$17,628,324	\$9,880	7	1.07	0.93																					
31	2038	\$71,626,017	\$5,705,491	\$37,295,455	\$818,770	\$115,445,733	\$0	\$65,347	0.14	\$16,388,532	\$9,277	8	1.08	0.92																					
32	2039	\$70,916,848	\$5,649,001	\$36,926,193	\$810,664	\$114,302,706	\$0	\$65,347	0.13	\$15,235,933	\$8,710	9	1.09	0.91																					
33	2040	\$70,214,701	\$5,593,071	\$36,560,587	\$802,637	\$113,170,996	\$0	\$65,347	0.13	\$14,164,397	\$8,179	10	1.10	0.91																					
34	2041	\$69,519,506	\$5,537,694	\$36,198,601	\$794,690	\$112,050,491	\$0	\$65,347	0.12	\$13,168,221	\$7,680	11	1.12	0.90																					
35	2042	\$68,831,194	\$5,482,865	\$35,840,199	\$786,822	\$110,941,081	\$0	\$65,347	0.11	\$12,242,106	\$7,211	12	1.13	0.89																					
36	2043	\$68,149,697	\$5,428,579	\$35,485,346	\$779,032	\$109,842,654	\$0	\$65,347	0.10	\$11,381,124	\$6,771	13	1.14	0.88																					
37	2044	\$67,474,948	\$5,374,831	\$35,134,006	\$771,319	\$108,755,103	\$0	\$65,347	0.10	\$10,580,694	\$6,358	14	1.15	0.87																					
38	2045	\$66,806,879	\$5,321,615	\$34,786,144	\$763,682	\$107,678,320	-\$681,583,000	150000	-\$681,433,000	0.09	\$9,836,558	-\$62,249,815	15	1.16	0.86																				
Totals																																			
<table border="0"> <tr><td>Benefit/cost ratio =</td><td colspan="11">1.03</td></tr> <tr><td>Net present value =</td><td colspan="11">\$8,488,693</td></tr> </table>												Benefit/cost ratio =	1.03											Net present value =	\$8,488,693										
Benefit/cost ratio =	1.03																																		
Net present value =	\$8,488,693																																		

Internal Rate of Return

Use the same spreadsheet but adjust the discount rate until the total discounted benefits equal the total discounted costs. This discount rate will be the internal rate of return

Discount rate = 36.83%

Year	Benefits				Costs			Discount Factor	Discounted Total Benefits	Discounted Total Costs								
	Benefit 1	Benefit 2	Total Benefits	Cost 1	Cost 2	Total Costs												
0	\$50,000	\$1,000	\$51,000	\$100,000	\$7,500	\$107,500	1.00	\$51,000	\$107,500									
1	\$50,000	\$1,000	\$51,000	\$50,000	\$5,000	\$55,000	0.73	\$37,273	\$40,196									
2	\$50,000	\$1,000	\$51,000	\$1,000	\$2,000	\$3,000	0.53	\$27,240	\$1,602									
3	\$50,000	\$1,000	\$51,000	\$1,000	\$0	\$1,000	0.39	\$19,908	\$390									
4	\$50,000	\$1,000	\$51,000	\$1,000	\$0	\$1,000	0.29	\$14,549	\$285									
Totals																		
<table border="0"> <tr><td>Benefit 1</td><td>\$250,000</td><td>\$5,000</td><td>\$255,000</td><td>\$153,000</td><td>\$14,500</td><td>\$167,500</td><td>\$149,970</td><td>\$149,974</td></tr> </table>										Benefit 1	\$250,000	\$5,000	\$255,000	\$153,000	\$14,500	\$167,500	\$149,970	\$149,974
Benefit 1	\$250,000	\$5,000	\$255,000	\$153,000	\$14,500	\$167,500	\$149,970	\$149,974										

Result

Internal rate of return = 37%

Cost-effectiveness

To determine the cost to obtain a given benefit, use only the cost portion of the spreadsheet. Enter the given benefit in cell H54.

Discount rate = 3%

Total discounted benefit = \$100,000 units of benefit (can be in dollars, tons of emissions removed, or any other metric)

Year	Costs			Discount Factor	Discounted Total Benefits					
	Cost 1	Cost 2	Total Costs							
0	\$50,000	\$1,000	\$51,000	1.00	\$51,000					
1	\$50,000	\$1,000	\$51,000	0.97	\$49,515					
2	\$50,000	\$1,000	\$51,000	0.94	\$48,072					
3	\$50,000	\$1,000	\$51,000	0.92	\$46,672					
4	\$50,000	\$1,000	\$51,000	0.89	\$45,313					
Totals										
<table border="0"> <tr><td>Cost 1</td><td>\$250,000</td><td>\$5,000</td><td>\$255,000</td><td>\$240,572</td></tr> </table>						Cost 1	\$250,000	\$5,000	\$255,000	\$240,572
Cost 1	\$250,000	\$5,000	\$255,000	\$240,572						

Result

Cost-effectiveness = + F63/H54 = \$2.41 per unit of benefit

To determine the benefit from the investment of a given cost, use only the benefit portion of the spreadsheet. Enter the given cost in cell H54.

Discount rate = 3%

Total discounted cost = \$200,000

Year	Benefits (any type of unit)			Discount Factor	Discounted Total Costs					
	Benefit 1	Benefit 2	Total Benefits							
0	\$100,000	\$7,500	\$107,500	1.00	\$107,500					
1	\$50,000	\$5,000	\$55,000	0.97	\$53,398					
2	\$1,000	\$2,000	\$3,000	0.94	\$2,828					
3	\$1,000	\$0	\$1,000	0.92	\$915					
4	\$1,000	\$0	\$1,000	0.89	\$888					
Totals										
<table border="0"> <tr><td>Benefit 1</td><td>\$153,000</td><td>\$14,500</td><td>\$167,500</td><td>\$165,529</td></tr> </table>						Benefit 1	\$153,000	\$14,500	\$167,500	\$165,529
Benefit 1	\$153,000	\$14,500	\$167,500	\$165,529						

Result

Cost-effectiveness = F82/H73 = 0.83 units of benefit per dollar

Payback Period

The payback period is the number of years until the total benefits exceed the total costs

Discount rate = 3%

Year	Benefits				Costs			Discount Factor	Discounted Total Benefits	Discounted Total Costs	Payback Period	Cumulative Benefits minus Costs								
	Benefit 1	Benefit 2	Total Benefits	Cost 1	Cost 2	Total Costs														
0	\$50,000	\$1,000	\$51,000	\$100,000	\$7,500	\$107,500	1.00	\$51,000	\$107,500		-\$56,500									
1	\$50,000	\$1,000	\$51,000	\$50,000	\$5,000	\$55,000	0.97	\$49,515	\$53,398		-\$60,383									
2	\$50,000	\$1,000	\$51,000	\$1,000	\$2,000	\$3,000	0.94	\$48,072	\$2,828		-\$15,139									
3	\$50,000	\$1,000	\$51,000	\$1,000	\$0	\$1,000	0.92	\$46,672	\$915		\$30,618									
4	\$50,000	\$1,000	\$51,000	\$1,000	\$0	\$1,000	0.89	\$45,313	\$888		\$75,043									
Totals																				
<table border="0"> <tr><td>Benefit 1</td><td>\$250,000</td><td>\$5,000</td><td>\$255,000</td><td>\$153,000</td><td>\$14,500</td><td>\$167,500</td><td>\$240,572</td><td>\$165,529</td></tr> </table>												Benefit 1	\$250,000	\$5,000	\$255,000	\$153,000	\$14,500	\$167,500	\$240,572	\$165,529
Benefit 1	\$250,000	\$5,000	\$255,000	\$153,000	\$14,500	\$167,500	\$240,572	\$165,529												

Result The payback period is between 2 and 3 years

