

Case 50 - Capital Planning Consultants

ISE 460 Group 9 - November 21, 2022

Group 9

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Introduction

Case Study 50 Summary

In the given study, our consulting firm is tasked with helping We Wish This Were a Deterministic World (WWTWDW) with their capital budgeting. We are presented 4 projects to elect from in Table 50-1, each with a set of mutually exclusive alternatives. Each project: 1, 2, 3, 4, are defined by a First Cost, Annual Benefit, Useful Life, and Salvage Value. After electing the best alternatives amongst all choices, we are tasked with applying an existing budget of \$100,000 and the choice of taking out a \$10,000 loan at 18%. Our analysis utilizes a Minimum attractive rate of return (MARR) of 15%, however WWTWDW averages 20% of its investment.

Table 50-1 WWTWDW Capital Projects									
Project Alternative	First Cost			Annual Benefit			Useful Life	Salvage Value	
1A	\$20,000			\$4,900			8 10 12	0	
1B	\$30,000			\$7,500			8 10 12	0	
1C	\$35,000			\$9,100			8 10 12	0	
1D	\$40,000			\$10,000			8 10 12	0	
2E	\$24,000			\$4,000	\$6,500	\$7,500	6 10 15	0 0	\$5,000
2F	\$25,000			\$2,000	\$8,000	\$9,000	8 10 12	0 0	\$10,000
3G	\$20,000			\$4,000	\$5,000	\$6,000	8 10 15	0	
3H	\$35,000			\$9,000	\$12,000	\$18,000	8 10 15	0	
3I	\$40,000	\$50,000	\$60,000	\$15,000	\$20,000	\$30,000	8 10 15	0 0	\$10,000
4J	\$15,000			\$3,500	\$4,000	\$4,500	8 9 12	0	
4K	\$20,000	\$25,000	\$30,000	\$3,500	\$7,000	\$10,000	7 10 15	0	

Analysis Methodology

The team's main approach consists of assessing the mutually exclusive alternatives within each project to determine the best choice or two choices. Each team member determined the best metric or KPI (NPV, IRR, ERR, AW) for their own project. Then a sensitivity analysis was performed over the changing parameters given.

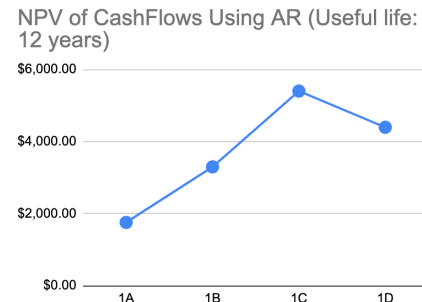
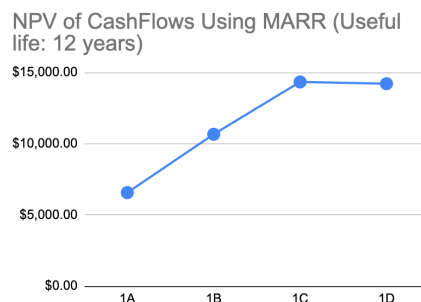
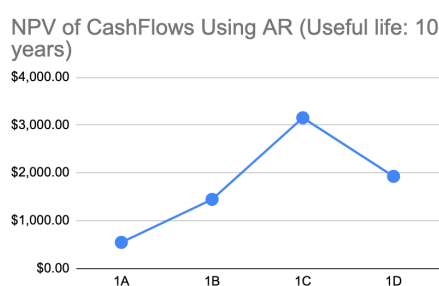
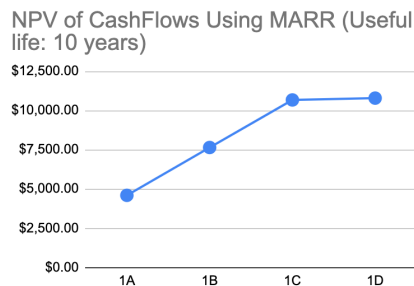
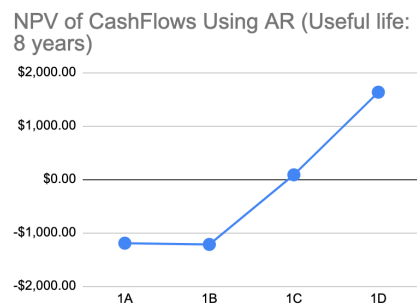
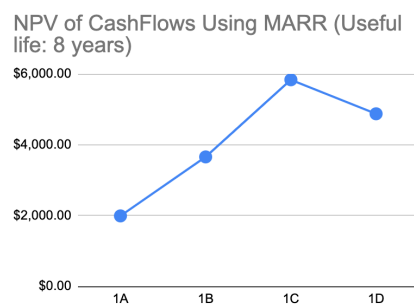
After individual project analyses were conducted and the best alternative was selected, the team put together different pairings of the best alternatives that added up to less than \$110,000 and determined the most profitable investments under the NPV metric. Groupings were done under the assumptions of a 10-year planning horizon for all projects, base-case first costs and annual benefits, and no salvage value at the end of life. Projects were matched under the assumptions that pairings' initial costs were under \$100,000 of the capital budget and under \$110,000 with the use of a loan.

Investment Options

Project 1

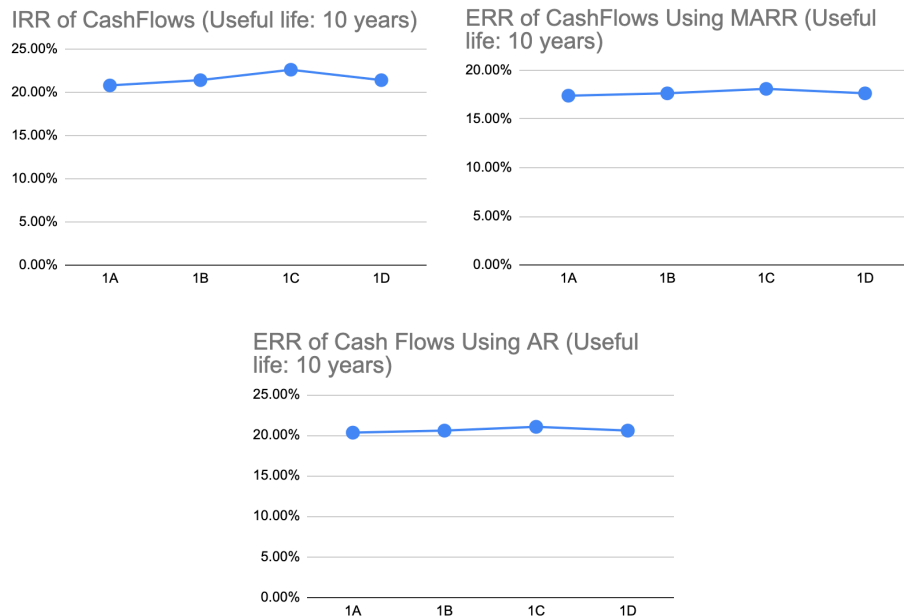
Either of the 4 alternatives in Project 1 is most likely to be profitable, so Project 1 is worth pursuing. All alternatives for Project 1 only vary in first cost and base case annual benefit. There are no salvage values and each alternative is to be considered on useful lives of 8, 10, and 12.

After looking at the NPV metric, using the MARR and Average Return, 1C shows to be the most profitable for all useful lives. The only time this is an exception and 1D proves to be the most profitable, is under the conditions of Average Return being used to calculate NPV on a useful life of 8 years. Using the average useful life of 10 years, the four alternatives are compared in combinations of 2 alternatives at a time. Between alternatives 1A and 1B, 1B is more profitable over 1A by \$900.43. Between alternatives 1B and 1C, 1C is more profitable by \$1,707.96 and 1C is more profitable than 1D by \$1,226.78.



Taking a look at other KPI metrics such as IRR and ERR under an average useful life of 10 years, it is confirmed that 1C is the best alternative under these metrics as well. $IRR(1A) < IRR(1B)$, $IRR(1B) < IRR(1C)$, and $IRR(1C) > IRR(1D)$, thus 1C is the best alternative. Additionally, based on the ERR decision rule that if $ERR > MARR$, the project is economically justified, 1A,

1B, 1C, 1D are all higher than MARR, therefore economically justified. Thus, all projects are more beneficial than doing nothing according to this KPI, However, 1C has the highest ERR using MARR and AR.

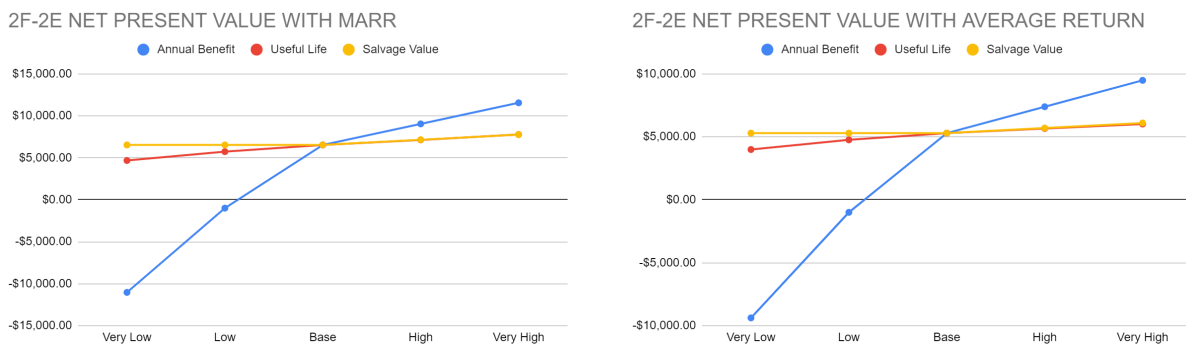


After analyzing all 3 KPIs that take into account first cost and base case annual benefit differences amongst alternatives, it is concluded that 1C is the best alternative for Project 1.

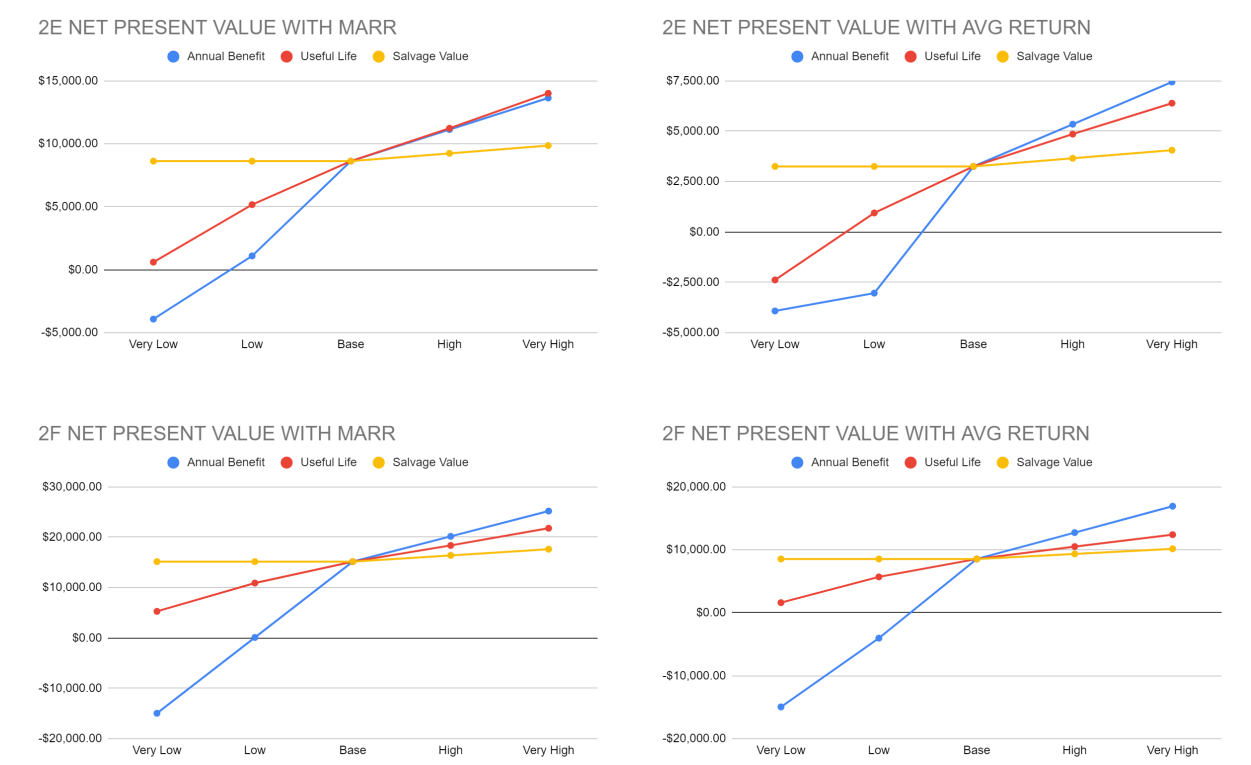
Project 2

Either alternative in Project 2 is most likely to be profitable, so Project 2 is worth pursuing. The assessment involved studying the influence change in annual benefit, useful life, and potential salvage value have on the net present value (NPV) of the 2E and 2F alternatives, as well as the difference between the two.

2F is expected to have over \$5,000 in profit over 2E as seen in the charts below. But the wider range of deviation from the expected annual benefit can quickly deteriorate the profit margin and net value of the investment. Other variables analyzed showed consistency in 2F being the stronger alternative. 2E's advantage is it has a cheaper up-front cost, but only by \$1,000.



When looking at each alternative individually, the large impact of a lower than expected annual benefit is evident. The Useful Life and Salvage Value parameters show a more advantageous side of each project where, when evaluating with the MARR, all cases analyzed were profitable.



The analysis and impact of changes in the three variables on each alternative are described further below.

Annual Benefit

The largest fluctuating factor in both alternatives is the potential annual benefit. The difference between 2F and 2E was analyzed as each alternative transitions between the pessimistic and optimistic estimates identified in the Capital Projects table. It was assumed the average useful life of 10 years and expected \$0 salvage value for both alternatives held constant. Cases were judged using both the MARR and Average Return.

Cells highlighted in red indicate both 2E and 2F had negative NPVs and should not be pursued, cells highlighted yellow indicate 2E is the stronger alternative of the two, and remaining cells indicate 2F is the more profitable alternative.

2F-2E NPV from Change in Annual Benefit with MARR

		2F										
		\$2,000.00						\$8,000.00		\$9,000.00		
2E		25.0%	37.5%	50.0%	62.5%	75.0%	87.5%	100.0%	112.5%	125.0%		
	\$4,000.00	61.54%	-\$11,038.04	-\$6,019.27	-\$1,000.50	\$4,018.27	\$9,037.04	\$14,055.80	\$19,074.57	\$24,093.34	\$29,112.11	

	69.23%	-\$13,546.67	-\$8,527.90	-\$3,509.13	\$1,509.64	\$6,528.40	\$11,547.17	\$16,565.94	\$21,584.71	\$26,603.48
	76.92%	-\$16,055.30	-\$11,036.53	-\$6,017.76	-\$999.00	\$4,019.77	\$9,038.54	\$14,057.31	\$19,076.08	\$24,094.85
	84.62%	-\$18,567.20	-\$13,548.43	-\$8,529.66	-\$3,510.89	\$1,507.88	\$6,526.65	\$11,545.42	\$16,564.18	\$21,582.95
	92.31%	-\$21,075.83	-\$16,057.06	-\$11,038.29	-\$6,019.52	-\$1,000.75	\$4,018.02	\$9,036.78	\$14,055.55	\$19,074.32
\$6,500.00	100.00%	-\$23,584.46	-\$18,565.69	-\$13,546.92	-\$8,528.15	-\$3,509.38	\$1,509.38	\$6,528.15	\$11,546.92	\$16,565.69
	107.69%	-\$26,093.09	-\$21,074.32	-\$16,055.55	-\$11,036.78	-\$6,018.02	-\$999.25	\$4,019.52	\$9,038.29	\$14,057.06
\$7,500.00	115.38%	-\$28,601.72	-\$23,582.95	-\$18,564.18	-\$13,545.42	-\$8,526.65	-\$3,507.88	\$1,510.89	\$6,529.66	\$11,548.43

2F-2E NPV from Change in Annual Benefit with Average Return

		2F						\$8,000.00		\$9,000.00	
		\$2,000.00									
2E		25.0%	37.5%	50.0%	62.5%	75.0%	87.5%	100.0%	112.5%	125.0%	
\$4,000.00	61.54%	-\$9,385.36	-\$5,192.89	-\$1,000.42	\$3,192.05	\$7,384.52	\$11,577.00	\$15,769.47	\$19,961.94	\$24,154.41	
	69.23%	-\$11,480.97	-\$7,288.50	-\$3,096.03	\$1,096.45	\$5,288.92	\$9,481.39	\$13,673.86	\$17,866.33	\$22,058.81	
	76.92%	-\$13,576.58	-\$9,384.11	-\$5,191.63	-\$999.16	\$3,193.31	\$7,385.78	\$11,578.25	\$15,770.73	\$19,963.20	
	84.62%	-\$15,674.91	-\$11,482.44	-\$7,289.97	-\$3,097.49	\$1,094.98	\$5,287.45	\$9,479.92	\$13,672.39	\$17,864.87	
	92.31%	-\$17,770.52	-\$13,578.05	-\$9,385.57	-\$5,193.10	-\$1,000.63	\$3,191.84	\$7,384.32	\$11,576.79	\$15,769.26	
\$6,500.00	100.00%	-\$19,866.12	-\$15,673.65	-\$11,481.18	-\$7,288.71	-\$3,096.24	\$1,096.24	\$5,288.71	\$9,481.18	\$13,673.65	
	107.69%	-\$21,961.73	-\$17,769.26	-\$13,576.79	-\$9,384.32	-\$5,191.84	-\$999.37	\$3,193.10	\$7,385.57	\$11,578.05	
\$7,500.00	115.38%	-\$24,057.34	-\$19,864.87	-\$15,672.39	-\$11,479.92	-\$7,287.45	-\$3,094.98	\$1,097.49	\$5,289.97	\$9,482.44	

*The positive NPV is deceiving here, it is just because a larger negative 2E value is being subtracted from a negative 2F value

Of the 72 MARR cases, 6 (8.33%) show Project 2 should not be pursued, 30 (41.67%) show 2E should be picked, and 36 (50%) show 2F should be selected. Of the 72 Average Return cases, 16 (22.22%) show Project 2 should not be pursued, 22 (30.56%) show 2E should be picked, and 34 (47.22%) show 2F should be selected.

Despite the risk of 2F only achieving a quarter of its expected Annual Benefit of \$8,000, it is still most likely the most profitable alternative.

Useful Life

The projects were analyzed over 6, 8, 10, 12, and 15 year life spans, although 2F is not anticipated to reach the highest or lowest of those. Both alternatives are likely to be profitable, with the exception of 2E with a 6-year useful life when assessed with WWTWDW's average return. In all cases, 2F is the most profitable and is always worth pursuing if capital funds allow.

Lifespan	NPV Over Varying Useful Life with MARR and No Salvage Value			NPV Over Varying Useful Life with Avg Return and No Salvage Value		
	2E NPV	2F NPV	2F-2E NPV	2E NPV	2F NPV	2F-2E NPV
6	\$599.14	\$5,275.86	\$4,676.72	-\$2,384.18	\$1,604.08	\$3,988.27
8	\$5,167.59	\$10,898.57	\$5,730.98	\$941.54	\$5,697.28	\$4,755.74
10	\$8,622.00	\$15,150.15	\$6,528.15	\$3,251.07	\$8,539.78	\$5,288.71

12	\$11,234.02	\$18,364.95	\$7,130.93	\$4,854.91	\$10,513.73	\$5,658.83
15	\$14,007.91	\$21,778.96	\$7,771.06	\$6,390.57	\$12,403.78	\$6,013.21

Salvage Value

No salvage value is expected out of either alternative, but there is potential for one. As seen in the previous examples, 2F already is predisposed to have a higher NPV than 2E; it also has the higher potential salvage value which increases the profitability of 2F.

NPV from Change in Salvage Value with MARR over a 10 Year Lifespan

2E Cash Flow NPV			2F Cash Flow NPV		
\$0	0%	\$8,622.00	\$0	0%	\$15,150.15
	25%	\$8,930.98		25%	\$15,768.11
	50%	\$9,239.96		50%	\$16,386.07
	75%	\$9,548.94		75%	\$17,004.03
\$5,000	100%	\$9,857.92	\$10,000	100%	\$17,622.00

		2F	\$0					\$10,000
2E			0%	25%	50%	75%	100%	
\$0	0%	\$6,528.15	\$7,146.11	\$7,764.08	\$8,382.04	\$9,000.00		
	25%	\$6,219.17	\$6,837.13	\$7,455.10	\$8,073.06	\$8,691.02		
	50%	\$5,910.19	\$6,528.15	\$7,146.11	\$7,764.08	\$8,382.04		
	75%	\$5,601.21	\$6,219.17	\$6,837.13	\$7,455.10	\$8,073.06		
\$5,000	100%	\$5,292.23	\$5,910.19	\$6,528.15	\$7,146.11	\$7,764.08		

NPV from Change in Salvage Value with Average Return over a 10 Year Lifespan

2E Cash Flow NPV			2F Cash Flow NPV		
\$0	0%	\$3,251.07	\$0	0%	\$8,539.78
	25%	\$3,452.95		25%	\$8,943.54
	50%	\$3,654.83		50%	\$9,347.30
	75%	\$3,856.71		75%	\$9,751.07
\$5,000	100%	\$4,058.60	\$10,000	100%	\$10,154.83

		2F	\$0					\$10,000
2E			0%	25%	50%	75%	100%	
\$0	0%	\$5,288.71	\$5,692.47	\$6,096.24	\$6,500.00	\$6,903.76		
	25%	\$5,086.83	\$5,490.59	\$5,894.35	\$6,298.12	\$6,701.88		
	50%	\$4,884.94	\$5,288.71	\$5,692.47	\$6,096.24	\$6,500.00		
	75%	\$4,683.06	\$5,086.83	\$5,490.59	\$5,894.35	\$6,298.12		
\$5,000	100%	\$4,481.18	\$4,884.94	\$5,288.71	\$5,692.47	\$6,096.24		

Project 3

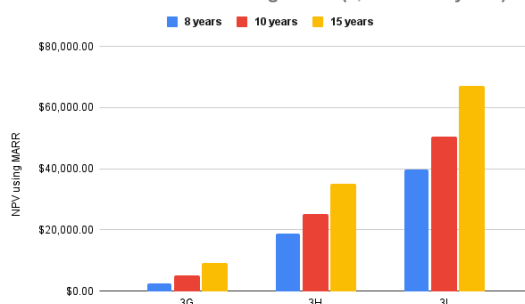
3I and 3H is most likely to be profitable, so project 3 is worth pursuing. All alternatives for Project 3 only vary in first cost and base case annual benefit. 3I has a maximum salvage value of \$10,000 and each alternative is to be considered for useful lives of 8, 10 and 15 years.

Since the time frame is the same for all the alternatives, evaluation criterias like NPV and IRR have been used to compare the investment alternatives. According to the two mentioned methods, if NPV is greater than 0 then the project is accepted otherwise rejected. On the other hand, if the IRR is greater than the MARR, the project is accepted otherwise rejected. It can be noted that NPV cannot be the only criteria since, there are more than 1 investment alternative with a positive NPV using MARR, hence IRR is useful that brings the net present values of the cash flow to 0.

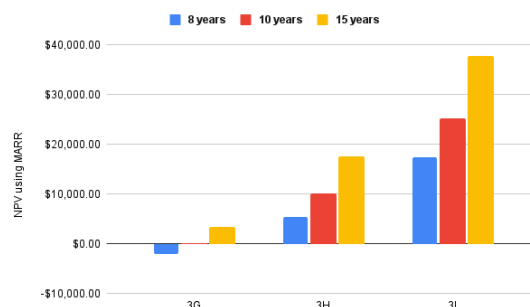
Using the first case (base first cost and base annual benefit) for 8, 10 and 15 years time period, it is observed that the IRR of 3I is the highest (also greater than MARR) and has the highest NPV value. Between alternatives 3G and 3H, 3H has greater NPV using MARR and average return, in addition to a IRR greater than 3G. 3H is profitable by \$11,860.12, \$14,347.30 and \$17,728.31 than 3G in the 8, 10 and 15 years respectively. Between alternatives, 3I and 3G, 3I is profitable by \$15,697.28, \$18,539.78 and \$22,403.78 than 3H for the 8, 10 and 15 years respectively. Moreover, $IRR(3I) > IRR(3H)$.

Net Present value comparison between alternatives for 8, 10 and 15 years:

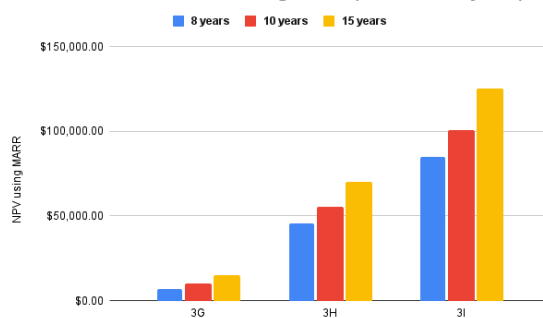
Case 1: NPV of cashflows using MARR (8, 10 and 15 years)



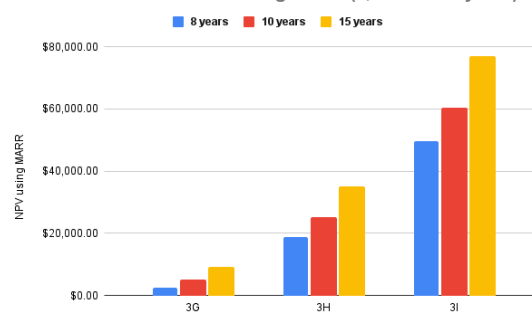
Case 2: NPV of cashflows using MARR (8, 10 and 15 years)



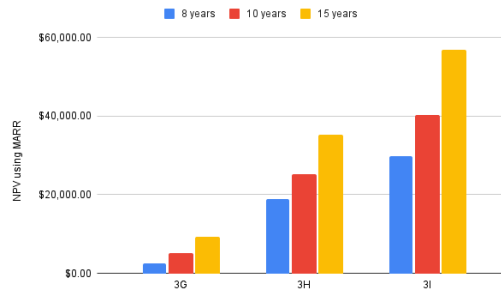
Case 3: NPV of cashflows using MARR (8, 10 and 15 years)



Case 4: NPV of cashflows using MARR (8, 10 and 15 years)

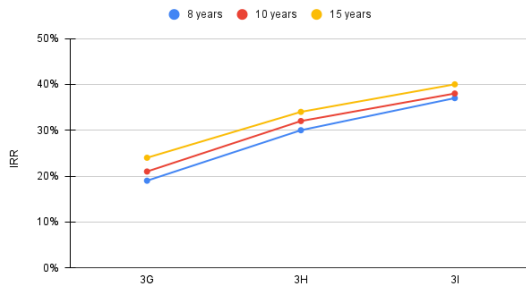


Case 5: NPV of cashflows using MARR (8, 10 and 15 years)

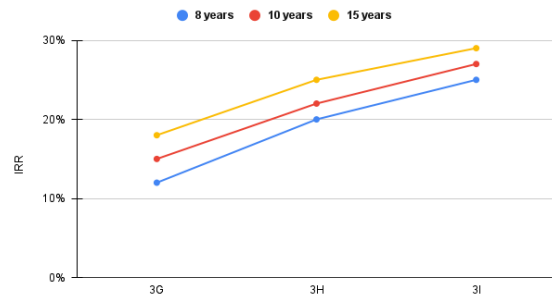


IRR comparison between alternatives for 8, 10 and 15 years:

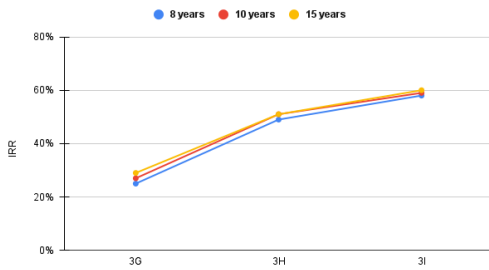
Case 1: IRR of cashflows (8, 10 and 15 years)



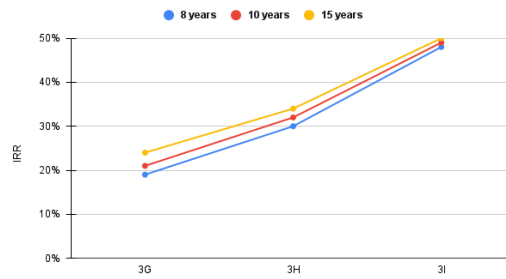
Case 2: IRR of cashflows (8, 10 and 15 years)



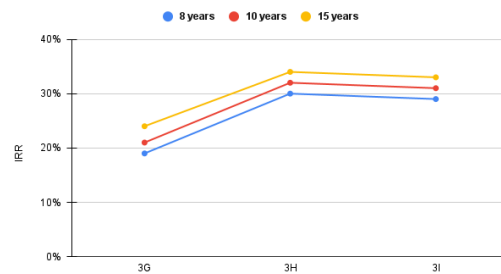
Case 3: IRR of cashflows (8, 10 and 15 years)



Case 4: IRR of cashflows (8, 10 and 15 years)



Case 5: IRR of cashflows (8, 10 and 15 years)



Similarly to the first comparison, the investment alternatives have been compared using 1 - base first cost and minimum annual benefit, 2 - base first cost and maximum annual benefit, 3 - minimum first cost and base annual benefit, 4 - maximum first cost and base annual benefit. It is during case 5 (max first cost and base annual benefit) that while performing incremental analysis using each we observe that the IRR of 3H > IRR of 3I for each 8, 10 and 15 year useful

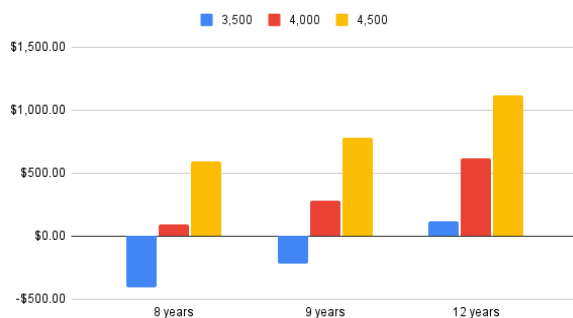
time span. However, for the rest of the cases 3I has the maximum IRR. After analyzing all the KPIs, it is certain that 3I is most profitable across the each time frame, it has the highest NPV value compared to the other investment alternatives and maximum IRR overall. 3H is a close second and is a profitable investment. 3G is not economically viable and should not be invested.

Project 4

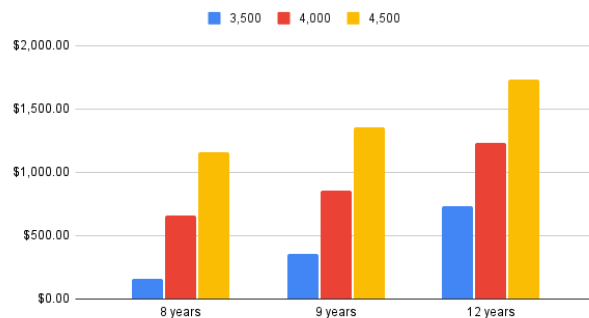
Either of the alternatives in Project 4 is most likely to be profitable, so Project 4 is worth pursuing. Both alternatives in project 4 vary not only in first cost and base case annual benefit, but also in useful life. There is no salvage value in both alternatives. Both of the alternatives have different useful lives, 4J: 8, 9, 12 and 4K: 7, 10, 15, internal rate of return and external rate of return can not be applied.

The alternatives 4J and 4K are applied annual worth and future worth with different useful life, first cost and base case annual benefit. Based on the rule of annual worth, the negative values can not be accepted. The highest values of average return and MARR need to be chosen. AW(4J): $MARR > \text{Average Return}$, $\$1732.69 > \1121.03 . This value is 4J with $\$15,000$ first cost and $\$4,500$ annual benefit.

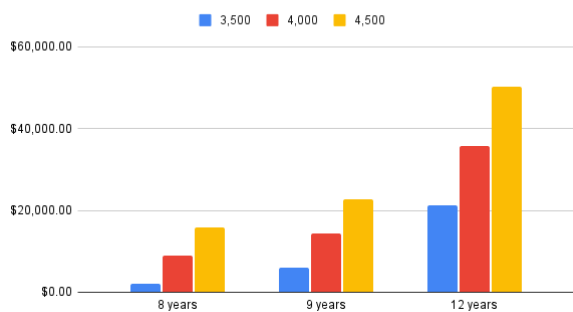
AW with Average Return for 4J



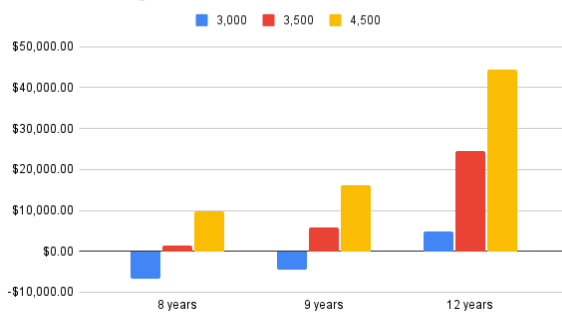
AW with MARR for 4J



FW with MARR for 4J



FW with Average Return for 4J



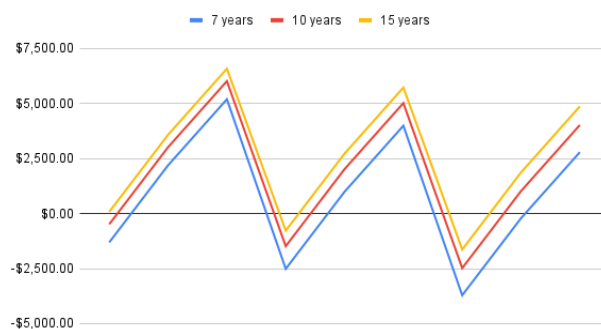
Based on the rule of future worth, the negative values should be rejected and the highest value should be kept. FW(4J): $MARR > \text{Average return}$, $\$50253.75 > \44370.75 . This value is 4J with

\$15,000 first cost and \$4,500 annual benefit. Based on annual worth and future worth, 4J with \$15,000 and \$4,500 is the best choice for 4J.

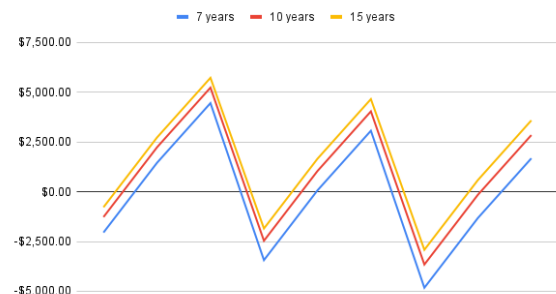
For 4K, after applying annual worth with different first cost and annual benefit, the highest value for MARR is \$6579.66 with \$20,000 first cost and \$10,000 annual benefit, and for average return is \$5722.36 with \$20,000 first cost and \$10,000 annual benefit, keeping this choice. Applying the future worth, the highest value for MARR is \$31306.88 with \$20,000 first cost and \$10,000 annual benefit, and the highest value for average return is \$412210.65 with \$20,000 first cost and \$10,000 annual benefit. Based on these two results, 4K-\$20,000 first cost and \$10,000 annual benefit should be chosen.

Since $\$1732.69 < \6579.66 and $\$31306.88 < \412210.65 , 4K-\$20,000 first cost and \$10,000 annual benefit is more profitable.

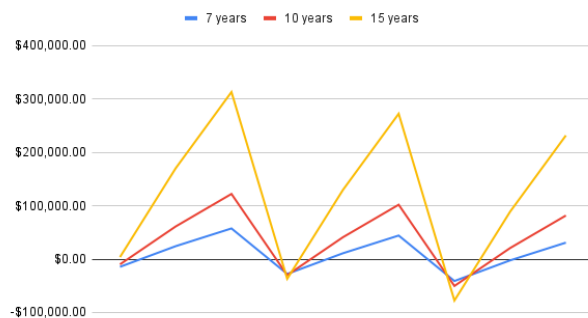
AW with MARR for 4K



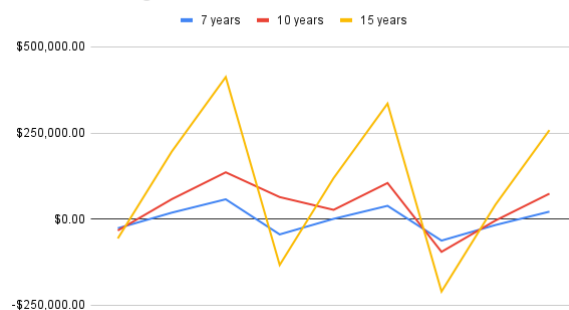
AW with Average Return for 4K



FW with MARR for 4K



FW with Average Return for 4K



Investment Options

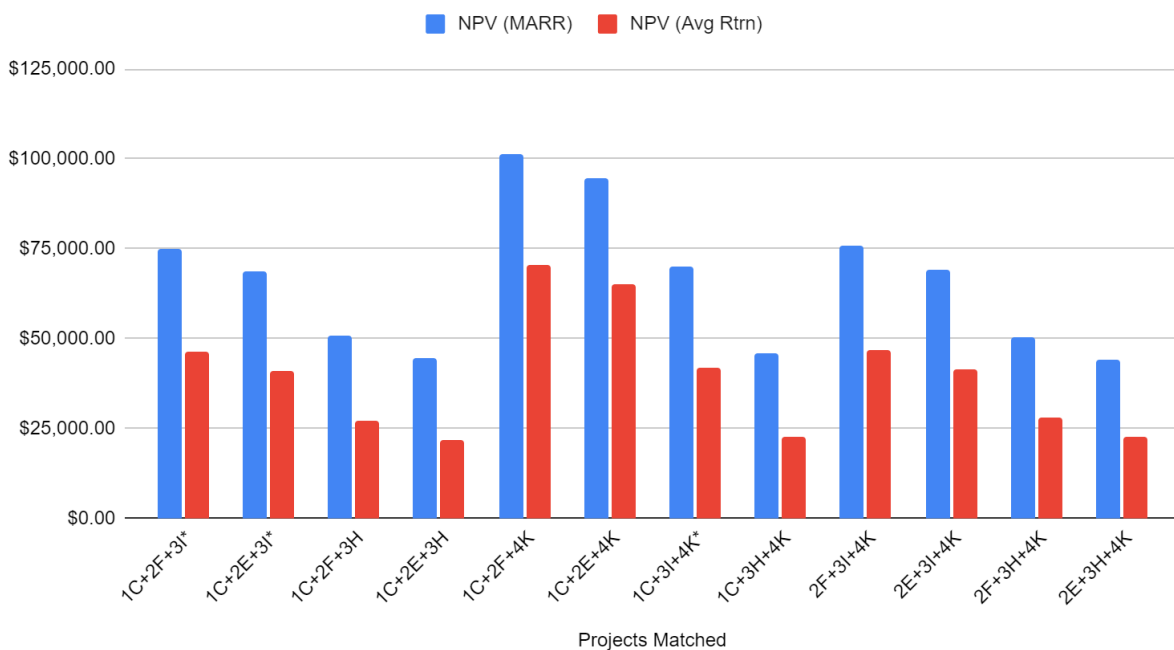
After analyzing the mutually exclusive alternatives within each project, the strongest option(s) from each were matched up to see if a loan is necessary and what the potential investment options are. Since sensitivity analysis weeded out the weaker investments, the final comparison was done over the standard 10-year planning horizon with no salvage values at the end of life.

Base case first cost and annual benefit were used to determine the cash flows. Projects were matched up until the total initial cost was either under \$100,000 or \$110,000. In the cases that had initial costs above \$100,000, a loan was required and the payments were factored into the cash flows. Loan duration was arbitrarily set to the planning horizon length of 10 years.

Only 1C was selected from Project 1 since the second-best alternative, 1D, was more expensive to start and would reduce the options for other projects that can be invested in. Project 2 favors 2F, but 2E was also matched since the lower initial cost helps with finding pairings that avoid taking out a loan. 3H and 3I were both assessed as potential investments from Project 3. 4K was the strongest investment in Project 4 and was the only alternative used in the final investment comparisons.

After looking at 12 pairings of projects and analyzing with the MARR and average return in mind, the clear standout investment is the combination of projects 1C, 2F, and 4K where the expected net present value is \$101,196 with the MARR and \$70,540 with the average return. Projects 1C, 2E, and 4K are a close alternative that saves \$1,000 up front and has an expected NPV of \$94,668 with MARR and \$65,252 with the average return.

Net Present Value of Different Investment Matches



Only three pairings, marked with an asterisk in the chart above, had a cumulative initial cost of above \$100,000 and below \$110,000. These cases would require WWTWDW to take out a loan and the loan payments at 18% are reflected in their cash flows and net present values.

Conclusion

We Wish This Were a Deterministic World should invest in the combination of 1C, 2F, and 4K for \$85,000. This was determined by seeing which pairings of projects had the highest net present value. The analysis was limited to only NPV and ignored other factors like payback period. The other limitation was the loan analysis only considered a loan spanning the 10 year investment period. Loan duration was not specified at the beginning of the case study and would impact the net value of the 3 options that required a loan, potentially changing the result of best investment.

Appendix

For a more comprehensive look at our analysis, please see the [Analysis Spreadsheet](#).