1.011Project Evaluation: Comparing Costs & Benefits

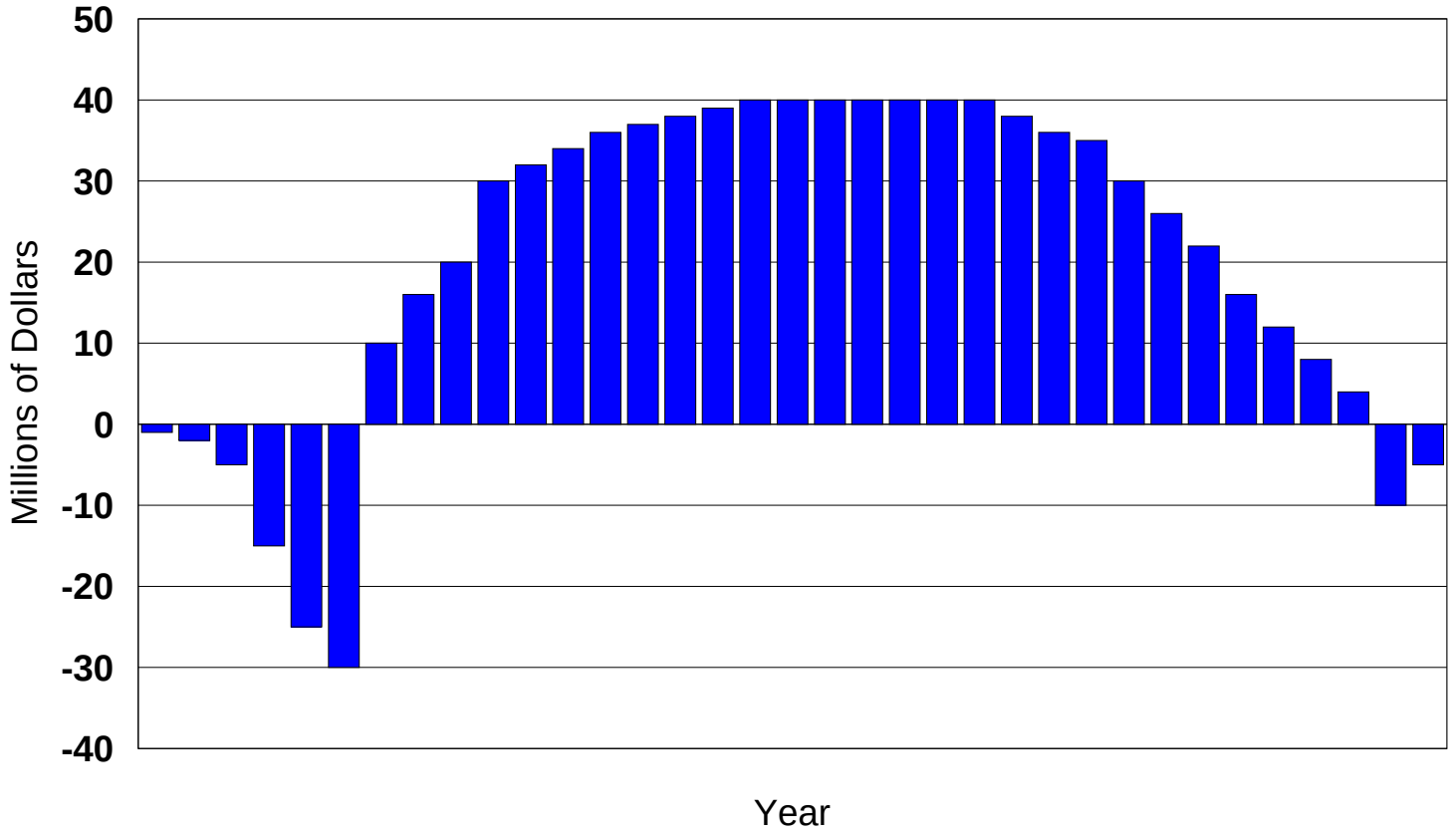
Carl D. Martland

- Basic Question:
  - Are the future benefits large enough to justify the costs of the project?
- Present, Future, and Annual Worth
- Internal & External Rates of Return

How Do We Justify a Project?

- Is this project worthwhile?
  - *Are the benefits greater than the costs?*
    - ***Are MY benefits greater than MY costs?***
- Is this the best way to achieve these benefits (either engineering & institutional options)?
  - *Can similar benefits be achieved more efficiently by some other approach?*
- Is this the best place to allocate resources?
  - *Do other projects have greater payoff?*
  - *Are other types of benefits more important?*

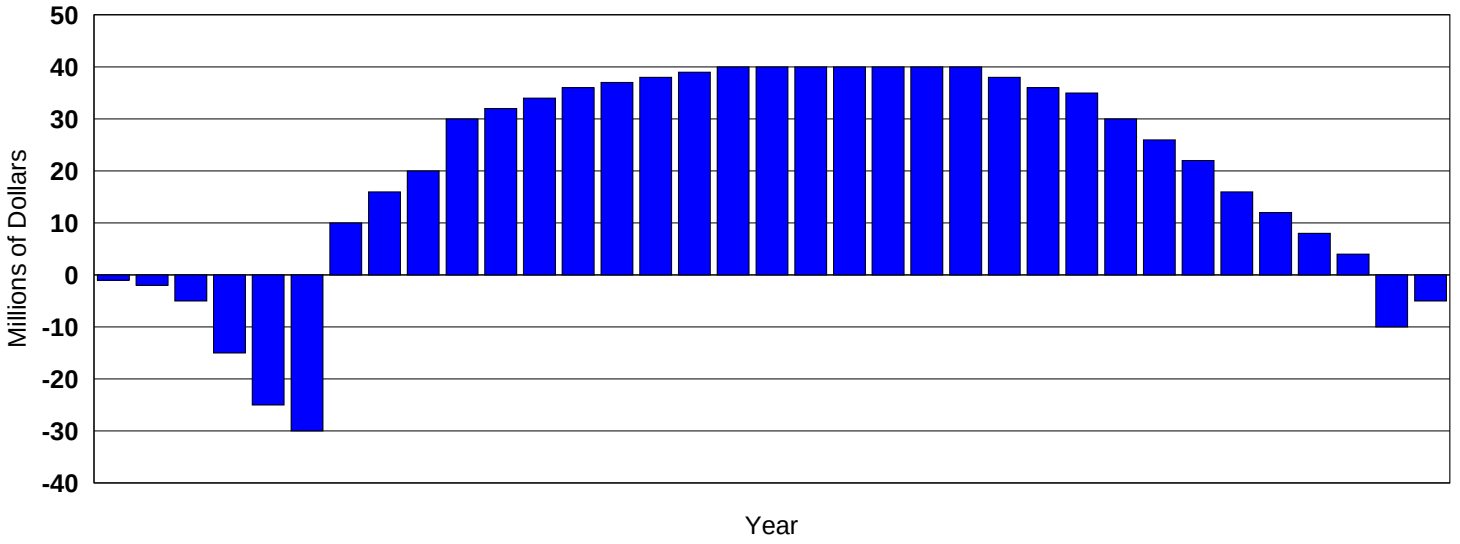
Cash Flow of a Typical CEE Project

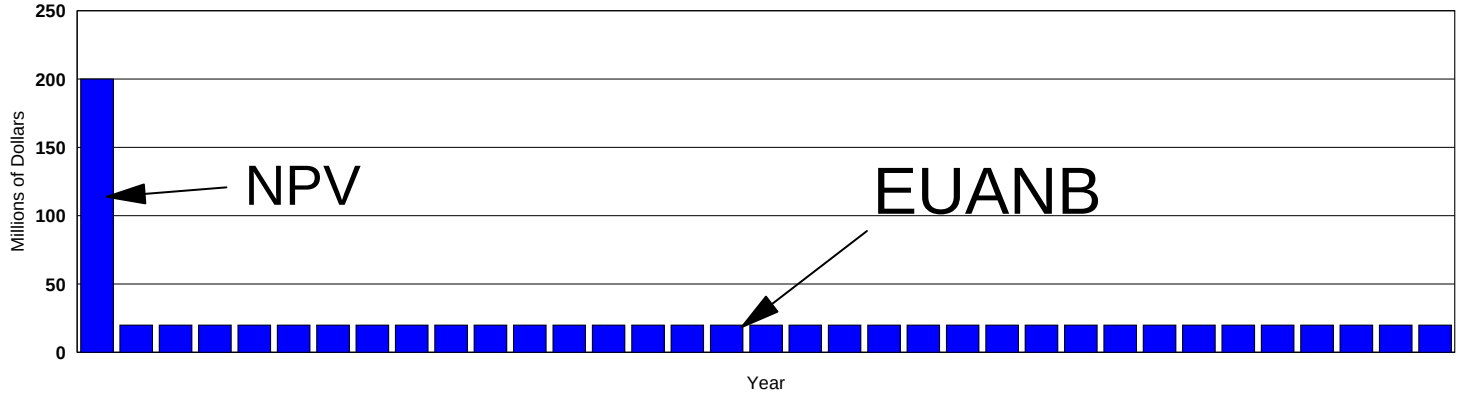


Evaluating a Time Stream of Monetary Costs & Benefits

- Key concepts:
  - Time value of money
  - Risk vs. required return
  - Present Worth (= Net Present Value)
  - Equivalence (for PW, FW, and AW)
  - Project Life

Cash Flows, NPV, and Equivalent Uniform Annual Net Benefits

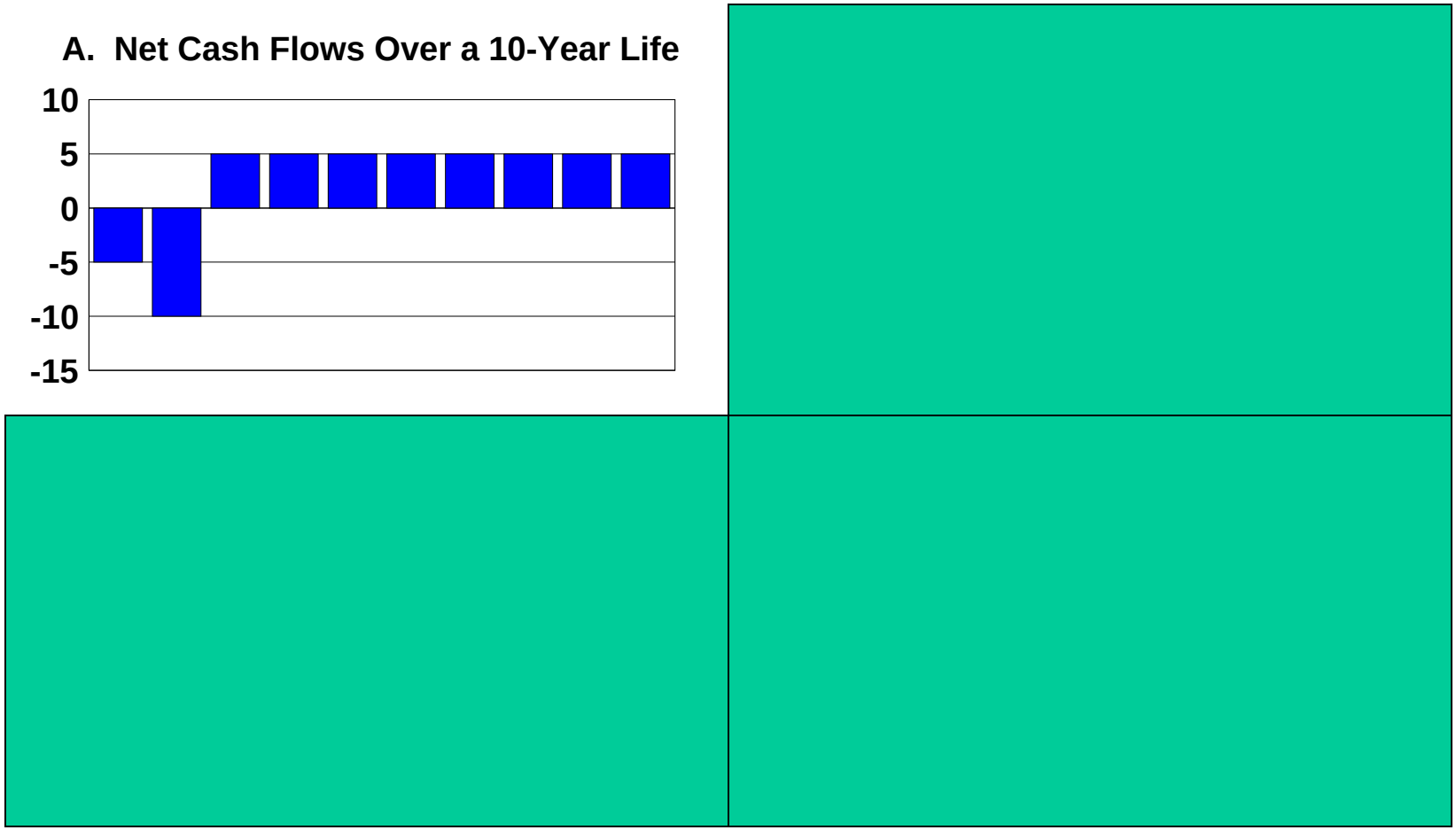




Importance of the Project Life

- Projects need to be evaluated over a reasonable project life (and the economic life will be shorter than physical life)
  - However, your choice of a project life should NOT determine the outcome of the analysis (if it does, you must show sensitivity of the results to project life)
- Because of discounting, the "out years" do not add much to the NPV, so a 20 to 50 year life is usually sufficient for analysis
  - The proper assumption is that the very long term effects will be positive or neutral - NOT that we can live it up now and let our children and grandchildren worry about the future!
- Risks increase with time
  - So we don't want to be dependent on long-term benefits to recover our investment.

Choice of a Project Life Should NOT Determine the Outcome of Your Analysis!



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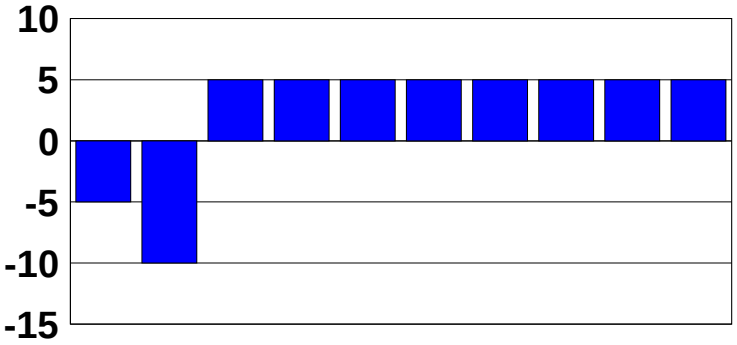
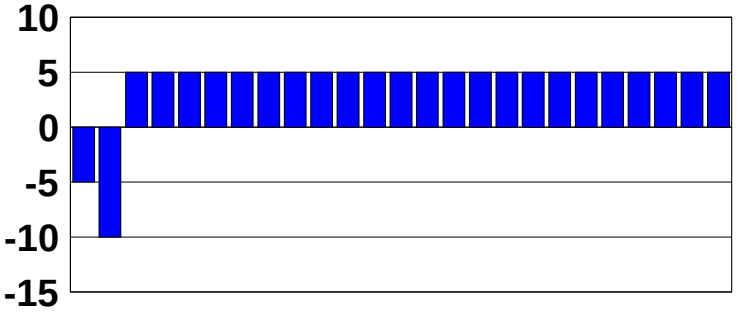
A. Net Cash Flows Over a 10-Year Life



B. Net Cash Flows Over 25 Years (Assuming Steady State After Year 10)



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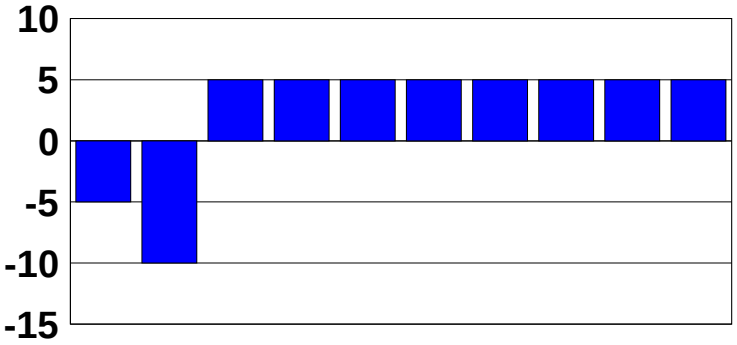

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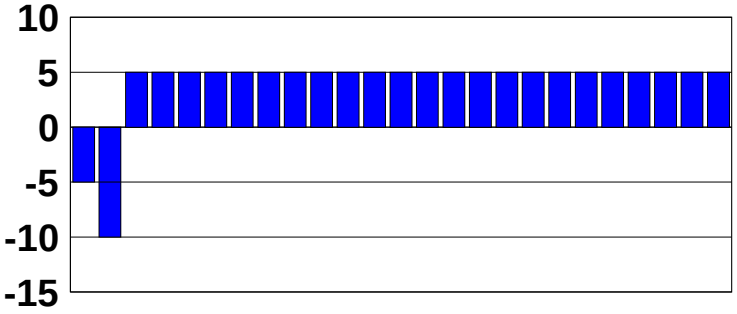
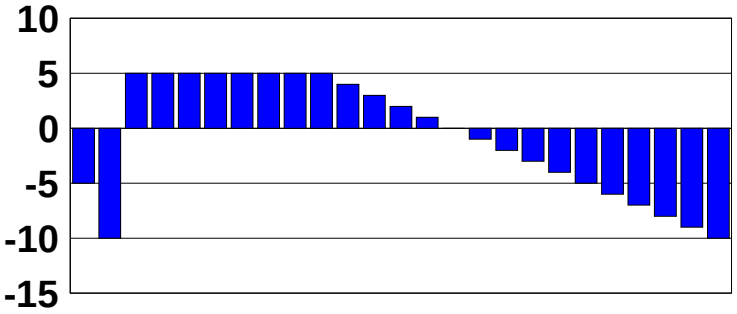


C. Cash Flows Over 25 Years (Increasing Competition & Maintenance)



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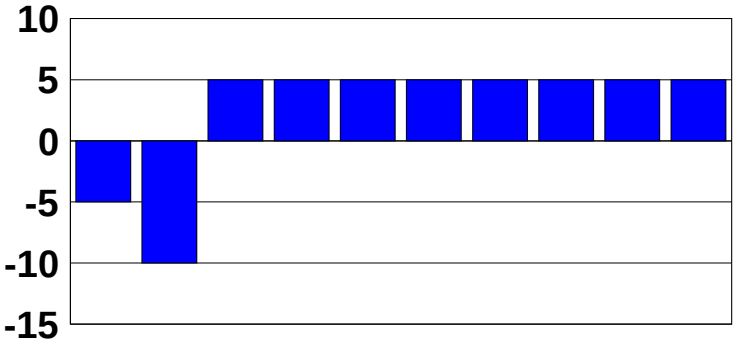

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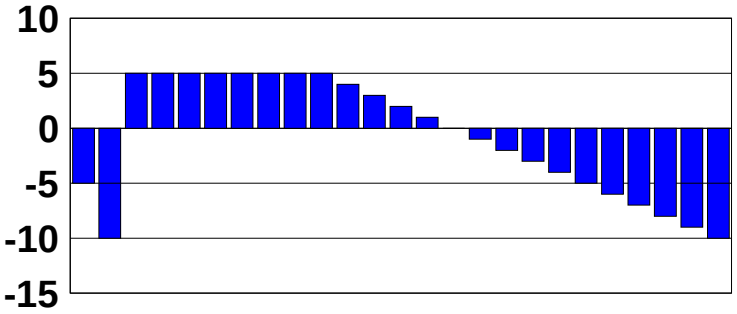
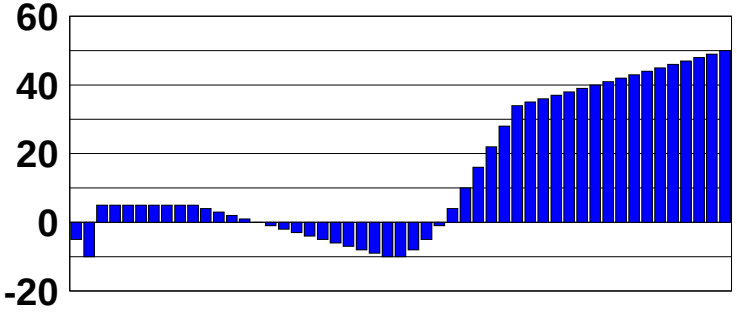


D. Net Cash Flows Over 50 Years (Rehab and Expansion in Prime Location)



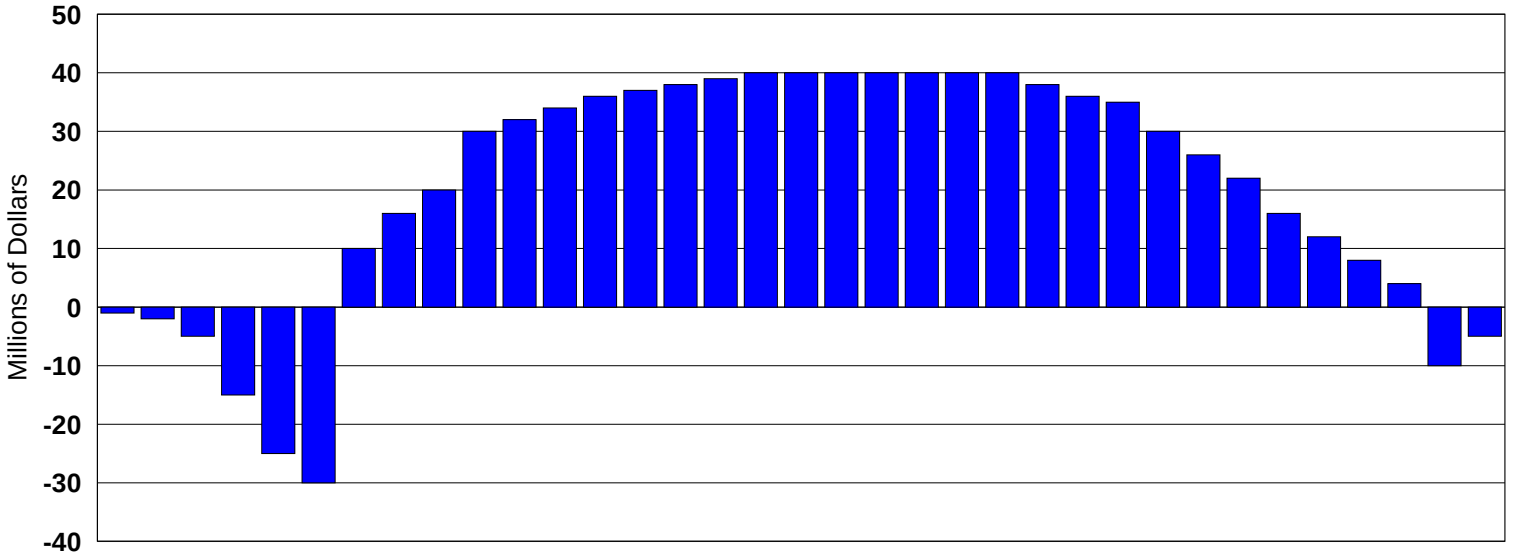
Meaning of NPV

- NPV > 0, using a discount rate of i%
  - This project is better than making an investment at i% per year for the life of the project
  - This project is worth further consideration
- NPV < 0, using a discount rate of i%
  - This project does not provide enough financial benefits to justify investment, since alternative investments are available that will earn i% (that is what is meant by "Minimum Acceptable Rate of Return")
  - The project will need additional, possibly non-cash benefits to be justified

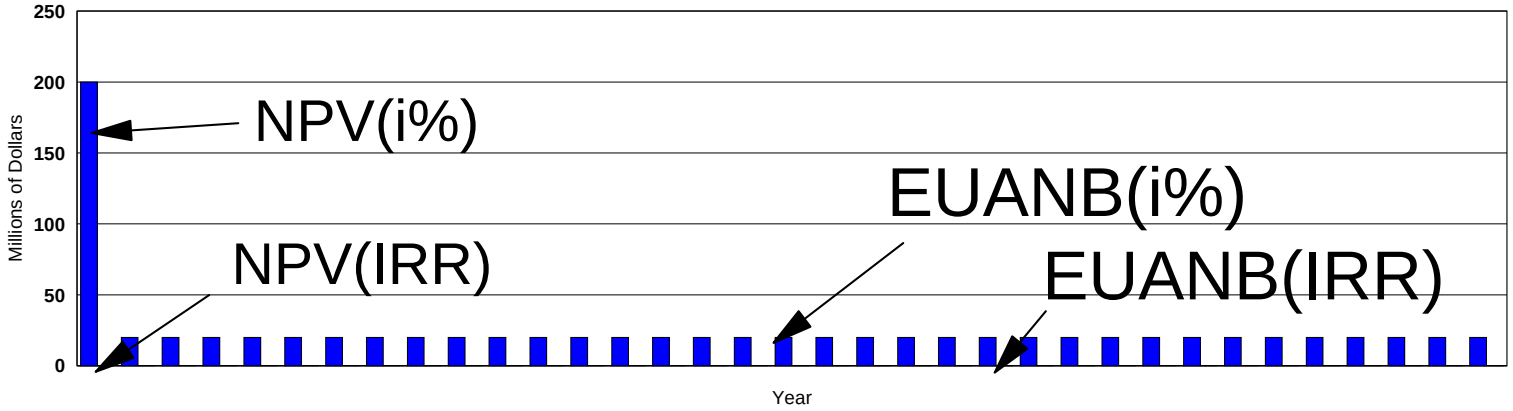
Other Ways to Evaluate Cash Flows

- Benefit/Cost Ratios
  - NPV(Benefits)/NPV(Costs)
  - Commonly used in public policy analyses
    - Required in order to ensure that benefits (by SOME measue at least!) are greater than costs
    - A political, not a methodological statement!
- Internal and External Rates of Return (IRR and ERR)
  - Very common in private sector, but there may be problems with IRR (which can be fixed by using ERR)
- Payback Period
  - How many years to recoup my investment? (A rather unsatisfactory approach that may be useful for quick assessment of some projects)

Calculating the Internal Rate of Return



Choose discount rate such that the NPV = 0



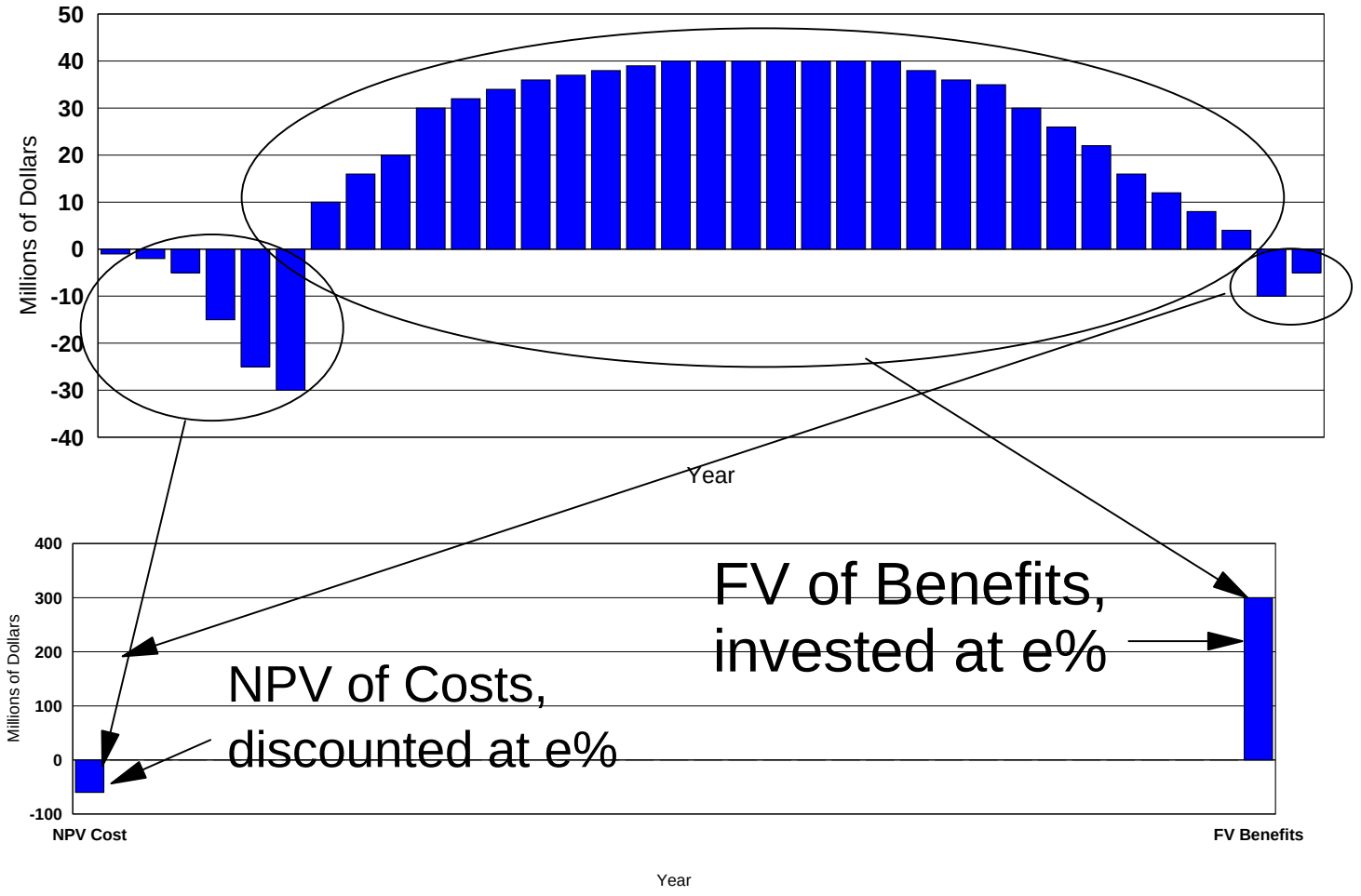
Problems With the Internal Rate of Return

- If the cash flows switch signs more than once, there could be two or more IRR for which NPV(IRR) = 0
- This method assumes that all intermediate cash flows can be discounted/reinvested at the IRR
  - This is unrealistic when the IRR is very high
- The private sector uses this method very commonly despite these problems

A Better Approach: The External Rate of Return

- Use a different discount rate (called the "External Rate of Return") to
  - Discount all expenses to time 0
  - Reinvest all benefits for the remaining time in the project life
- Then compare the NPV of the costs and the Future Value of the benefits
  - The external rate of return is the discount rate s.t. the NPV of the costs is equivalent to the FV of the benefits

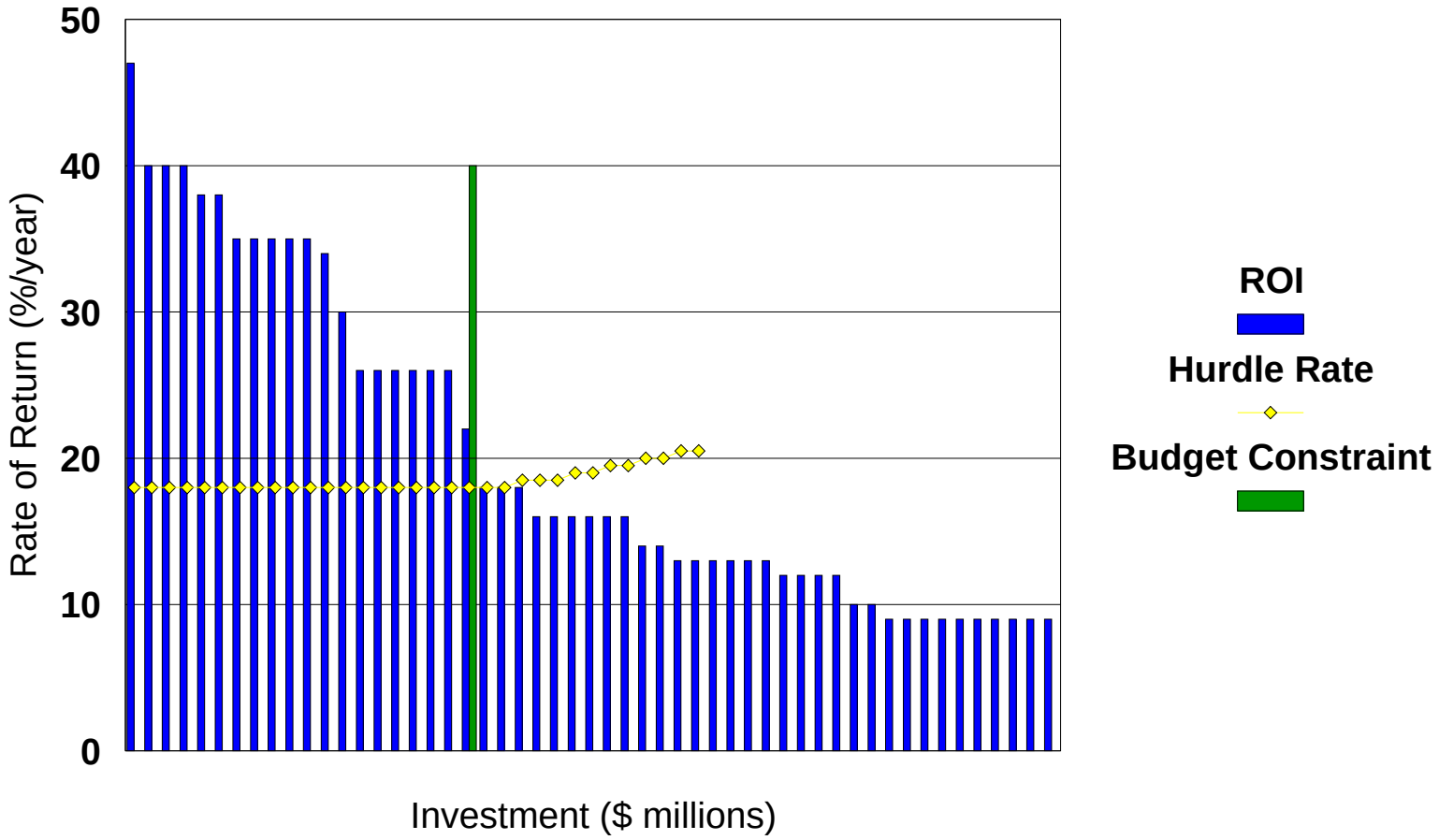
Calculating the External Rate of Return



Can We Justify this Project Against Competing Projects?

- In principle, any project with NPV > 0 is worth pursuing.
- In practice, capital budgets are limited, so that choices must be made:
  - *What set of projects gives the greatest benefits from using the available resources?*
- Common approach in private sector: Hurdle rate of return:
  - Rank independent projects by rate of return (typically IRR, but should be ERR):
  - Choose projects (or sets of projects) with highest return subject to a budget constraint

Selecting Projects Based Upon a Hurdle Rate of Return



Ranking Projects

- Using PW, AW or FW will give the same ranking for independent projects or independent sets of projects.
- Maximizing PW does seem to be the right objective.
- QUESTIONS:
  - Will IRR rank projects the same way as PW, AW or FW?
  - Will IRR select the wrong projects?

Mutually Exclusive Projects

- “Sometimes you have to finally decide, make up your mind, let the other one ride”
- You want the best project – and some projects with apparently acceptable returns really are not acceptable
- You need to be very careful when using IRR to rank projects

An Example of Inconsistent Rankings
(E.E. Section 5.4.2.1)

	A	B	A-B
Capital Investment	-$60,000	-$73,000	-$13,000
Revenue - Expense	$22,000/yr	$26,225/yr	$4,225/yr
PW	$9,738	**$10,131**	
IRR	**17.3%**	16.3%	
Project life	4 years	4 years	

How Do We Resolve the Inconsistency?

Is the smaller investment acceptable? Yes, PW > 0

Is the INCREMENTAL investment of $13,000 justified by the incremental return?

$4,225 extra for four years, at MARR = 10%

PW = $4225 * (P/A,10%,4) = $4,225*3.169

= $13,393 > $13,000

The PW of the INCREMENTAL investment is positive, so the incremental investment is better, even though the IRR is lower!

Example 1: Lesson

- Of all the options with PW > 0, let the base case be the option with the lowest capital cost
- Consider the next largest investment if the incremental return on the incremental investment is greater than the MARR
  - This means that the IRR on the incremental investment exceeds the MARR
- Recommend the largest investment where the incremental investment is justifiable

Example 2: More Options

(Amounts in $1000s)

		Invest	Net Income
Park	Parking Lot	$200	$22
B1	1 Story Building	4,000	$600
B2	2 Story Building	5,500	$720
B3	3 Story Building	7,500	$960

Example 2: Incremental Analysis

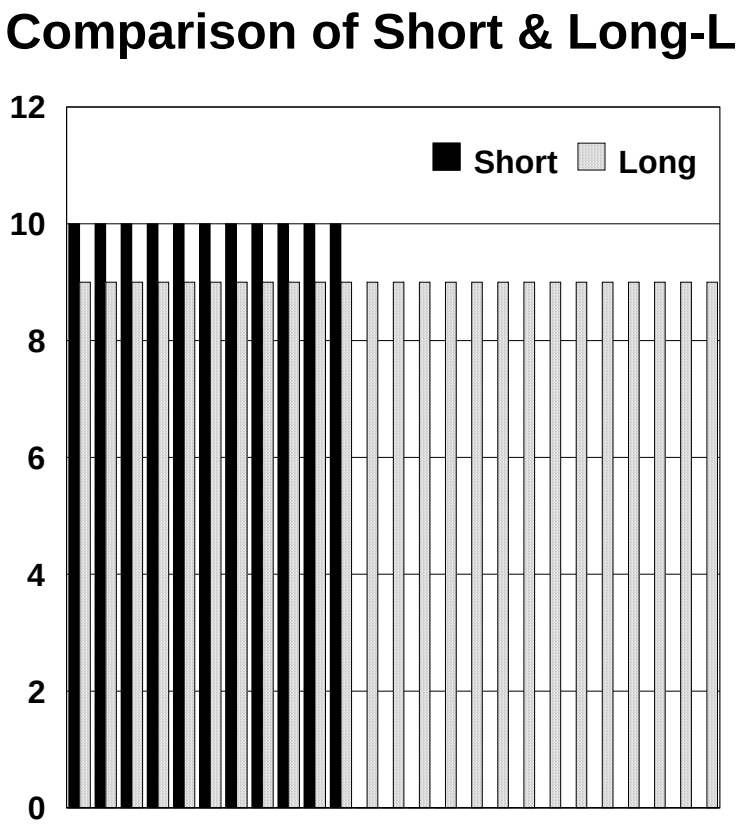
(Amounts in $1000s)

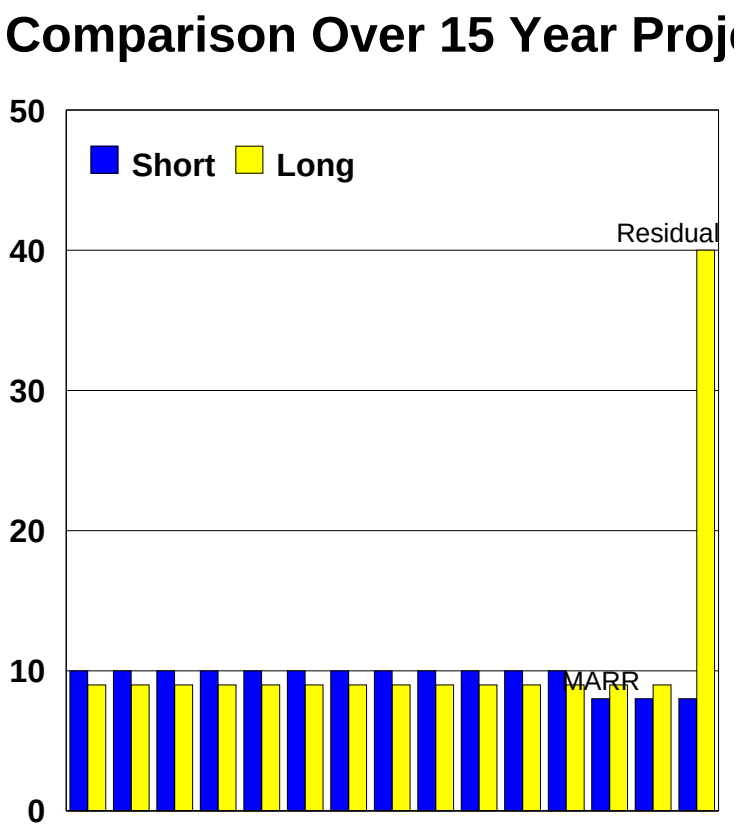
	B1-P	B2-B1	B3-B1
∆ K	-$3,800	-$1,550	-$3,500
∆Inc	$578	$120	$360
∆IRR	15.2%	7.7%	10.3%
	OK	NDG!	OK

If Project Lives Are Different

- Use a longer life that is an integral multiple of both lives, e.g. use a 20 year life to compare projects of 4, 5, or 10 years duration
- Estimate a residual value for the project with a longer life and use the life of the shorter-lived project
- Use a sufficiently long life that the differences will be neglible
- Use the AW method (and assume that you would replace your project with one that is at least that good)
- Use common sense and do sensitivity analysis if you are in doubt! There is NO right method!

Comparing Projects With Unequal Lives Using MARR & Residual Value





Summary

- The equivalent worth methods are computationally less cumbersome to use and to understand
- Both the equivalent worth and the IRR/ERR methods will give the correct choice if used properly
- IRR/ERR methods will give the WRONG choice if a manager insists on the highest return rather than ensuring that the incremental IRR is greater than the MARR

Questionable Assumptions

- We know the MARR
  - *In principle we should, but this is a little fuzzy!*
- We know the limit for capital expenditures
  - *The limit is always negotiated - who has the power in the corporation? who can convince the board to go ahead? who can convince people to buy bonds?*
- We have an ordered list of ALL feasible projects, none of which are mutually exclusive
  - *Highly unlikely! No one who has seriously considered design assumes they can EVER know ALL of the alternatives, many of which are mutually exclusive!*
- Decision-makers use PW, AW, or FW methods
  - *In fact, they prefer using the Internal Rate of Return!*

Are There Alternatives For Achieving the Objectives of this Project?

- The NPV analysis only shows that a project can be justified relative to the discount rate that is used
- There may be other projects that are even better for achieving the same objectives:
  - Better materials & technologies to build the same facility
  - Different design for a structure to serve the same purpose
  - Different location for a similar structure
  - Different scale (larger or smaller)
- In general, you cannot prove that your design is the best, you can only defend and refine (or abandon) your design in response to other options

Broader Economic Issues

- Prices of resources may not reflect their true costs
  - Local rather than world rates for energy costs
  - Natural resources priced at extraction cost rather than at market cost
  - Opportunity cost of land may be omitted (build the highway through the park)
  - Government may require use of excess labor as a public policy
- Generational equity
  - Discounting of future costs and benefits may lead to long-term decline in the environment
  - "Worry about today and the future will take care of itself"

Broader Economic Issues (Continued)

- Distributional Equity
  - Costs and benefits will be unevenly distributed
  - If total benefits exceed total costs, there is at least a possibility of compensating the losers
  - Pareto optimality - some are better off and none are worse off (after compensation)
  - "No one is hurt" (a very strong constraint on development)\
- Regional Economic Impact
  - Multiplier effect of project expenditures on the local economy
  - Use of local labor & resources
- Non-financial Externalities
  - Many impacts - both positive and negative - may be left out of the cash flow analysis
  - Environmental impacts & need for remediation

Broader Economic Issues - Conclusions

- For any large project, there will be additional costs & benefits that must be considered in addition to the cash flows directly related to the project
- Some of these costs and benefits cannot readily be reduced to monetary measures
- Distribution of costs & benefits will be a concern
- In some cases, the non-quantifiable items will be the most important items to consider

1.011 Project Evaluation

Spring 2011