Life Cycle Analysis
Money… and More

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October 15, 2015

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listen • engage • advise • deliver

Factors affecting decision making

Goals of the organization

- Market-driven
- Core Business Delivery
- Public Image
- Political
- Financial Impact and Performance

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Performance

- Meeting functional needs
- Appropriate Utilization
  - Current and Projected
- Consumption of Limited Resources
  - Energy and water consumption
  - MONEY is a limited resource!

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Quantifying Financial considerations

- Is it prudent to invest in this building?
- Discounted Cash Flow analysis is the method to model and evaluate financial options on a "life cycle" basis.

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DISCOUNTED CASH FLOW ANALYSIS

- **DISCOUNTING** is the method of studying **time value of money.**
- **DISCOUNT RATE:** The cost of money
  - An opportunity cost of investment elsewhere
  - Long-term interest rate on a secure investment
  - Pro-rated cost of shareholder's ROI and debt service
  - Related to **CAP RATE** in valuing property
  - Impact of **RISK**
    - Lower rate for investment going forward
    - Higher rate for discounting uncertain future cash flows

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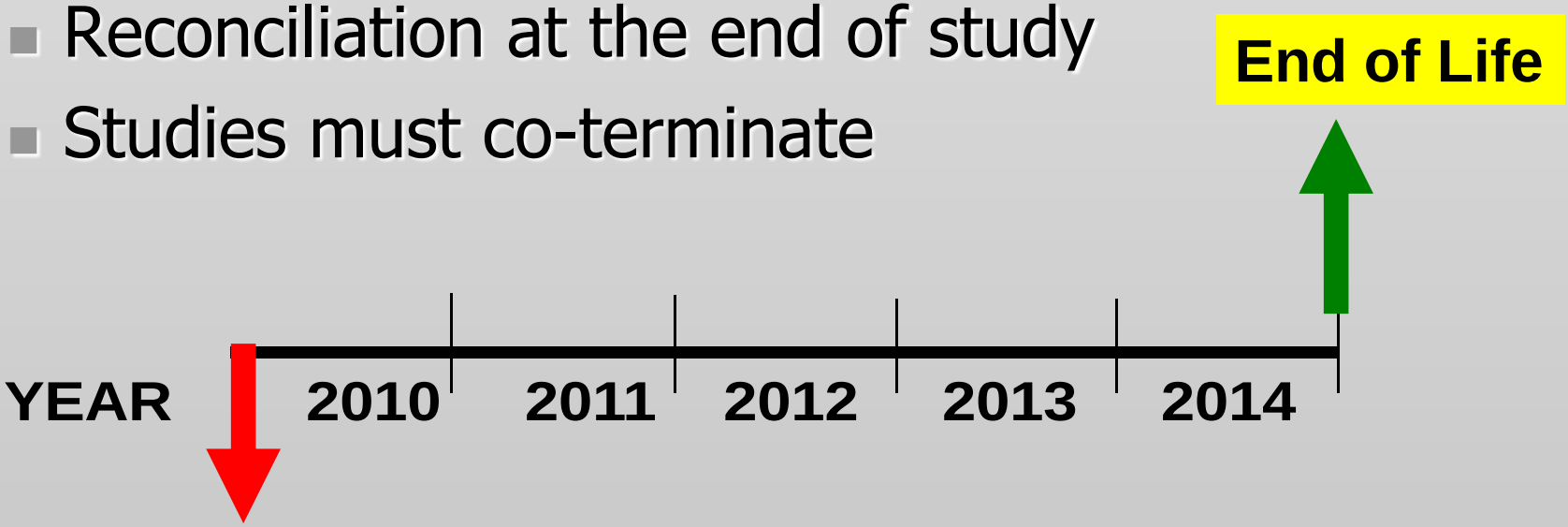
- **CAPITAL INVESTMENT**
  - Depreciation impact
  - Investment tax credits
- **RESIDUAL VALUE**
  - Added value at sale
  - Reconciliation at the end of study
  - Studies must co-terminate



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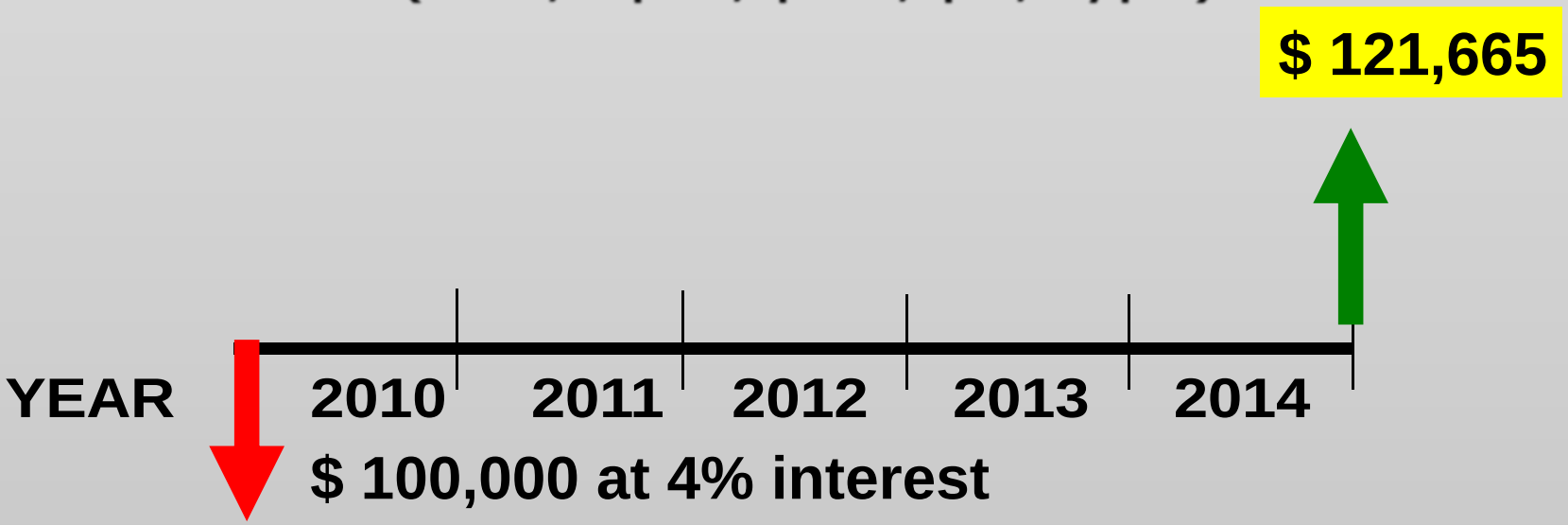
- **FUTURE VALUE**
  - The projected value into the future of an investment, escalated at a determined **DISCOUNT RATE**
  - $R \times (1+i)^n$
  - EXCEL FV(rate, nper, pmt, pv, type)



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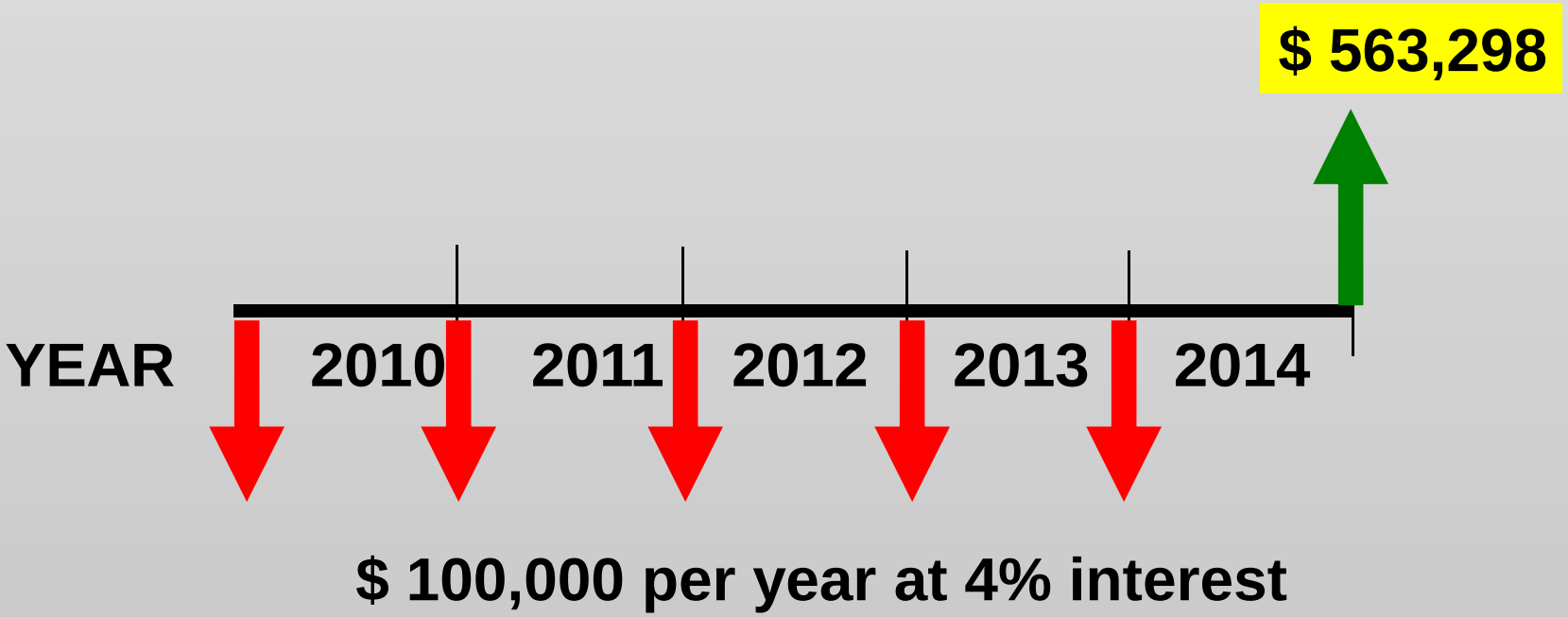
- **FUTURE VALUE of an ANNUITY**
  - The projected value into the future of an investment stream, escalated at a determined **DISCOUNT RATE**



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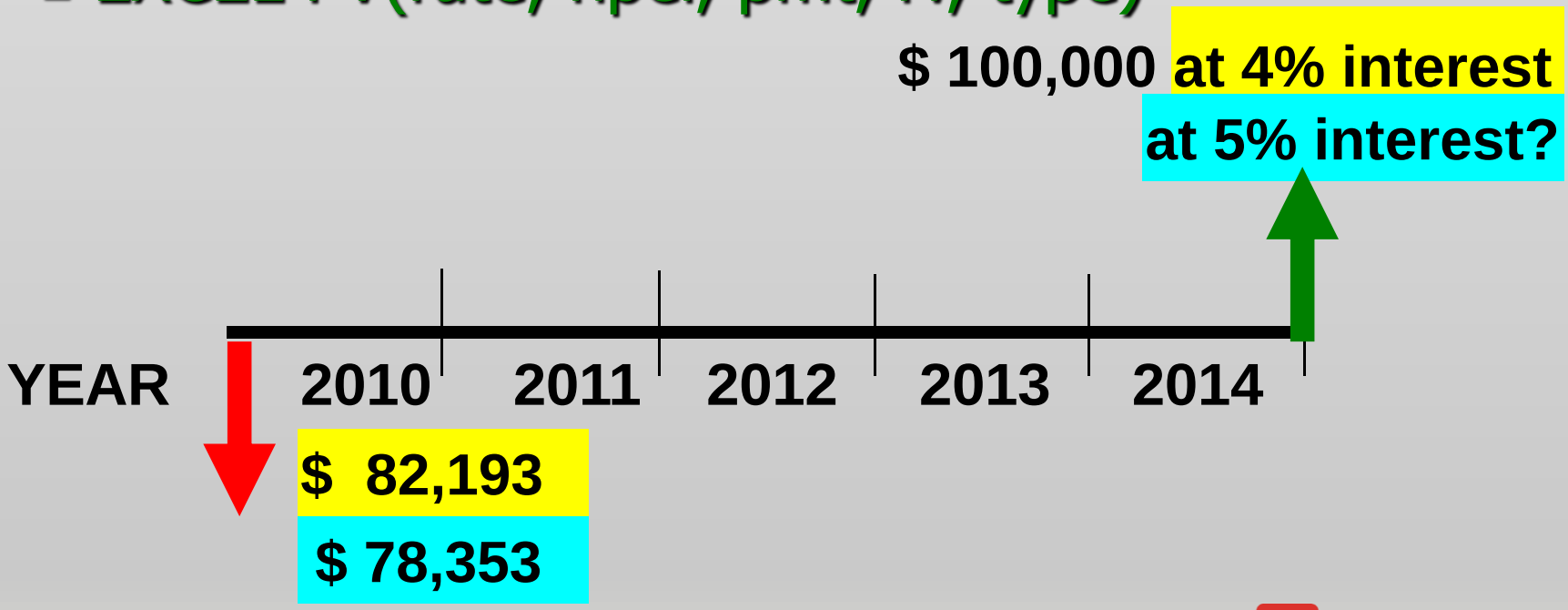
- **PRESENT VALUE**
  - The value in today's dollars of an expected future cash flow, calculated at a determined **DISCOUNT RATE**
  - $R / (1+i)^n$
  - EXCEL PV(rate, nper, pmt, fv, type)



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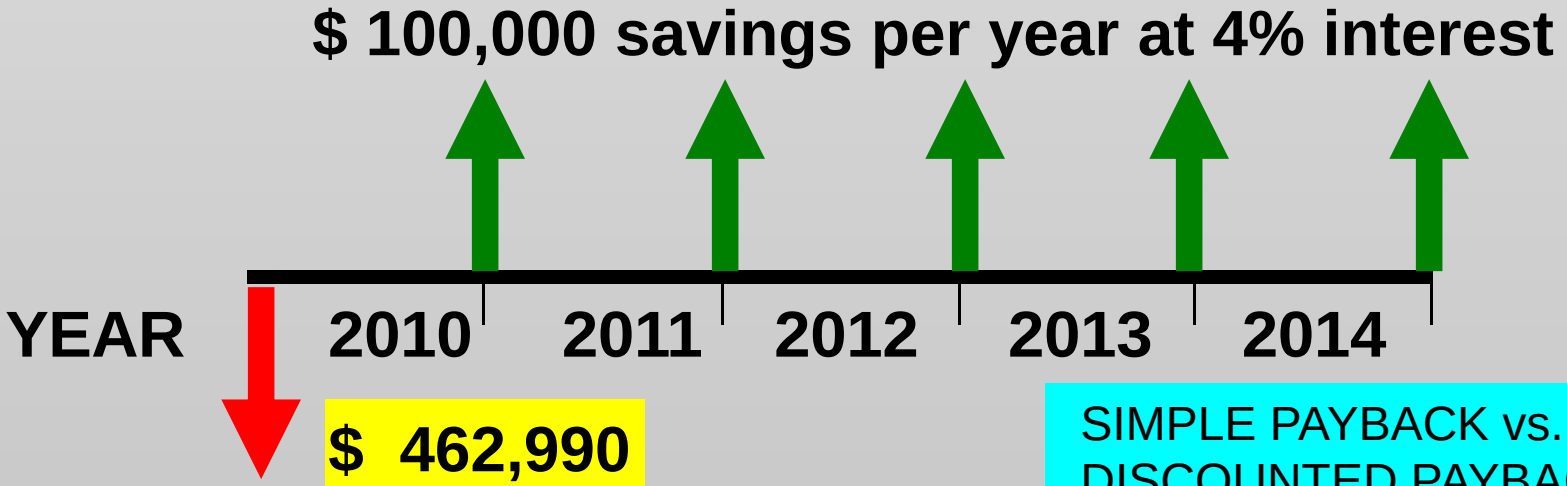
NET PRESENT VALUE

- The value in today's dollars of a projected stream of cash flows, calculated at a determined DISCOUNT RATE
- EXCEL NPV(rate, value1, value2…)
- A positive NPV means the study is viable at given discount rate



SIMPLE PAYBACK vs.
DISCOUNTED PAYBACK

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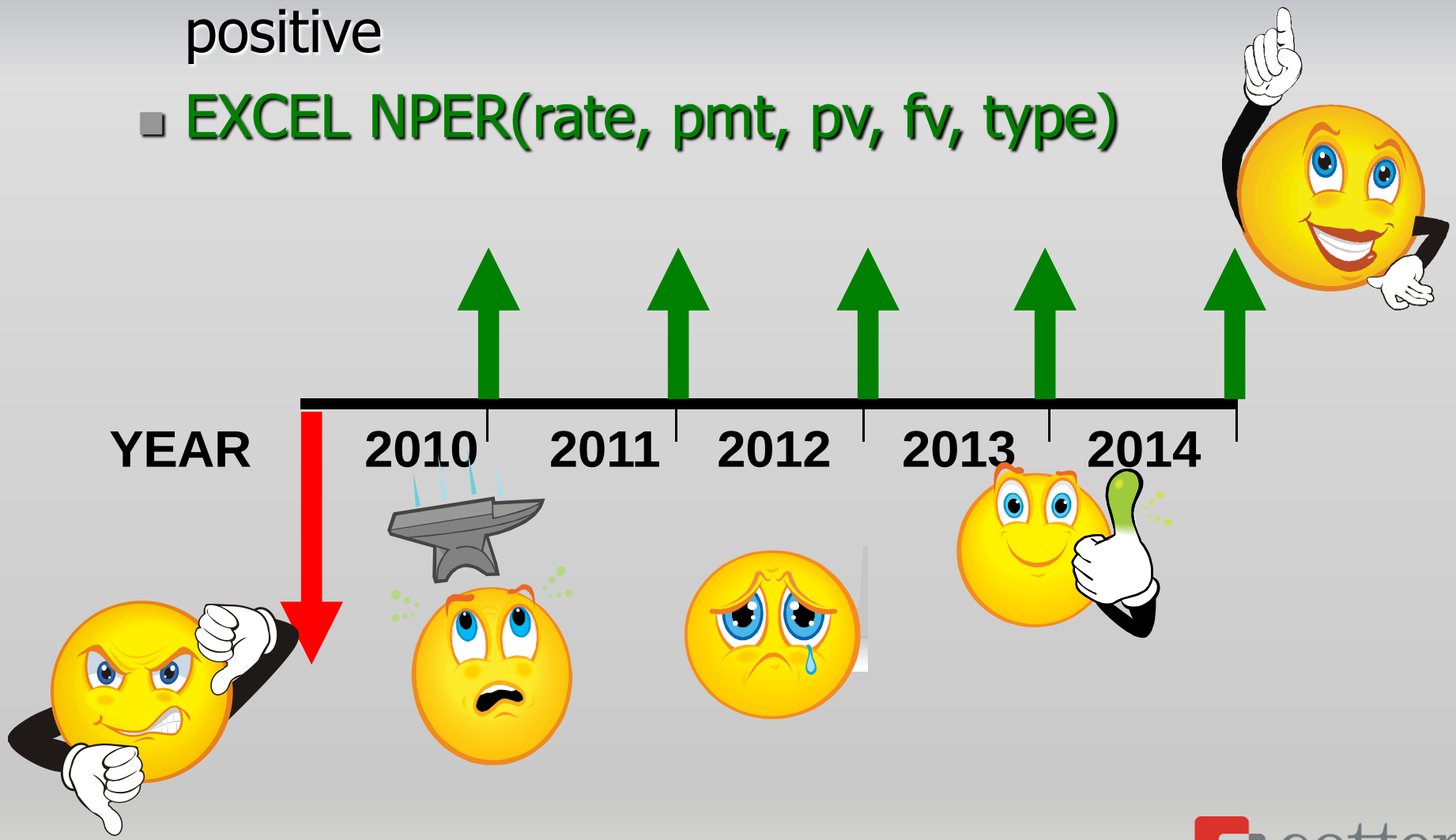
DISCOUNTED PAYBACK PERIOD

- The point at which the *cumulative* NPV turns positive
- EXCEL NPER(rate, pmt, pv, fv, type)



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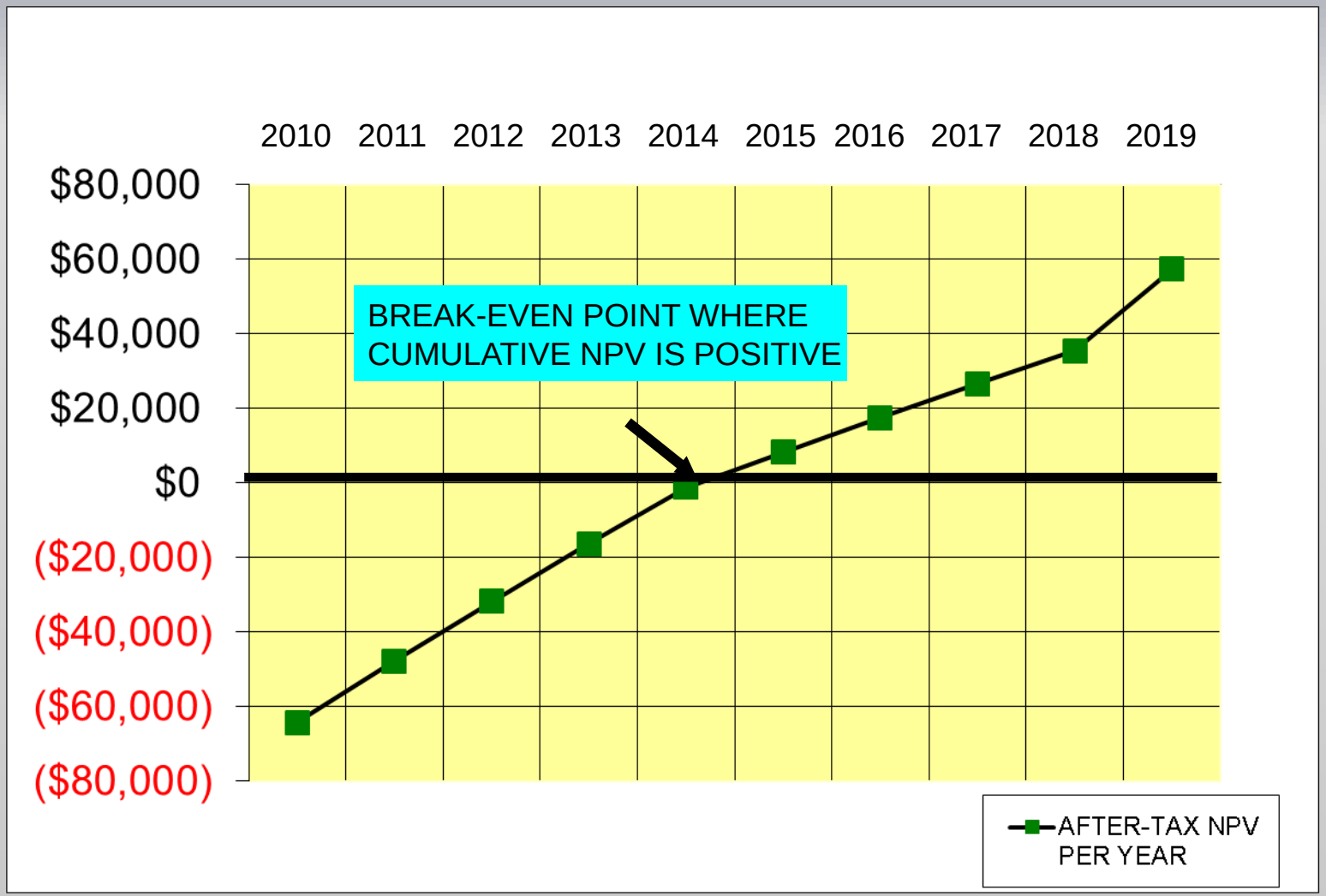
DISCOUNTED PAYBACK PERIOD



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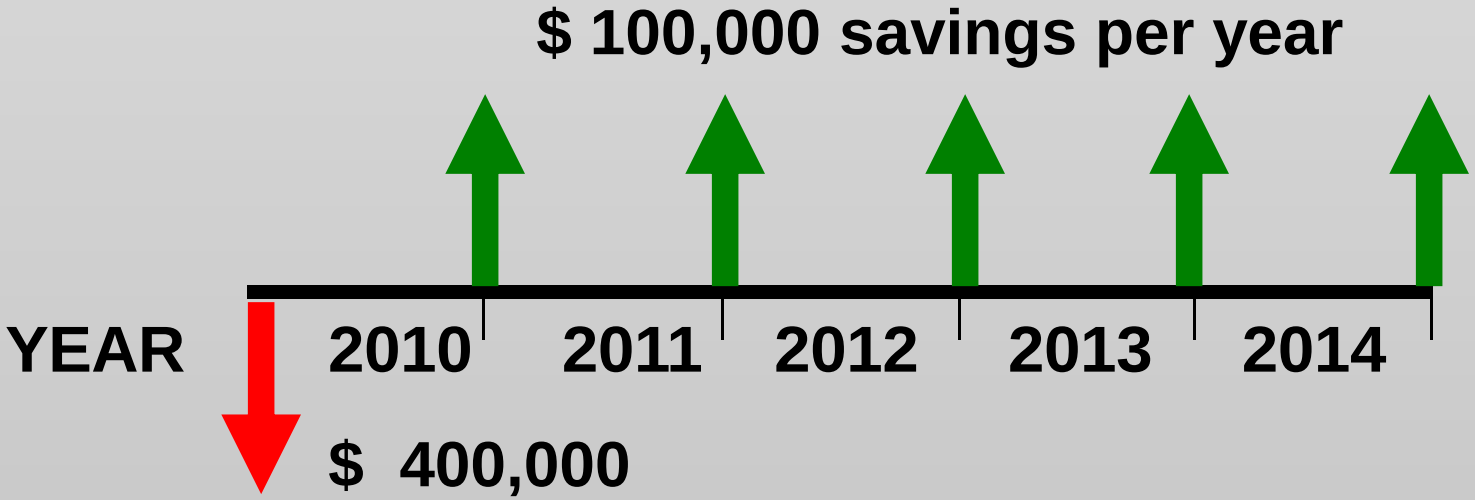
INTERNAL RATE OF RETURN

- The interest rate at which cash flows break even for the life of the study, or NPV=0
- EXCEL IRR(values, guess)
- Also referred to as the **RETURN ON INVESTMENT** or **ROI**.

IRR=7.93%



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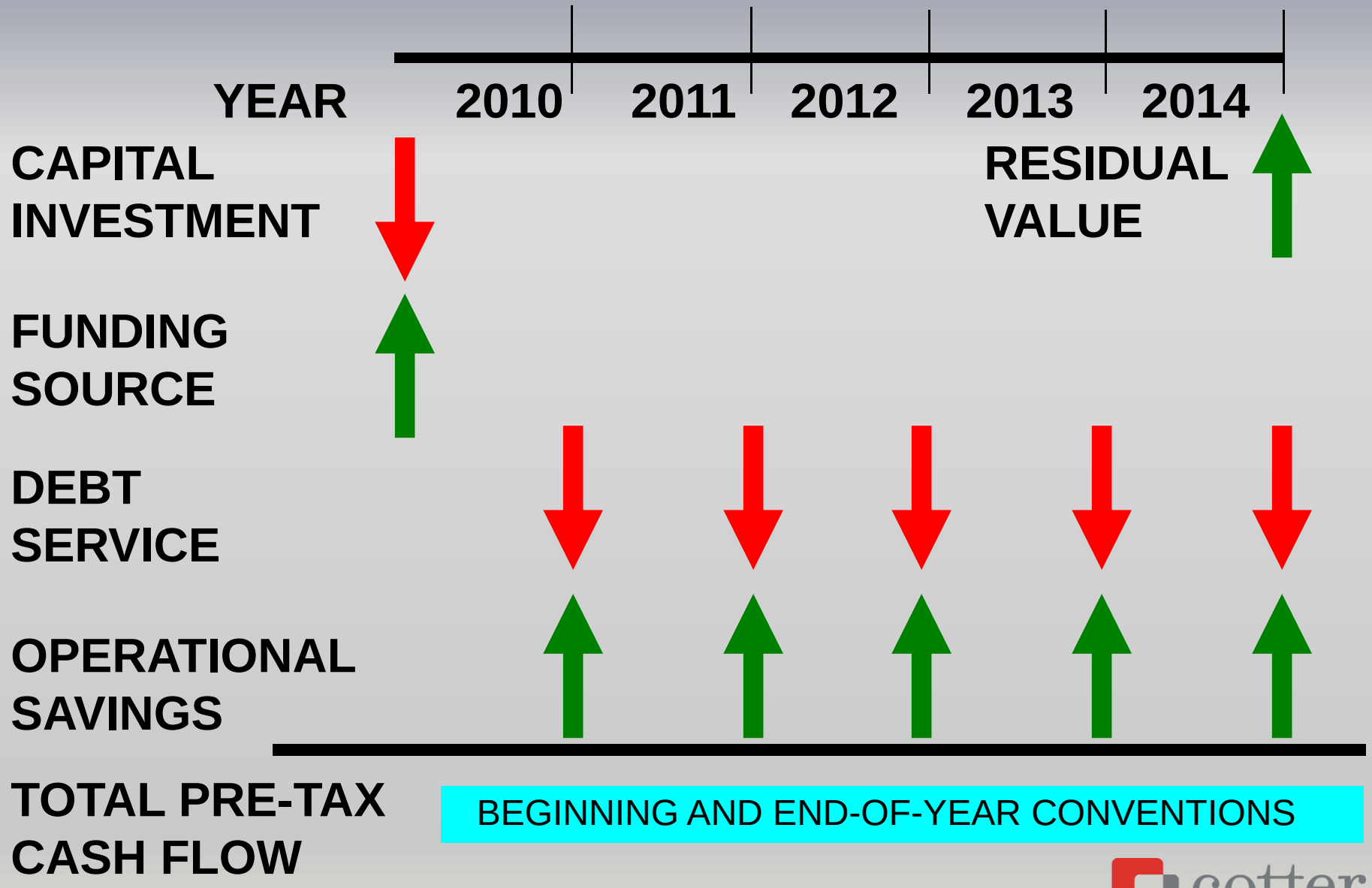
PRE-TAX CASH FLOWS



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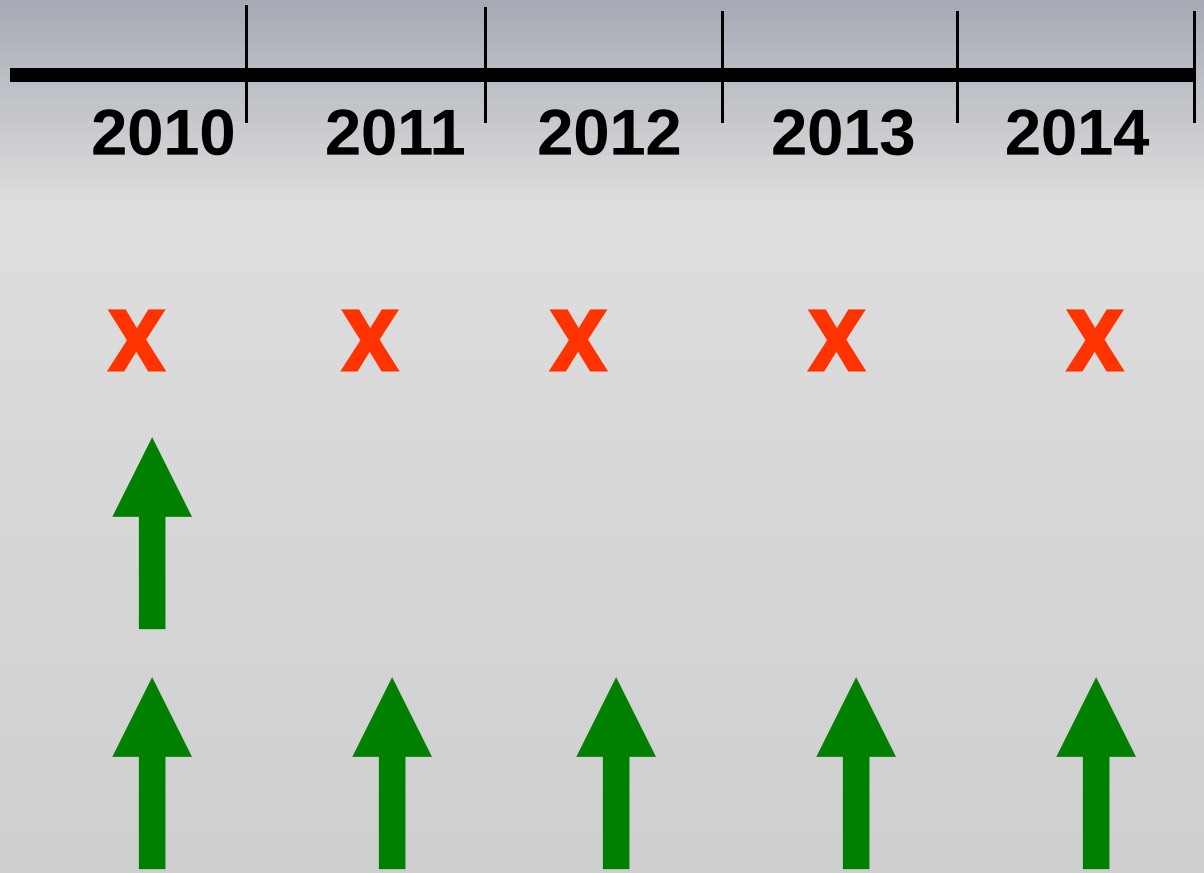
AFTER-TAX CASH FLOWS



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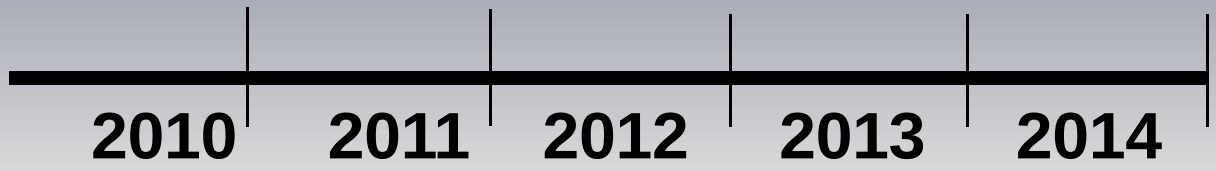
MULTIPLE OPTIONS



AFTER-TAX CASH FLOWS-

OPTION A
NPV=($500,000)

X X X X X

OPTION B
NPV=($750,000)

Y Y Y Y Y

A – B
NPV= $250,000

Z Z Z Z Z

OPTION WITH HIGHER NPV WINS

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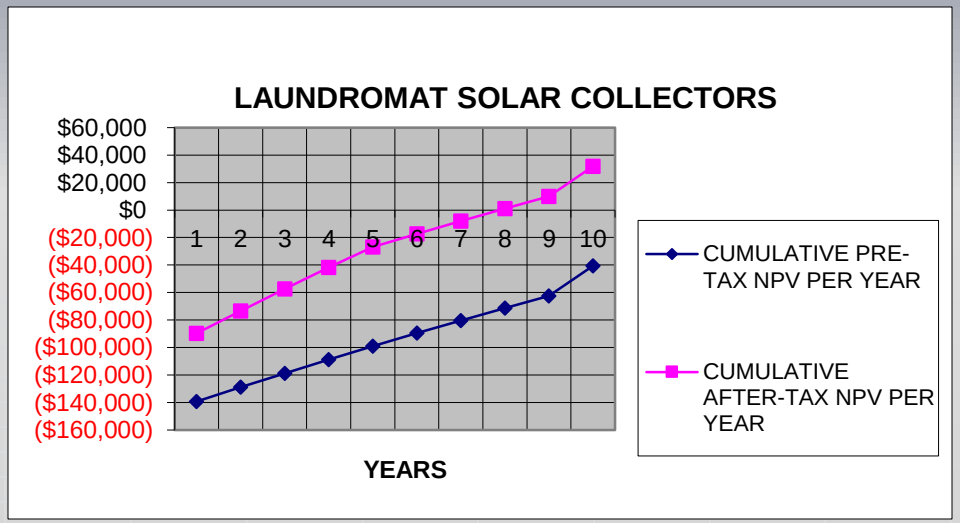
SAMPLE STUDY- SOLAR COLLECTORS



LAUNDROMAT SOLAR COLLECTORS	
COST OF MONEY	4.25%
GAS ENERGY ESCALATION	2.00%
ELEC ENERGY ESCALATION	4.00%
OPERATING EXPENSE ESCALATION	3.00%
TAX RATE	22.00%
RISK FACTOR	1.00
INITIAL CAPITAL INVESTMENT (Beg of Yr. 1)	($150,000)

PRE-TAX CASH FLOWS

		YEAR 0	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
end of yr	CAPITAL INVESTMTS	($150,000)										$20,000
end of yr	NGAS ENERGY COST or SAVINGS		$12,000	$12,240	$12,485	$12,734	$12,989	$13,249	$13,514	$13,784	$14,060	$14,341
end of yr	ELEC ENERGY COST or SAVINGS		($300)	($312)	($324)	($337)	($351)	($365)	($380)	($395)	($411)	($427)
end of yr	OPERATING EXP COST or SAVINGS		($600)	($618)	($637)	($656)	($675)	($696)	($716)	($738)	($760)	($783)
	TOTAL PRE-TAX CASH FLOIW	($150,000)	$11,100	$11,310	$11,524	$11,741	$11,963	$12,188	$12,418	$12,652	$12,889	$33,131
	PRE-TAX NPV ($40,563)											
	PRE-TAX IRR -0.98%											
	CUMULATIVE PRE-TAX NPV PER YEAR		($139,353)	($128,946)	($118,775)	($108,834)	($99,119)	($89,624)	($80,345)	($71,276)	($62,414)	($40,563)

AFTER-TAX CASH FLOWS

	30% ENERGY INVESTMENT TAX CREDIT		$45,000									
	DEPRECIATION TAX SAVINGS		$6,600	$6,600	$6,600	$6,600	$6,600					
	TAX IMPACT OF COST OR SAVINGS											
	TOTAL AFTER-TAX CASH FLOW	($150,000)	$62,700	$17,910	$18,124	$18,341	$18,563	$12,188	$12,418	$12,652	$12,889	$33,131
	AFTER-TAX NPV $31,780											
	AFTER-TAX IRR 9.38%											
	CUMULATIVE AFTER-TAX NPV PER YEAR		($89,856)	($73,377)	($57,380)	($41,852)	($26,777)	($17,282)	($8,002)	$1,066	$9,928	$31,780

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SAMPLE STUDY- CHILLER REPLACEMENT

PRE-TAX CASH FLOWS

CHILLER REPLACEMENT STUDY	
COST OF MONEY	1.00%
GAS ENERGY ESCALATION	1.00%
ELEC ENERGY ESCALATION	4.00%
OPERATING EXPENSE ESCALATION	3.00%
TAX RATE	22.00%
RISK FACTOR	1.00

The purpose of this model is to study replacing inefficient equipment that is near the end of its useful life sooner rather than later

PRE-TAX CASH FLOWS

ALTERNATE A- REPLACE EXISTING CHILLER NOW WITH HIGH-EFFICIENCY CHILLER

		YEAR 0	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
end of yr	CAPITAL INVESTMTS AND RESIDUAL	($220,000)										$73,700
end of yr	NGAS ENERGY COST or SAVINGS		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
end of yr	ELEC ENERGY COST or SAVINGS		($3,500)	($3,640)	($3,786)	($3,937)	($4,095)	($4,258)	($4,429)	($4,606)	($4,790)	($4,982)
end of yr	OPERATING EXP COST or SAVINGS		$0	$0	$0	$0	$0	($1,000)	($1,030)	($1,061)	($1,093)	($1,126)
	ALT A PRE-TAX CASH FLOW	($220,000)	($3,500)	($3,640)	($3,786)	($3,937)	($4,095)	($5,258)	($5,459)	($5,667)	($5,883)	$67,593
	PRE-TAX NPV	($197,853)										

ALTERNATE B- REPLACE EXISTING CHILLER IN FIVE YEARS

end of yr	CAPITAL INVESTMTS AND RESIDUAL						($242,000)					$92,000
end of yr	NGAS ENERGY COST or SAVINGS		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
end of yr	ELEC ENERGY COST or SAVINGS		($8,500)	($8,840)	($8,928)	($9,018)	($9,108)	($4,258)	($4,429)	($4,606)	($4,790)	($4,982)
end of yr	OPERATING EXP COST or SAVINGS		($6,000)	($6,180)	($6,365)	($6,556)	($6,753)	$0	$0	$0	$0	$0
	ALT B PRE-TAX CASH FLOW	$0	($14,500)	($15,020)	($15,294)	($15,574)	($257,861)	($4,258)	($4,429)	($4,606)	($4,790)	$87,018
	PRE-TAX NPV	($242,235)										

DIFFERENCE ALTERNATE A - ALTERNATE B

	YEAR 0	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
NET PRE-TAX CASH FLOW	($220,000)	$11,000	$11,380	$11,508	$11,637	$253,766	($1,000)	($1,030)	($1,061)	($1,093)	($19,426)

PRE-TAX NPV	$44,382
PRE-TAX IRR	5.48%

CUMULATIVE PRE-TAX NPV PER YEAR	($209,109)	($197,953)	($186,783)	($175,600)	$65,850	$64,908	$63,947	$62,967	$61,968	$44,382

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SAMPLE STUDY- CHILLER REPLACEMENT

AFTER-TAX CASH FLOWS

AFTER-TAX CASH FLOWS

ALTERNATE A- REPLACE EXISTING CHILLER NOW WITH HIGH-EFFICIENCY CHILLER

	YEAR 0	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
ALT A PRE-TAX CASH FLOW	($220,000)	($3,500)	($3,640)	($3,786)	($3,937)	($4,095)	($5,258)	($5,459)	($5,667)	($5,883)	$67,593
30% ENERGY INVESTMENT TAX CREDIT		$66,000									
DEPRECIATION TAX CREDIT		$9,680	$9,680	$9,680	$9,680	$9,680					
TAX IMPACT OF COST OR SAVINGS											
TOTAL AFTER-TAX CASH FLOW	($220,000)	$72,180	$6,040	$5,894	$5,743	$5,585	($5,258)	($5,459)	($5,667)	($5,883)	$67,593
AFTER-TAX NPV	($85,525)										
AFTER-TAX NPV PER YEAR		($148,535)	($142,614)	($136,893)	($131,374)	($126,059)	($131,013)	($136,104)	($141,337)	($146,716)	($85,525)

ALTERNATE B- REPLACE EXISTING CHILLER IN FIVE YEARS

	YEAR 0	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
ALT B PRE-TAX CASH FLOW	$0	($14,500)	($15,020)	($15,294)	($15,574)	($257,861)	($4,258)	($4,429)	($4,606)	($4,790)	$87,018
10% ENERGY INVESTMENT TAX CREDIT							$25,786				
DEPRECIATION TAX CREDIT							$11,346	$11,346	$11,346	$11,346	$11,346
TAX IMPACT OF COST OR SAVINGS											
TOTAL AFTER-TAX CASH FLOW	$0	($14,500)	($15,020)	($15,294)	($15,574)	($257,861)	($18,698)	$6,917	$6,740	$6,556	$98,364
AFTER-TAX NPV	($214,133)										
AFTER-TAX NPV PER YEAR		($14,356)	($29,080)	($43,924)	($58,891)	($304,237)	($321,851)	($315,400)	($309,175)	($303,181)	($214,133)

DIFFERENCE ALTERNATE A - ALTERNATE B

	YEAR 0	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
NET AFTER-TAX CASH FLOW	($220,000)	$86,680	$21,060	$21,188	$21,317	$263,446	$13,440	($12,376)	($12,407)	($12,439)	($30,771)
AFTER-TAX NPV	$128,608										
AFTER-TAX NPV PER YEAR		($134,178)	($113,533)	($92,968)	($72,483)	$178,177	$190,839	$179,295	$167,838	$156,465	$128,608

AFTER-TAX NPV	$128,608
AFTER-TAX IRR	17.42%

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SAMPLE STUDY– ELECTRIC VS. GAS HEAT

CMS ELECTRIC HTRS VS. GAS			Avg costs 9/13									
COST OF MONEY		3.00%		The purpose of this model is to study the energy cost of								
GAS ENERGY ESCALATION		0.75%	.917/ therm	electric vs. gas heat- just the two cab heaters in flex								
ELEC ENERGY ESCALATION		3.00%	.124/ kWH	spaces								
OPERATING EXPENSE ESCALATION		3.00%										
TAX RATE		0.00%										
RISK FACTOR		1.00										
PRE-TAX CASH FLOWS												
ALTERNATE A- ELECTRIC CABINET HEATERS; ASSUME 8kW 450 hours=3600kWH												
			YEAR 0	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
end of yr	CAPITAL INVESTMTS AND RESIDUAL												
end of yr	NGAS ENERGY COST or SAVINGS			$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
end of yr	ELEC ENERGY COST or SAVINGS			($446)	($460)	($474)	($488)	($502)	($517)	($533)	($549)	($565)	($582)
end of yr	OPERATING EXP COST or SAVINGS			$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
	ALT A PRE-TAX CASH FLOW		$0	($446)	($460)	($474)	($488)	($502)	($517)	($533)	($549)	($565)	($582)
	PRE-TAX NPV	($4,334)											
ALTERNATE B- GAS-FIRED HEAT; ASSUME 123 THERMS (1 THERM= 29.3kWH)													
end of yr	CAPITAL INVESTMTS AND RESIDUAL												
end of yr	NGAS ENERGY COST or SAVINGS			($113)	($114)	($114)	($115)	($116)	($117)	($118)	($119)	($120)	($121)
end of yr	ELEC ENERGY COST or SAVINGS				$0	$0	$0	$0		$0	$0	$0	$0
end of yr	OPERATING EXP COST or SAVINGS				$0	$0	$0	$0	$0	$0	$0	$0	$0
	ALT B PRE-TAX CASH FLOW		$0	($113)	($114)	($114)	($115)	($116)	($117)	($118)	($119)	($120)	($121)
	PRE-TAX NPV	($994)											
DIFFERENCE ALTERNATE A - ALTERNATE E													
			YEAR 0	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
	NET PRE-TAX CASH FLOW		$0	($334)	($346)	($359)	($372)	($386)	($400)	($415)	($430)	($446)	($462)
	PRE-TAX NPV	($3,340)											

- **LEED IMPACT**
  - EA Points incentive in energy model
  - Cost is not a factor
  - Cradle-to-Grave thinking: Coal vs Natural Gas

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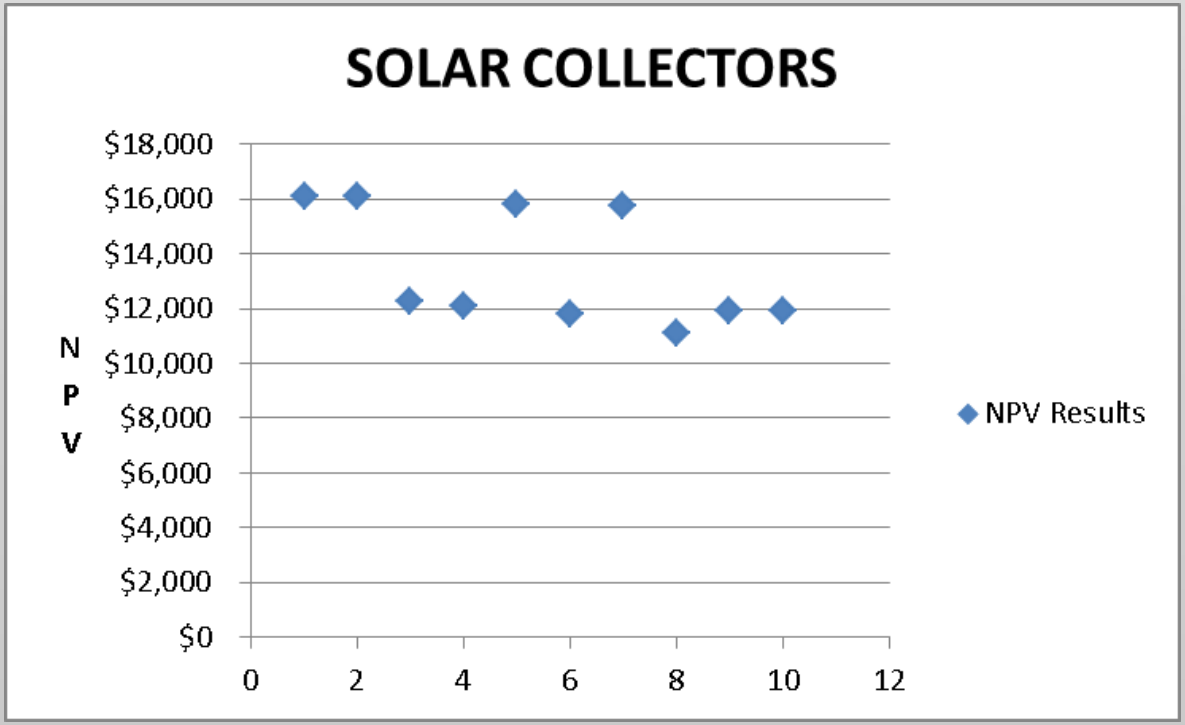
EVALUATING RISK:

IMPACT OF VARIABLES

LAUNDROMAT SOLAR COLLECTORS	
COST OF MONEY	4.00%
GAS ENERGY ESCALATION	2.00%
ELEC ENERGY ESCALATION	4.00%
OPERATING EXPENSE ESCALATION	3.00%
TAX RATE	22.00%
RISK FACTOR	1.00
INITIAL CAPITAL INVESTMENT (Beg of Yr. 1)	($150,000)

RANDOM NUMBER LIMITS	
MIN	MAX
1.50%	3.50%
2.00%	6.00%
-2.00%	2.00%

RANDOM NUMBER OUTPUT										
2.00%	3.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	3.00%	2.00%	3.00%
2.00%	5.00%	3.00%	3.00%	3.00%	4.00%	4.00%	3.00%	3.00%	2.00%	6.00%
1.00%	2.00%	1.00%	2.00%	-2.00%	2.00%	-2.00%	-2.00%	0.00%	-2.00%	1.00%



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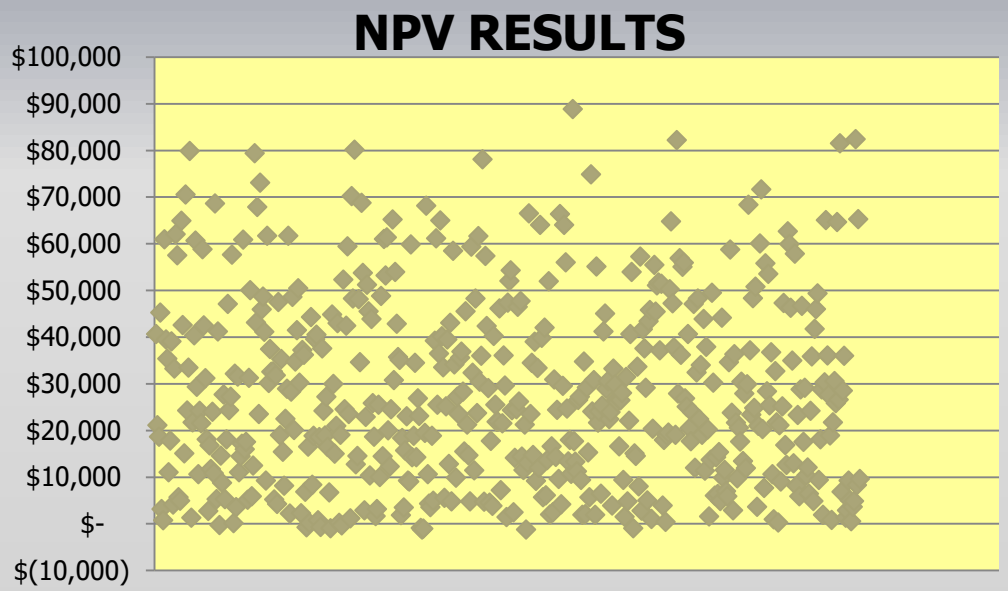
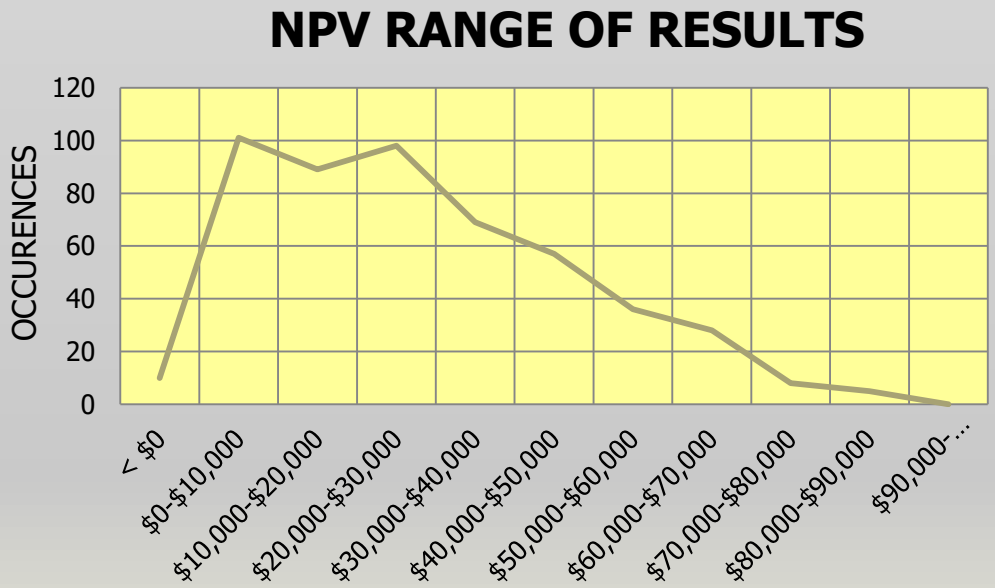
EVALUATING RISK:

SENSITIVITY

A METHOD OF STUDYING OPTIONS WITH A RANGE OF VARIABLES





MONTE CARLO MODEL

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WHAT'S NEW IN LIFE CYCLE ANALYSIS?

LEED v4 Building Life Cycle Impact Reduction

Compliant with ISO 14040 and ISO 14044

Up to five points

CRADLE-TO-GRAVE/ CRADLE CONSIDERATION

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WHAT'S NEW IN LIFE CYCLE ANALYSIS?

LEED v4 Building Product Disclosure

Environmental Product Declarations- Two points

Environmental Product Declaration

SPFA

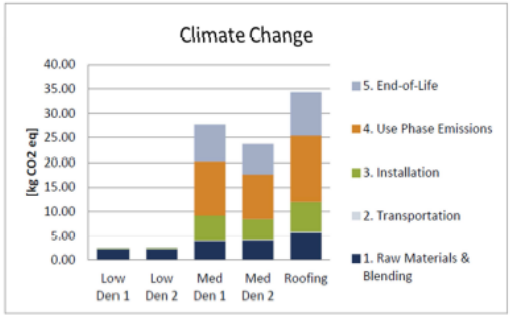
Spray Polyurethane Foam Insulation and Roofing Systems — According to ISO 14025

End-of-Life

At end of life, it was assumed that all insulation materials removed from demolition of a building are transported to a local construction waste landfill, using 100 miles as the average distance to a landfill.

Life Cycle Assessment-Product

In addition to embodied Primary Energy by Life Cycle Stage previously covered, impact assessment results are given below for each embodied life cycle stage. Impact categories were calculated using TRACI 2.0 methodology. All results are based on 1 m^2 of spray foam insulation with a thickness that provides R_{SI} = 1.



Environment

Table 4a – Life Cycle Impacts per Functional Unit (R_{SI}=1 @1m^2 or R5.68 @ 1m^2)

Life Cycle Impact	Units	Spray Foam Classification: Open-Cell Low Density (LD-SPF)	Closed-Cell Medium Density (MD-SPF)	Closed-Cell Roofing (Roof-SPF)
Primary Energy Demand	MJ	50.5	94.8	136.7
Climate Change or Global Warming	kg CO_2 equiv.	2.4	27.6	34.3
Acidification	mol H^+ equiv.	0.396	0.780	1.073
Eutrophication	kg N equiv.	4.33E-04	8.99E-04	1.33E-04
Ozone Depletion	kg CFC-11 equiv.	6.59E-08	1.15E-08	1.67E-07
Smog Creation	kg O_3 equiv.	0.094	0.180	0.267

ENVIRONMENTAL PRODUCT DECLARATIONS FOR ENTIRE LIFE CYCLE

THIRD-PARTY VERIFICATION

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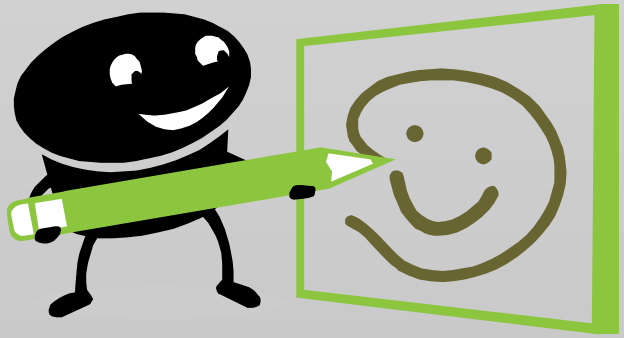
CONCLUSION

Planning and decision-making driven by many life-cycle factors

- Short and Long-term Utilization
- Financial Considerations
- Risk Analysis
- Cradle to Grave Life Cycle impact



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