ENERGY ECONOMY

Problem 1 (ME436s14h9)

The current heating bill for a large house is 3200 TL per year. Determine the maximum price that could be paid for a solar heating system which will pay for itself in 10 years. Assume that the system supplies 80 percent of the space heating requirement and the final salvage value of the system is 50 percent of the initial investment. The available interest for the initial investment and energy payments is 7 %, compounded annually, and that the annual heating costs escalate because of inflation at an annual rate of 2 percent per year. Also, evaluate the total annual heating cost during the tenth year if the solar system is not installed.

Answer: $C_s \leq$ 26 688 TL ; Annual heating cost = 3824 TL

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Problem 2 (ME436s14m2-4 / ME436s17q5)

A replacement residential natural gas hot water heater is 1400 TL while an equivalent solar hot water heater is 14000 TL. Last year's heating costs were 2400 TL. Using a rate of inflation of 6 % for a discount rate with a fuel cost escalation of 4 %, what tax incentive value is required to make the present values of the two systems equal after 5 years of use?

Useful relations:

$$\frac{P_n}{P_0} = (1 + i\,\tau)^n\,(1 + j\,\tau)^n = \left[(1 + i\,\tau)\,(1 + j\,\tau)\right]^n$$

$$P_n = S\left[\frac{(1 + j\,\tau)^n - 1}{j\,\tau}\right]$$

Compounding: $P_n = P_0\,(1 + j\,\tau)^n$

$$P_n = S\left[\frac{(1 + j\,\tau)^{n+1} - 1}{j\,\tau}\right] \qquad P_0 = S\left[\frac{(1 + j\,\tau)^n - 1}{(j\,\tau)\,(1 + j\,\tau)^n}\right]$$

$$\text{TER} = \left[(1 + i\,\tau)\,(1 + j\,\tau) - 1\right]$$

Answer: Tax incentive = 1597 TL (present value)

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Problem 3 (ME436s14f-4)

A car dealer has launched a promotion: When you buy a new car, the dealer provides 12000 TL loan with no interest, but asks 780 TL as “expenses”. The loan is to be paid back to the dealer in 12 months with a monthly payment of 1000 TL. On the other hand, one can get a loan from a bank with 12 % annual interest. This is to be paid back to the bank at the end of 12 months. The annual interest rate of the bank for a deposit is 10 %. Which loan is more advantageous, the dealer’s loan or the bank loan?

Useful relations:

$$\frac{P_n}{P_0} = (1 + i\,\tau)^n\,(1 + j\,\tau)^n = \left[(1 + i\,\tau)\,(1 + j\,\tau)\right]^n$$

$$P_n = S\left[\frac{(1 + j\,\tau)^n - 1}{j\,\tau}\right]$$

Compounding: $P_n = P_0\,(1 + j\,\tau)^n$

$$P_n = S\left[\frac{(1 + j\,\tau)^{n+1} - 1}{j\,\tau}\right] \qquad P_0 = S\left[\frac{(1 + j\,\tau)^n - 1}{(j\,\tau)\,(1 + j\,\tau)^n}\right]$$

Total Escalation Rate: $TER = \left[(1 + i\,\tau)\,(1 + j\,\tau) - 1\right]$

Answer: The loan from the bank

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Problem 4 (ME436s14fm-4)

A proposed solar-heating system for a home costs $6,000 and has a rated operational life of 20 years. Purchase and installation of the system is to be financed by a 60-month loan with an annual percentage rate of 7.2%. The salvage value of the solar-heating system will essentially be zero. Determine the maximum effective yearly heating costs for the system to pay for itself if the annual savings could be invested at 6% interest compounded annually. Assume no inflation and no escalation of fuel cost, but include the opportunity cost of the capital investment, i.e., interest that can be obtained when it is invested.

Useful relations:

$$\frac{P_n}{P_0} = (1 + i\,\tau)^n\,(1 + j\,\tau)^n = \left[(1 + i\,\tau)\,(1 + j\,\tau)\right]^n$$

$$P_n = S\left[\frac{(1 + j\,\tau)^n - 1}{j\,\tau}\right]$$

Compounding: $P_n = P_0\,(1 + j\,\tau)^n$

$$P_n = S\left[\frac{(1 + j\,\tau)^{n+1} - 1}{j\,\tau}\right] \qquad P_0 = S\left[\frac{(1 + j\,\tau)^{n} - 1}{(j\,\tau)\,(1 + j\,\tau)^{n}}\right]$$

Total Escalation Rate: $TER = \left[(1 + i\,\tau)\,(1 + j\,\tau) - 1\right]$

Answer: S > 749 USD

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Problem 5 (ME405f15q5 / ME436s16q6)

Calculate the payback period for a PV (photovoltaic) system with 18000 TL cost after incentives, an output of 2500 kWh/year, 0.5 TL/kWh cost of electricity, and interest (discount) rate of 5 %.

Related relations:

Future worth, P_n, of present amount, P_0, with j % interest rate: $P_n = P_0\,(1 + j)^n$

Present worth, P_0, of a future spending, P_n, with j % interest rate: $P_0 = \dfrac{P_n}{(1 + j)^n}$

Future worth, P_n, of a continuous payment, S, with j % interest rate: $P_n = S\left[\dfrac{(1 + j)^n - 1}{j}\right]$

Future worth, P_n, of a continuous payment, S, with j % interest rate and d % inflation rate:

$$P_n = S\left[\frac{(1 + j)^n - (1 + d)^n}{j - d}\right]$$

Present worth, P_0, of a continuous payment, S, with j % interest rate and d % inflation rate:

$$P_0 = S\left[\frac{(1 + j)^n - (1 + d)^n}{(1 + j)^n\,(j - d)}\right]$$

Answer: n = 26 years

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Problem 6 (ME405f15h5 / ME436s16h5)

Two alternative sites are considered for a bridge to cross the Bosphorus in Istanbul.

1. A suspension bridge will cost $50 million to be built over 5 years with annual inspection and maintenance costs of $35,000. The building cost is spread out evenly over the 5 years. In addition, the concrete deck will have to be resurfaced every 10 years at a cost of $100,000.

The cost of purchasing the right-of-way (on day 1) is expected to be $2 million for the suspension bridge.

2. A truss bridge and approach roads are expected to cost $30 million to be built over 2 years and annual maintenance costs of $20,000. The building cost is spread out evenly over the 5 years. The bridge will have to be painted every 3 years at a cost of $40,000. In addition, the bridge will have to be sandblasted every 10 years at a cost of $190,000. The cost of purchasing the right-of-way (on day 1) is expected to be $15 million for the truss bridge.

Compare the alternatives on the basis of their capitalized cost if the interest rate is 6 % per year.

- Capitalized cost, CC, refers to the present worth of cash flows which go on for an infinite period of time. Some public work projects like dams, bridges and parks fall into this category.
- To compare two or more alternatives on the basis of capitalized cost, find CC for each alternative.
- The alternative with the smallest capitalized cost should be selected.
- Does your answer change if the interest rate is 10 % per year?

Answer: With 6 % interest rate, it is alternative 2

With 10 % interest rate, it is alternative 1

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Problem 7 (ME405f15m2-3 / ME436s22f-4 / ME405s22f-4 / ME405f24m-4)

A solar-heating system for a home costs 20 000 TL and has a rated operational life of 20 years. Purchase and installation of the system is to be financed by a 3 year loan with an annual interest rate of 10 %. The salvage value of the solar-heating system is essentially zero. Determine the maximum effective yearly heating cost for the system to pay for itself if the annual savings could be invested at 6 % interest rate compounded annually.

Relations:

$$P_n = P_0 \left(1 + j\right)^n \qquad P_n = S \left[\frac{\left(1 + j\right)^n - 1}{j}\right]$$

Answer: S = 1 948.8 TL

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Problem 8 (ME436s16m1-4 / ME405f16m1-4 / ME436s17m1-4)

(a) If we want to have $5,000,000 when we retire in 50 years, and if our money will earn 10 % interest, how much we need to put in the bank now?

(b) However, we realized that we don't have that much money. If we commit to saving some money every month between now and retirement, then how much do we need to save monthly to have $5,000,000 at the end of 50 years? Again, assume a 10% interest rate. There are 600 months in 50 years.

Relations:

$$P_n = P_0 \left(1 + j\right)^n \qquad P_0 = \frac{P_n}{\left(1 + j\right)^n} \qquad P_n = S \left[\frac{\left(1 + j\right)^n - 1}{j}\right] \qquad P_n = S \left[\frac{\left(1 + j\right)^n - \left(1 + d\right)^n}{j - d}\right]$$

$$P_0 = S \left[\frac{\left(1 + j\right)^n - \left(1 + d\right)^n}{\left(1 + j\right)^n \left(j - d\right)}\right]$$

Answer: S = $288.6

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Problem 9 (ME436s20q5)

Dr. Arinc has just won $100,000,000 in the lottery and is about to resign his position at the university. Before he does, he needs some financial advice from his ME-436 students. Should he

a) Take the $100,000,000 in the form of annual payments of $5,000,000 for the next 20 years; or
b) Take $40,000,000 as a lump sum payment now?

Assume that, with both options, he won't spend any of the money, but will instead invest all of it at 9 % interest compounded yearly. Neglect the effect of taxes on both options.

Comment on the assumptions.

Answer: Option 1

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Problem 10

Dr. Cronk is considering whether or not to re-finance the mortgage on his home. He owes $100,000 on his home, and will continue paying the mortgage for the next 25 years. He currently is paying 7% interest on the mortgage.

(a) What are his current monthly payments?

(b) How much interest will he pay over the next 25 years if he keeps his present mortgage? (In other words, how much does his current loan cost?)

If Dr. Cronk re-finances the home, he will have to pay the mortgage company $4,000 for the costs of refinancing the loan. The company will add that to his balance, so that he will owe $104,000 on the house. However, the interest rate will drop to 6.5%. Assuming that Dr. Cronk re-finances for 25 years, then:

(c) What will his new monthly payment be?

(d) How much will his new loan cost? (Hint: Include interest charges and the cost of refinancing.)

(e) Should Dr. Cronk keep his current loan or re-finance his home? Why?

Answer: (a) S = $706.78

(b) Total interest = $112,034

(c) S = $702.2

(d) Loan cost = $110,665

(e) Keep the loan.

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Problem 11

The Biomedical Engineering Program is interested in purchasing a new scanning electron microscope (SEM). The cost of the microscope is $50,000; however, the prices have been dropping at the rate of about 5% per year. The program can set aside about $8000 annually into an account that will accrue interest at 10%. How long will it be before BME can purchase the microscope?

Answer: 5 years

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Problem 12

A solar-powered home heating system can be built for $8000 and will supply all of the heating requirements for 20 years. Assume that the salvage value of the solar heating system just compensates for the maintenance and operational costs over the 20 year period. If the interest on money is 8 %, compounded annually, what is the effective cost of heating the house?

Another way to ask this question is “How much would you have to save per year to equal the future value of $8,000 invested for 20 years at 8 %?"
The discount rate is based on the lost future value of the $8000 at 8 % compounded annually. Therefore, the total capital cost is based on the build cost plus the lost future value of an alternative investment.

Answer: S = 814.8 TL

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Problem 13 (ME436s20h5)
A proposed solar-heating system for a home costs $6,000 and has a rated operational life of 20 years. Purchase and installation of the system is to be financed by a 60-month loan with an annual percentage rate of 7.2 %. The salvage value of the solar-heating system will essentially be zero. Determine the maximum effective yearly heating costs for the system to pay for itself if the annual savings could be invested at 6 % interest compounded annually.

Answer: S = 559.7 TL

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Problem 14
What should be the annual savings in heating costs in order to “break even" after twenty years on an $8000 solar-powered residential heating system? Consider two cases, one without inflation and one with inflation.
Case 1 (future value without inflation)

- long-term investment at 8% per year, compounded annually
- no operational or maintenance costs,
- no inflation
- no fuel cost escalation
- no salvage value or tax incentives
- savings reinvested at 6 % APR, compounded monthly

Case 2 (future value with inflation)

- long-term investment at 8 % per year, compounded annually
- no operational or maintenance costs,
- Inflation rate 4 %,
- no fuel cost escalation

- no salvage value or tax incentives
- savings reinvested at 6 % APR, compounded monthly

Answer: Case 1: S = $995.27 per year

Case 2: S = $722.15 per year

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Problem 15

A good example of the need to calculate present value is with a home mortgage. A lump sum is borrowed at a fixed annual interest rate and uniform series payments are made on the mortgage while interest is accruing. Consider a 30-year fixed-rate mortgage for $250,000 at 6% per year.

Answer: S = $18 162 per year; S = $1500 per month

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Problem 16

You are in charge of purchasing several new fleet of vehicles. You are offered two payment options. Option A requires a $30,000 payment at the end of the year for four years. Option B requires a $39,000 payment at the end of the year for the next three years. Which is the least costly option if the long-term interest is 8 %, compounded annually. In other words, what is the minimum amount of cash that should be set aside now to make the annual payments?

The two options require uniform payments, but over different periods of time. In order to compare the two options, calculate how much money today (present value) would be required to make the payments if the lump sum was invested at 8 %, compounded annually.

Answer: Option A: $P_0 = \$99\ 364$; Option B: $P_0 = \$100\ 507$

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Problem 17 (ME405f16f-2 / ME436s17f-2 / ME436s22q6 / ME405s22q6)

A small municipality is considering installing a 1 MWe wind turbine that will cost $6.5 million to install, and then generate a net annuity of $400,000 per year for twenty-five years, with an estimated salvage value of $1 million. The inflation rate is estimated to be 5 % per year.

Calculate the present value of the total cost and assess the economic viability.

Relations: $P_0 = \frac{P_n}{(1+j)^n}$, $P_n = S\left[\frac{(1+j)^n - 1}{j}\right]$

Answer: Not economical.

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Problem 18

A series of payments will be made annually for ten years. The initial payment is $20,000 and each year the payment increases by $5,000. The interest rate is 10 %, compounded annually. Determine the equivalent uniform series value from the non-uniform series value.

Answer: S = $38 600 per year

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Problem 19 (ME405f22m-4)

An electric power plant that produces 2 billion kWh_e per year has a capital cost of $500 million and anticipated lifetime of 20 years. The salvage value is estimated to cover the cost of dismantling the plant. The capital cost of the plant is repaid at 7 % interest, compounded annually. The total annual operational cost of the plant is $25 million, and the annual return to investors is estimated at 10 % of the operating cost plus the capital repayment cost. Determine the levelized cost of electricity for this plant, in $/$kWh_e$.

Answer: Levelized cost = 0.0397 $/kWh

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Problem 20 (ME436s16q5 / ME405s23h6)

The Mechanical Engineering department of Bilkent University is interested in purchasing a new micro-machining device. The cost of the device is 50 000 TL; however, the prices have been dropping at a rate of about 5 % per year. The department can set aside about 8 000 TL annually into an account that will accrue interest at 10 %. How long will it be before the ME Department can purchase the device?

Answer: 5 years

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Problem 21

Find the cost of buying a car, using it for 5 years, and selling it at the end. Consider the following cases:

(a) You pay 50000 TL cash up front, and sell the car for 20000 TL at the end of 5 years. The annual interest rate is 6 %.

(b) You pay 20000 TL up front. The remaining is to be paid to the car company in monthly installments of 3500 TL per month for 10 months. You sell the car for 20000 TL at the end of 5 years. The annual interest rate is 6 %.

(c) Same as (b). Include payment of 500 TL every 6 months as tax for 5 years.

(d) Same as (c). Include payment for gasoline which is 1000 TL per month.

(e) Same as (d). Include 1000 TL annual maintenance cost.

(f) Same as (e). Include 5 % inflation rate.

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Problem 22 (ME405f16h4 / ME436s17h5)

If energy usage guidelines expect future increases in deep freeze efficiency, which one of two energy efficiency improvements is more economical based on future worth at an interest rate of 10% per year? A 20% increase is expected to add $150 to the current price of a freezer, while a 35% increase will add $340 to the price. The estimated cost for energy is $115 per year with the 20% increase in efficiency and $80 per year with the 35% increase. Assume a 15-year life for all freezer models

Answer: Case 2

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Problem 23 (ME436s17h6)

A wind turbine rated at 250 kW costs $450,000 and has a swept are of 1200 m^2. It is installed in a location with year-round average power density available in the wind of 320 W/m^2, and on average converts 25 % of the energy into electricity. The electricity is sold to the grid at $0.039 per kWh, paid at the location of the turbine (i.e., no transmission cost). The project has a 20-

year time horizon with salvage value of $20,000, and the MARR is 8 %. Calculate the net present value (NPV) of this investment.
Minimum attractive rate of return (MARR) is the minimum interest rate required for returns from a project in order for it to be financially attractive, which is set by the business, government agency, or other entity that is making a decision about the investment.

Answer: NPV = - $123 700

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Problem 24 (ME436s18q6 / ME405s18q6)
Investment A costs 10 000 TL today and pays back 11 500 TL two years from now. Investment B costs 8 000 TL today and pays back 4 500 TL each year for two years. If an interest rate of 5 % is used, which alternative is superior?

Answer: Alternative A is superior

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Problem 25 (ME436s18h4 / ME405s18h4)
A proposed solar-heating system for a home costs 6 000 TL and has a rated operational life of 20 years. Purchase and installation of the system is to be financed by a 60-month loan with an annual finance rate of 12 %. The salvage value of the solar-heating system will essentially be zero. Determine the maximum effective yearly heating costs for the system to pay for itself if the annual savings could be invested at 10 % interest compounded annually. Assume that there is 7 % inflation. The interest and inflation rates remain constant.

Answer: 1308 TL/year

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Problem 26 (ME436s18h5)
Perform a present worth analysis of equal-service machines with the costs shown below, if the MARR is 10% per year. Revenues for all three alternatives are expected to be the same.

	Electric-powered	Gas-powered	Solar-powered

First cost, $	- 2500	- 3500	- 6000
Annual operating cost, $/year	- 900	- 700	- 50
Salvage value, $	200	350	100
Life, years	5	5	5

Answer: PW_E = - 5787.52 PW_G = - 5936.23 PW_S = - 6127.45

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Problem 27 (ME436s18m2-3 / ME405s18m2-3 / ME436s18m2-3)

A proposed solar-heating system for a home costs 6 000 TL and has a rated operational life of 20 years. Purchase and installation of the system is to be financed by a 60-month loan with an annual percentage rate of 12 %. The salvage value of the solar-heating system will essentially be zero. Determine the maximum effective yearly heating costs for the system to pay for itself if the annual savings could be invested at 10 % interest compounded annually. Assume that there is no inflation, and the interest rate remains constant.

Relations: $P_n = P_0 (1 + j)^n$ $P_n = S \left[\frac{(1 + j)^n - 1}{j} \right]$

Answer: S = 795 TL

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Problem 28 (ME436s18f-2 / ME405s18f-2)

Your company has two separate projects it may pursue over the next several years. The required amount to start each project (initial investments) now and the anticipated cash flows over the expected lives are given in the table below. At MARR = 15 % per year (minimum acceptable rate of return), determine which project should be pursued.

Project	Initial Investment, TL	Annual Net Cash Flow, TL	Life, years
A	- 8000	3800	6
B	- 10 000	2900	9

Relations: $P_0 = \frac{P_n}{(1 + j)^n}$, $P_n = S \left[\frac{(1 + j)^n - 1}{j} \right]$

Answer: Project A

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Problem 29 (ME436s19q6 / ME405s19q6)

A company is considering the purchase of either machine A or machine B.

	Machine A	**Machine B**
Initial Cost	80 000 TL	100 000 TL
Estimated Life	20 years	25 years
Salvage value	20 000 TL	25 000
Other costs	18 000 TL per year	15 000 TL per year for the first 15 years
		20 000 TL per year for the next 10 years

The interest rate is 10%, and all the cash flows may be treated as end-of-year cash flows. Assume that equivalent annual cost is the value of the constant annuity equal to the total cost of a project.

Make an economic judgement about which machine should be purchased.

Answer: Machine B

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Problem 30 (ME436s19h5 / ME405s19h5)

The estimated cost and savings from the purchase and operation of a wind machine over 20 years are given in the Table

Year	**Costs**	**Savings**		**Year**	**Costs**	**Savings**
0	9000			11	227	669
1	127	2324		12	2241	719
2	234	1673		13	2255	773
3	242	375		14	271	831
4	151	403		15	287	894
5	160	433		16	304	961
6	168	466		17	322	1033
7	180	501		18	342	1110
8	191	539		19	362	1194
9	202	579		20	251	1283

10	214	622				

a) Compare the total costs with the total savings.

b) Find the present values of the cost and savings. Use an annual discount rate of 10%. Would this be a good investment?

c) Determine the pay-back period for the wind machine.

d) What is the breakeven cost of the machine?

e) Estimate the cost of energy produced by the wind machine if it is expected to produce 9,000 kWh annually.

Answers:

(a) Total cost = 13531 ; Total saving = 17382

(b) Total present value of costs = 10644 ; Total present value of savings = 7717

(c) No payback period

(d) 7717

(e) 0.14 per kWh

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Problem 31 (ME436s19m2-3 / ME405s19m2-3)

Consider the application of a small 1 kW wind turbine with a capital cost of $2500. The installation and setup cost raises its total installed cost to $4500. Assume that the $2500 capital cost is to be paid for with a 15 year, 7% loan. Also, assume that operation and maintenance (O&M) costs will be $200 per year. Estimate the (simplified) cost of energy over the 15 year period if the capacity factor (CF) is 0.30.

The capacity factor (CF) is the average power generated, divided by the rated peak power. There is 8760 hours in a year.

Formulas: $P_n = P_0 \left(1 + j\right)^n$ $P_n = S \left[\frac{\left(1 + j\right)^n - 1}{j} \right]$

Answer: Cost of energy = 0.264 dollars/kWh if j = 0.07

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Problem 32 (ME436s19f-2 / ME405s19f-2)

A 2.4 MW wind turbine has an installation cost of 2.4 10^6 dollars. Assume that the annual operating and maintenance costs (O&M) are 2 % of the initial installation cost. The wind regime at this site results in a capacity factor (CF) of 0.35. It is also assumed that the lifetime of this turbine is 25 years and that the electrical output can be sold for 0.05 dollars per kWh. For a 5 % discount rate, calculate the following economic parameters for this system:

(a) Annual energy production in kWh per year

(b) Average annual return (from sale of electricity) in dollars per year

(c) Simple payback period (How long it takes, in years, to get back the installation cost)

(d) Net present value of the income (NVP_{income})

(e) Net present value of the total cost (NPV_{cost})

Hint: $NPV = S \left[\frac{(1 + j)^n - 1}{j (1 + j)^n} \right]$

Answers:

(a) Annual energy production = 7 358 400 kWh in a year

(b) Average annual return = 367 920 dollars in a year

(c) Simple payback period = 6.52 years

(d) NPV_{income} = 5 185 444 dollars

(e) Net present value of the total cost = 3 076 509 dollars

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Problem 33 (ME436s21q7 / ME405s21q7)

Assume that a consumer has a choice between the following three different air conditioner models that have the same cooling capacity but different energy efficiency ratings. The air conditioners last for ten years.

Model	Purchase Price	Annual Operating Cost
1	$ 200	$ 75
2	$ 250	$ 60
3	$ 300	$ 50

Calculate the total life-cycle cost for each model assuming that the AC unit is purchased at the beginning of year 1, and the annual interest rate is 10 % per year

Answer:

Model	Capital Cost	Operating Cost	Total Cost
1	519	1195	1714
2	648	956	1605
3	778	797	1575

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Problem 34 (ME436s21h7 / ME405s21h7)

Assume that a consumer has a choice between the following three different air conditioner models that have the same cooling capacity but different energy efficiency ratings. The air conditioners last for ten years.

Model	Purchase Price	Annual Operating Cost
1	$ 200	$ 75
2	$ 250	$ 60
3	$ 300	$ 50

(a) Calculate the total life-cycle cost for each model assuming that the AC unit is purchased at the beginning of year 1 and the annual interest rate is 10 % per year

(b) Which model would a consumer with a 10 % discount rate choose?

(c) Which model would a consumer with a 15 % discount rate choose?

(d) How high would a consumer's discount rate have to be for her to choose Model #1?

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Problem 35 (ME436s21m-2 / ME405s21m-2 / ME436s22m-4 / ME405s22m-4)

A man wants to replace his existing domestic electric hot water heating system with a solar powered hot water heating system. There are two alternative offers for the solar system:

Offer 1: The cost is 30000 TL. This is to be paid back (to the manufacturing company) in 5 years by monthly repayments with 12 % APR (annual interest rate).

Offer 2: The cost is 40000 TL. This is to be paid back (to a bank) in 5 years by monthly repayments with 8 % APR (annual interest rate).

Both systems have a life cycle of 10 years and have no salvage value.

Which offer is more economical?

Base your comparison on present values of the capital investments if banks provide 6 % APR on savings.

Show all your calculations and give brief explanations in words.

Answer: The first offer is more economical

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Problem 36 (ME436s22h7 / ME405s22h6)

A hypothetical wind turbine takes one year to build and costs 1.5 million TL. The operating and maintenance costs are 300,000 TL per year which increases by 2 % each year. The wind turbine's lifespan is 10 years, and it is estimated to produce 3 million kWh_e each year. The associated discount rate for the project is 8 %. What is the levelized cost of electricity for this project?

Answer: 0.183 TL/kWh

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Problem 37 (ME405f22q7)

A project engineer with the company EnvironCare is assigned to start up a new office in a city where a contract has been finalized to collect and analyze ozone-level readings. Two lease options are available, each with a first cost, annual lease cost, and deposit-return estimates shown below. The MARR is 15% per year.

	Location A	**Location B**
First cost, TL	-15 000	-18 000
Annual lease cost, TL per year	-3 500	-3 100
Deposit return, TL	1 000	2 000

(a) EnvironCare has a practice of evaluating all projects over a 5-year period. If the deposit returns are not expected to change, which location should be selected?

(b) Perform the present–worth analysis using an 8-year planning horizon.

Answer: Choose A

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Problem 38 (ME405f22h7)

A municipality is considering three proposals for increasing the capacity of the main drainage canal in a region.

Proposal A requires dredging the canal. The state is planning to purchase the dredging equipment and accessories for 650 000. The equipment is expected to have a 10-year life with a 17 000 salvage value. The annual operating costs are estimated to total 50 000. To control weeds in the canal itself and along the banks, environmentally safe herbicides will be sprayed during the irrigation season. The yearly cost of the weed control program is expected to be 120 000.

Proposal B is to line the canal walls with concrete at an initial cost of 4 million. The lining is assumed to be permanent (that means a very long life time), but minor maintenance will be required every year at a cost of 5000. In addition, lining repairs will have to be made every 5 years at a cost of 30 000.

Proposal C is to construct a new pipeline along a different route. Estimates are: an initial cost of 6 million, annual maintenance of 3000 for right-of-way, and a life of 50 years.

Compare the alternatives on the basis of annual worth, using an interest rate of 5 % per year.

Answer: Select B

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Problem 39 (ME405s23q6)

A green algae, chlamydomonas reinhardtii, can produce hydrogen when temporarily deprived of sulfur for up to 2 days at a time. How much could a small company afford to spend now to commercialize the process if the net value of the hydrogen produced is $280,000 per year? Assume the company wants to earn a rate of return of 18 % per year and recover its investment in 8 years.

Answer: 1 141 718 USD

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Problem 40 (ME405s23m-2)

The HVAC engineer of a company that constructed one of the world's tallest buildings (Burj Dubai in the United Arab Emirates) requested that $500,000 be spent on software and hardware to improve the efficiency of the environmental control systems. This is expected to save $10,000 per year for 10 years in energy costs and $700,000 at the end of 10 years in equipment refurbishment costs.

Does the company make money If the MARR (minimum expected rate of return) is 6 %?

$$P_n = P_0 (1 + j)^n \quad , \quad P_n = S \left[\frac{(1 + j)^n - 1}{j} \right]$$

Answer: No

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Problem 41 (ME405f23q6)

The addition of a regenerator in a gas turbine costs $135,000 and is expected to operate for 20 years. What is the annual cost of this investment if the discount rate of the corporation is 7%, and 15%? Comment and the results.

Capital Investment = P_0

Annual cost of capital investment = S

Answer: $12743 and $21568

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Problem 42 (ME405f23h6)

An electricity production corporation considers the investment of $5,600,000 in a new 30 MW gas turbine. The annual fuel cost of the turbine is estimated to be $3,700,000, the maintenance and operation costs are $400,000, and the turbine is expected to operate for 30 years and produce annual revenue $5,200,000. The discount rate of the corporation is 12 %. Determine the profitability of the gas turbine.

Answer: $404 800

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Problem 43 (ME405f23f-3)

A proposed wind farm installation is based on the use of thirty 2 MW wind turbines. The installed capital cost is estimated at $1000 / kW and the annual operation and maintenance costs are estimated to be 3 % of the original capital cost each year. Financing for the project is to come from two sources:

(1) 75 % of the capital cost is to be financed with a 20 year loan at 7 % interest, and

(2) 25 % of the capital cost is met by an equity investment that has a return of 15 %, yearly

The average capacity factor of the wind farm is estimated to be 0.35. Determine the estimated cost of energy ($ / kWh) from this proposed wind farm.

$$P_n = P_0 (1 + j)^n$$

$$P_n = S \left[\frac{(1 + j)^n - 1}{j} \right] \qquad P_0 = S \left[\frac{(1 + j)^n - 1}{j (1 + j)^n} \right]$$

Answer: $0.045 / kWh

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Problem 44 (ME405f23q6)

A sum of $50 000 8 years ago is equivalent to how much money at an interest rate of 12 % per year discounted quarterly?

Answer: P_n = $128 757

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Problem 45 (ME405f24h6)

The TT Racing and Performance Motor Corporation wishes to evaluate two alternative machines for NASCAR motor tuneups. Use the AW (annual worth) method at 9 % per year to select the better alternative.

	Machine R	**Machine S**
Capital cost, $	250 000	370 500
Annual operating cost, $/year	40 000	50 000
Life, years	3	5
Salvage value, $	20 000	20 000

Answer: Machine R is less costly. So, it is the better choice.

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Problem 46 (ME405f24f-3)

A rural utility company provides standby power to pumping stations using diesel-powered generators. An alternative has arisen whereby the utility could use a combination of wind and

solar power to run its generators, but it will be a few years before the alternative energy systems are available. The utility estimates that the new systems will result in savings of $15,000 per year for 3 years, starting 2 years from now, and $25,000 per year for 4 more years after that (i.e., through year 8). At an interest rate of 8 % per year, determine the equivalent annual worth (years 1–8) of the projected savings.

$$P_n = P_0\ (1 + j)^n;\ \ P_0 = S\left[\frac{(1 + j)^n - 1}{j\ (1 + j)^n}\right]$$

Answer: $16 819.54

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