Lecture – 5A

Energy Resources, Economics and Environment

Rangan Banerjee
Department of Energy Science and Engineering

IIT Bombay

Energy Economics

Decisions

- Yes/ No – Viability of a specific option
- Best Possible option - Ranking or choice between different possible options

All Technical Feasible Options included

Criteria – Cost-Initial cost, Operating cost

Reliability

Emissions

Operational flexibility/ convenience

Investing in Renewable Energy/ Energy Efficient Equipment ?

What are the factors that determine the cost-effectiveness of the additional investment?

Parameters affecting Decision

- Amount of Investment
- Amount of Energy Saving (fossil fuel)
- Price of Energy
- Life of Equipment/ project
- Time Value of Money

Renewables – usually higher initial cost, lower operating cost

Economic Criteria

- Simple Payback Period (SPP)
- Net Present Value (NPV)
- Benefit/ Cost Ratio (B/C)
- Internal Rate of Return (IRR)
- Life Cycle Costing
  - Life Cycle Cost
  - Annualised Life Cycle Cost (ALCC)

Simple Payback Period

- No of years in which investment pays for itself
- SPP = Initial Investment/ Annual Saving

Insulation: Example

- An energy auditor recommended additional insulation on a boiler. The cost of the insulation is Rs 300000. It is estimated that installing the insulation will result in savings of 5 kilo-litres of Light diesel oil priced at Rs 50/litre. What is the SPP for this ECO?

5000L * 50Rs/L = 2.5Lakh
3lakh/2.5lakh = 1.2

Simple Payback Period

- Limitations?
- A Inv Rs 100,000 , Saving Rs 50000
- B Inv Rs 120,000, Saving Rs 40,000
- Decision?

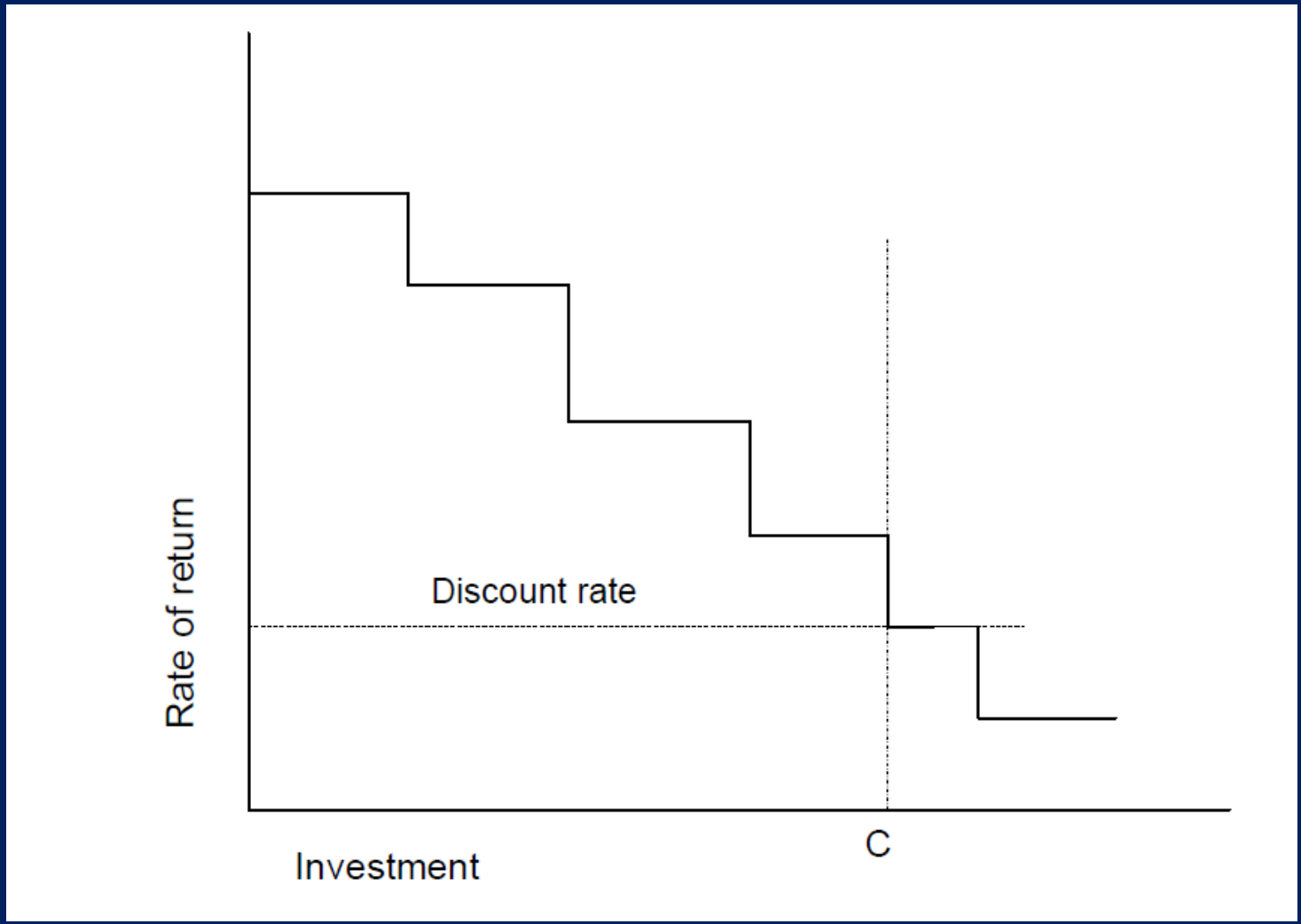
Discount Rate

- Compare investment today with expected future benefits
- Discount rate represents how money today is worth more than in the future
- No theoretically correct value
- Lower bound – bank interest rate

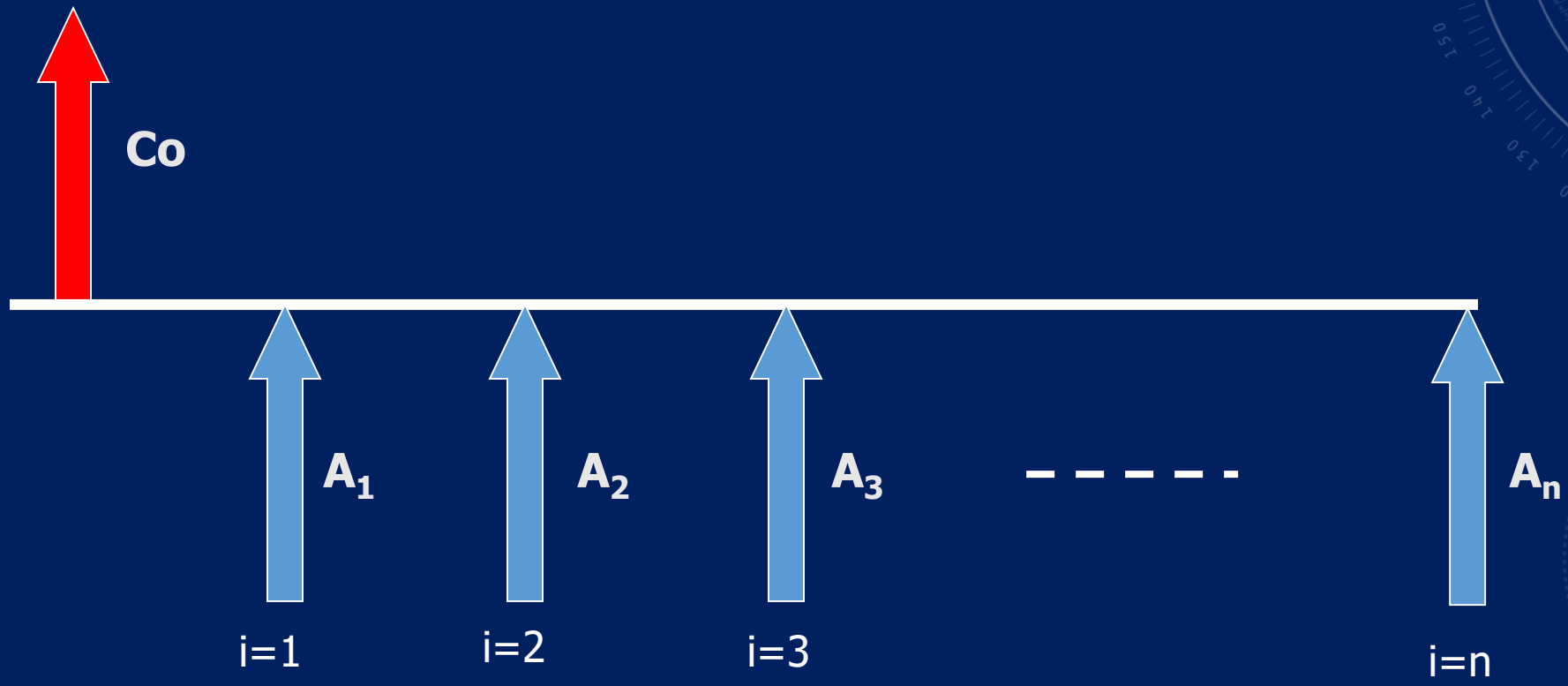
Discounting the future

	2019	2020	2019+k
Value in year	1	1	1
Present Value	1	$1/(1+d)$	$1/(1+d)^k$

Discount rate



Cash Flows



Present Value

$$P = \sum_{k=1}^{n} A_k/(1+d)^k$$

For constant annual cash flows A

$$P = A\,[\,(1+d)^n - 1]/[d(1+d)^n]$$

P = A [Uniform Present Value Factor]

Capital Recovery Factor (CRF)

$$CRF = A/P = [d(1+d)^n]/ [(1+d)^n-1]$$

CRF = f (d,n)

d – discount rate

n – life

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Lecture – 5B

Energy Resources, Economics and Environment

Rangan Banerjee
Department of Energy Science and Engineering

IIT Bombay

Energy Economics

Capital Recovery factor

- Consider an investment in an equipment with a life of 10 years and a real discount rate of 12%. [0.12*(1.12)^10] / [((1.12)^10) - 1]
- Calculate the capital recovery factor
- What does it signify?

Capital Recovery factor

- CRF (d=12%, n=10 years) = 0.177
- This implies that an investment of Rs 1000 today is equivalent to annual investments of Rs 177 over the lifetime of the equipment

What happens if d increases to 30%?

- What happens if the life increases to 20 years?

CRF(0.3,10) = 0.323

NPV, IRR and B/C ratio

$$NPV = \left[\sum_{k=1}^{n} \frac{A_k}{(1+d)^k} \right] - C_o$$

$$\frac{B}{C} = \frac{\left[\sum_{k=1}^{n} \frac{A_k}{(1+d)^k} \right]}{C_o}$$

$$C_o = \sum_{k=1}^{n} \frac{A_k}{(1+IRR)^k}$$

Example 2

A Inv Rs 100,000 , Saving Rs 50000 Life 3 years

B Inv Rs 120,000, Saving Rs 40,000 Life 8 years

Calculate CRF (d.n) for d = 12%

Example 2: Compute CRF

For A, $CRF(0.12,3) = [0.12(1.12)^3]/ [(1.12)^3-1]$
$=0.416$

For B, $CRF(0.12,8) = [0.12(1.12)^8]/ [(1.12)^8-1]$
$=0.201$

Option	Investment C_0 (Rs)	PV Savings (Rs)	NPV Rs	B/C ratio
A	100,000	120,092	20,092	1.20
B	120,000	198,706	78,706	1.66

Inflation

- Increase in the general level of prices
- Wholesale Price Index (WPI)
- Consumer Price Index (CPI)
- Indexed to a base year when prices relatively stable

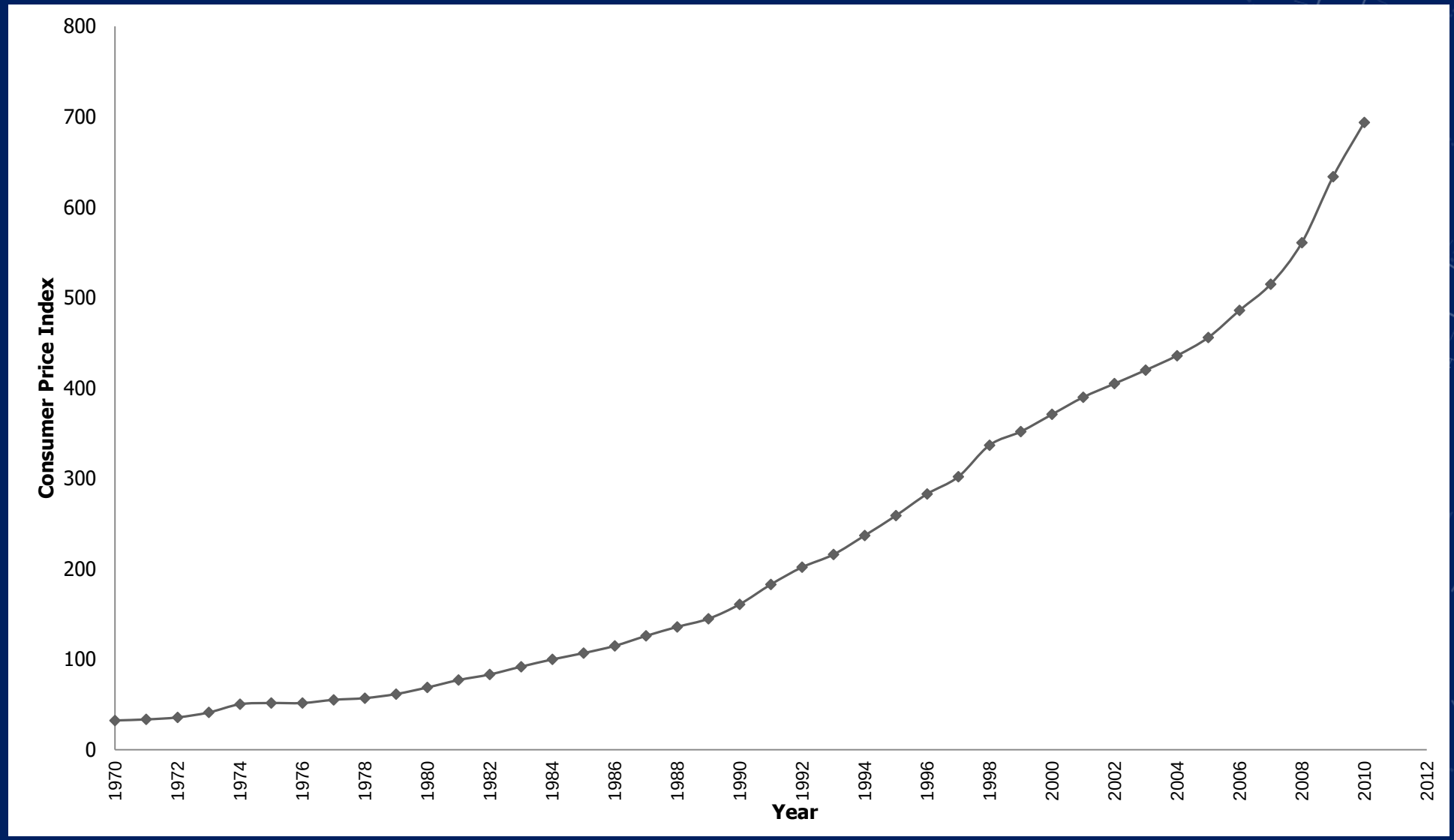
Components of CPI

Sl. No	Article	Unit	Godavrikhani	Guntur	Hyderabad	Vijayawada	Vishakhapatnam	Warrangal
1	2	3	4	5	6	7	8	9
1	Rice	Kg.	24.98	36.93	27.10	34.94	31.06	26.80
2	Wheat:							
	a. Wheat Whole	Kg.	25.75	#	29.01	#	26.32	29.00
	b. Wheat Atta	Kg.	26.75	36.00	29.43	29.50	39.50	38.50
3	Jowar	Kg.	#	#	25.50	#	#	#
4	Arhar Dal	Kg.	70.25	71.00	71.87	69.51	78.82	73.00
5	Moong Dal	Kg.	81.50	#	80.92	71.82	85.75	80.82
6	Masur Dal	Kg.	53.75	#	56.13	#	#	54.00
7	Groundnut oil	Litre	124.50	120.01	111.16	106.68	130.53	107.24
8	Mustard Oil	Litre	#	#	#	#	#	#
9	Vanaspati	Litre	#	#	#	#	73.50	#
10	Goat Meat/Mutton	Kg.	320.00	360.00	370.00	400.00	420.00	420.00
11	Fish Fresh	Kg.	180.00	130.00	110.33	110.00	90.00	#
12	Milk	Litre	30.00	40.00	42.67	35.00	38.00	40.00
13	Dairy Milk	Litre	#	34.00	31.34	34.00	34.00	#
14	Pure Ghee	Litre	#	320.00	376.67	273.00	291.20	#
15	Onion	Kg.	19.00	21.50	21.80	20.00	20.63	18.50
16	Chillies Dry	100 gms.	9.00	6.80	8.10	14.57	9.00	8.69
17	Sugar	Kg.	39.24	41.36	36.81	38.41	41.96	37.30
18	Gur	Kg.	#	#	46.42	43.94	42.00	#
19	Tea Leaf	100gms	24.95	37.50	25.00	37.75	39.00	38.00
20	Fire Wood	40 Kg.	200.00	180.00	200.00	400.00	200.00	160.00
21	Soft Coke	40 Kg.	#	#	#	#	#	#
22	Kerosene Oil	Litre	15.00	15.00	15.00	15.00	15.00	15.00
23	Toilet Soap	75gms.	15.86	15.75	17.50	12.30	21.00	12.45
24	Washing Soap	225 gms..	9.56	11.70	12.90	13.60	22.50	13.50

Wholesale Price Index (WPI)

Table 1: Comparative Statement of Commodities and price quotations								
	Number of Commodities				Number of price quotations			
Major Group/Group	1970-71	1981-82	1993-94	2004-05	1970-71	1981-82	1993-94	2004-05
All Commodities	**360**	**447**	**435**	**676**	**1295**	**2371**	**1918**	**5482**
Primary Articles	**80**	**93**	**98**	**102**	**411**	**519**	**455**	**579**
Food Articles	39	44	54	55	264	320	340	431
Non Food Articles	26	28	25	29	115	132	96	108
Minerals	15	21	19	18	32	67	19	40
Fuel and Power	**10**	**20**	**19**	**19**	**30**	**73**	**72**	**72**
Manufactured Products	**270**	**334**	**318**	**555**	**854**	**1779**	**1391**	**4831**
Food Products	37	35	41	57	117	231	168	406
Beverages, Tobacco and Tobacco Products	8	7	11	15	19	39	49	102
Textiles	12	27	29	55	99	120	100	457
Wood and Wood Products	4	2	2	10	13	14	9	64
Paper and Paper Products	4	11	11	18	16	74	67	138
Leather and Leather Products	4	3	1	13	18	26	9	91
Rubber and Plastic Products	7	13	15	45	42	73	55	351
Chemicals and Chemical Products	67	77	69	107	182	428	276	1111
Non-Metallic Mineral Products	21	22	9	26	63	125	42	225
Basic Metals, Alloys and Metal Products	42	57	53	69	125	235	203	696
Machinery and Machine Tools	35	44	56	107	104	266	312	903
Transport Equipments and Parts	21	22	21	33	39	118	101	287

Consumer Price Index Trend



Source: www.rbi.org.in › Publications/

WPI weightages

Table 2: Comparative Statement of Weights assigned to Product Groups					
Major Group/Group		**1970-71**	**1981-82**	**1993-94**	**2004-05**
All Commodities		**100.000**	**100.000**	**100.000**	**100.000**
Primary Articles		**41.667**	**32.295**	**22.025**	**20.118**
Food Articles		29.799	17.386	15.402	14.337
Non Food Articles		10.621	10.081	6.138	4.258
Minerals		1.247	4.823	0.485	1.521
Fuel and Power		**8.459**	**10.663**	**14.226**	**14.910**
Coal			1.256	1.753	2.094
Mineral Oils			6.666	6.987	9.364
Electricity			2.741	5.484	3.452
Manufactured Products		**49.874**	**57.042**	**63.749**	**64.972**
Food Products		13.322	10.143	11.538	9.974
Beverages, Tobacco		2.708	2.149	1.339	1.762
Textiles		11.026	11.545	9.800	7.326
Wood and Wood Products		0.174	1.198	0.173	0.587
Paper and Paper Products		0.851	1.988	2.044	2.034
Leather and Leather Products		0.385	1.018	1.019	0.835
Rubber and Plastic Products		1.207	1.592	2.388	2.987
Chemicals and Chemical Products		5.548	7.355	11.931	12.018
Non-Metallic Mineral Products		1.415	2.477	2.516	2.556
Basic Metals, Alloys and Metal Products		5.974	7.632	8.342	10.748
Machinery and Machine Tools		5.045	6.268	8.363	8.931
Transport Equipments and Parts		1.673	2.705	4.295	5.213
Other Industries		0.546	0.972	0.000	0.000

Inflation- Example

- In a state the CPI in 1995 was 140 (with 1990 as the base year). In 1990 an investment was made in a fixed deposit account which had an interest rate of 10%. What is the real interest rate obtained on the investment ?

Real and Nominal Discount Rate

$$(1+d_n) = (1+d_r)(1+i)$$

$$d_r \sim d_n - i$$

Example problem

A 100 h.p. motor is being used to run a pump in a process industry. The motor can be retrofitted with a variable speed drive that costs Rs. 8 lakhs. The motor runs for 7000 hours annually (3000 hours at part load). Take 90% as the full load efficiency. During part load operation, an average saving of 30 % of the full load consumption is possible with the variable speed drive (VSD). The life of the VSD can be taken as 10 years. The electricity price is Rs. 5 Rs/kWh. The minimum (real) rate of return on investment for the company is 30%. Calculate the simple payback period, Net Present Value, Benefit/Cost ratio, IRR, Cost of Saved Energy for the VSD. Comment on the viability of the VSD.

Annualised Life Cycle Cost

- Annualised Life Cycle Costs (ALCC) - annual cost of owning and operating equipment
- $ALCC = C_0\, CRF(d,n) + AC_f + AC_{O\&M}$
- $CRF(d,n) = [\, d(1+d)^n]/[(1+d)^n - 1]$
- discount rate d, Life n years, C_0 Capital Cost, AC_f, $AC_{O\&M}$, annual cost - fuel and O&M CRF – Capital recovery factor

Energy Efficient Refrigerator

- The cost of a standard refrigerator is Rs 10,000 and the expected electricity consumption per year is 450 kWh. The cost of an energy efficient refrigerator of the same capacity (and with the same features) is Rs 10,500. For the same load, the annual electricity consumption is expected to be 400 kWh. What is the cost of saved energy? The life of the refrigerator can be taken as 10 years.

Cost of Saved Energy

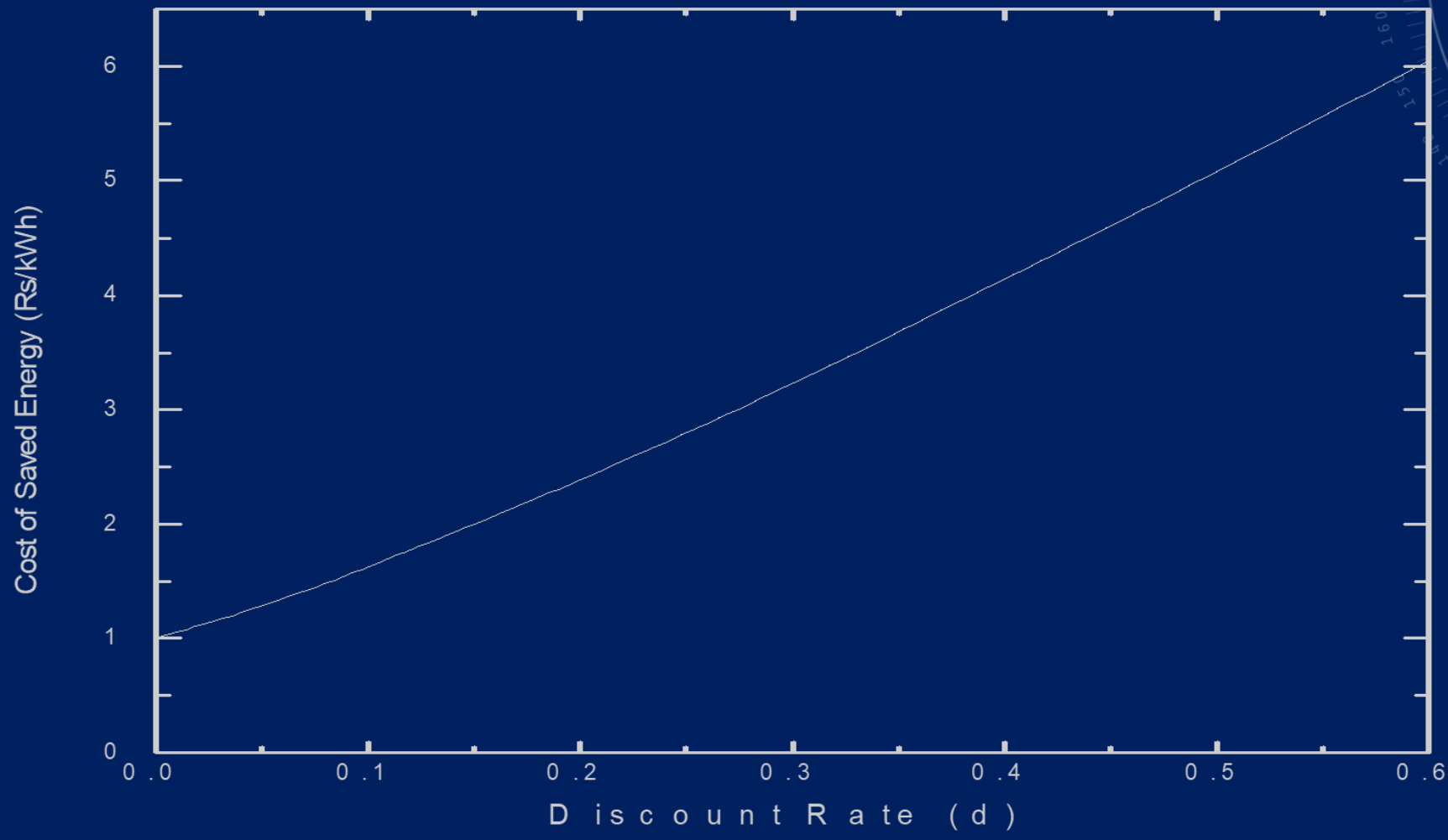
CSE = Annualised Investment / Annual Energy Saving

$= C_0 \, CRF(d,n) / ES$

Unit: Rs/(energy unit)

viz. Rs/kWh, Rs/kJ, Rs/kg of coal, Rs/litre of oil.

Refrigerator Example



Depreciation

Accounting concept

Annual depreciation (A_D)is

$A_D = (C_0 - S)/n$

S is the salvage value at the end of the life of the equipment

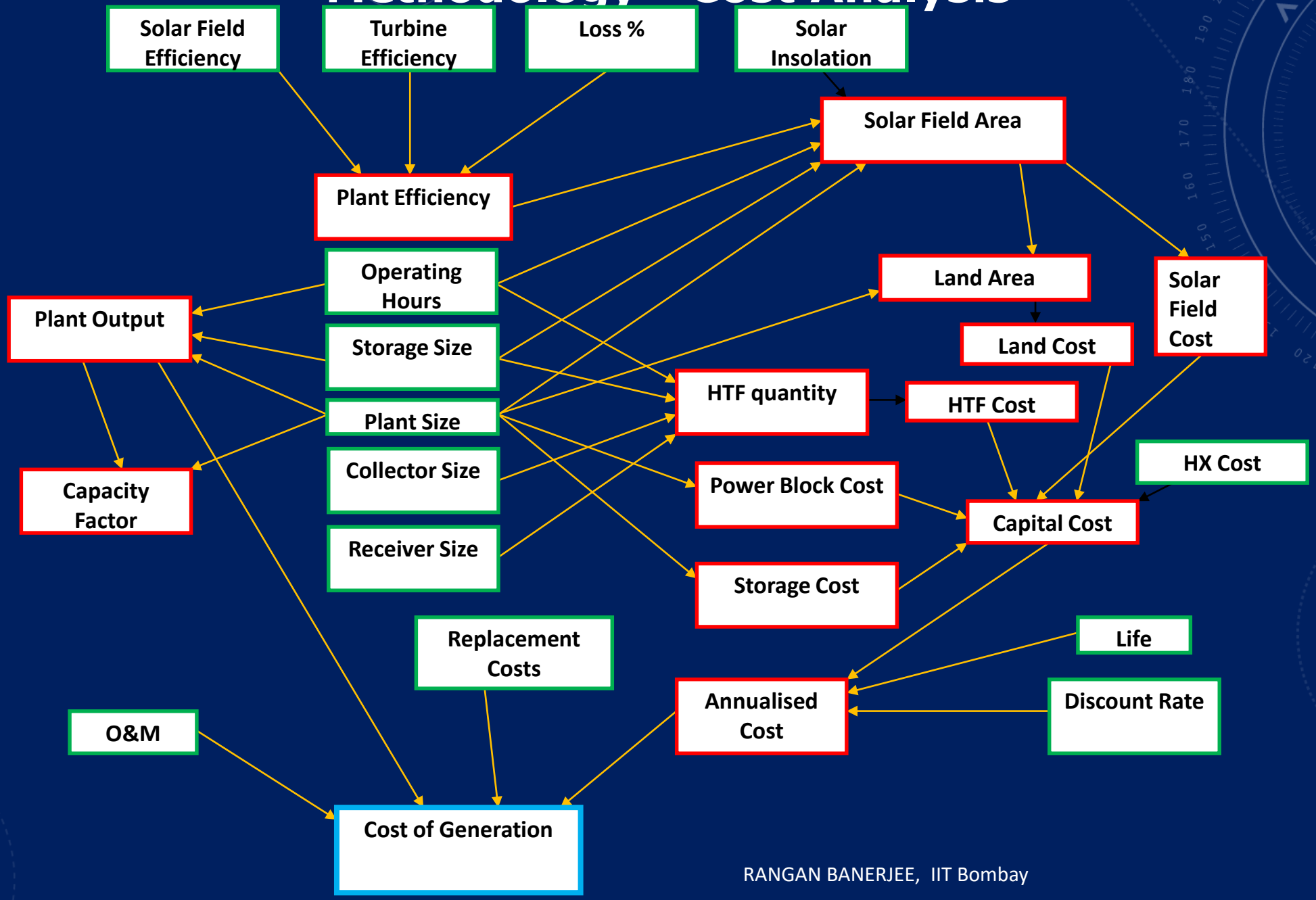
$A_D = C_0/n$ (if S=0)

Tax = t A_D where t is the tax rate

Tutorial problem 2 Solar Water Heater

- Capital cost Rs 400,000
- Annual savings Rs 150,000 Life 20 years
- Discount rate 30%
- 100% accelerated depreciation
- Tax rate 30%

Methodology - Cost Analysis



Solar Water Heater (Flat plate)

	Area	Cost	Viability
Residential Single	$2m^2$, 125lpd	20000	SPP 7.9 years CSE Rs 6.78/kWh
Six-Res HH	4 m^2 250 lpd	40000	SPP 2.4 years CSE Rs 1.99/kWh
Hospital 20 beds	16 m^2 1000 lpd	1.6 lakh	SPP 3.2 years CSE Rs 2.68/kWh
Hotel 30 rooms	34 m^2 2125lpd	3.4 lakh	SPP 3.9 years CSE Rs 3.31/kWh

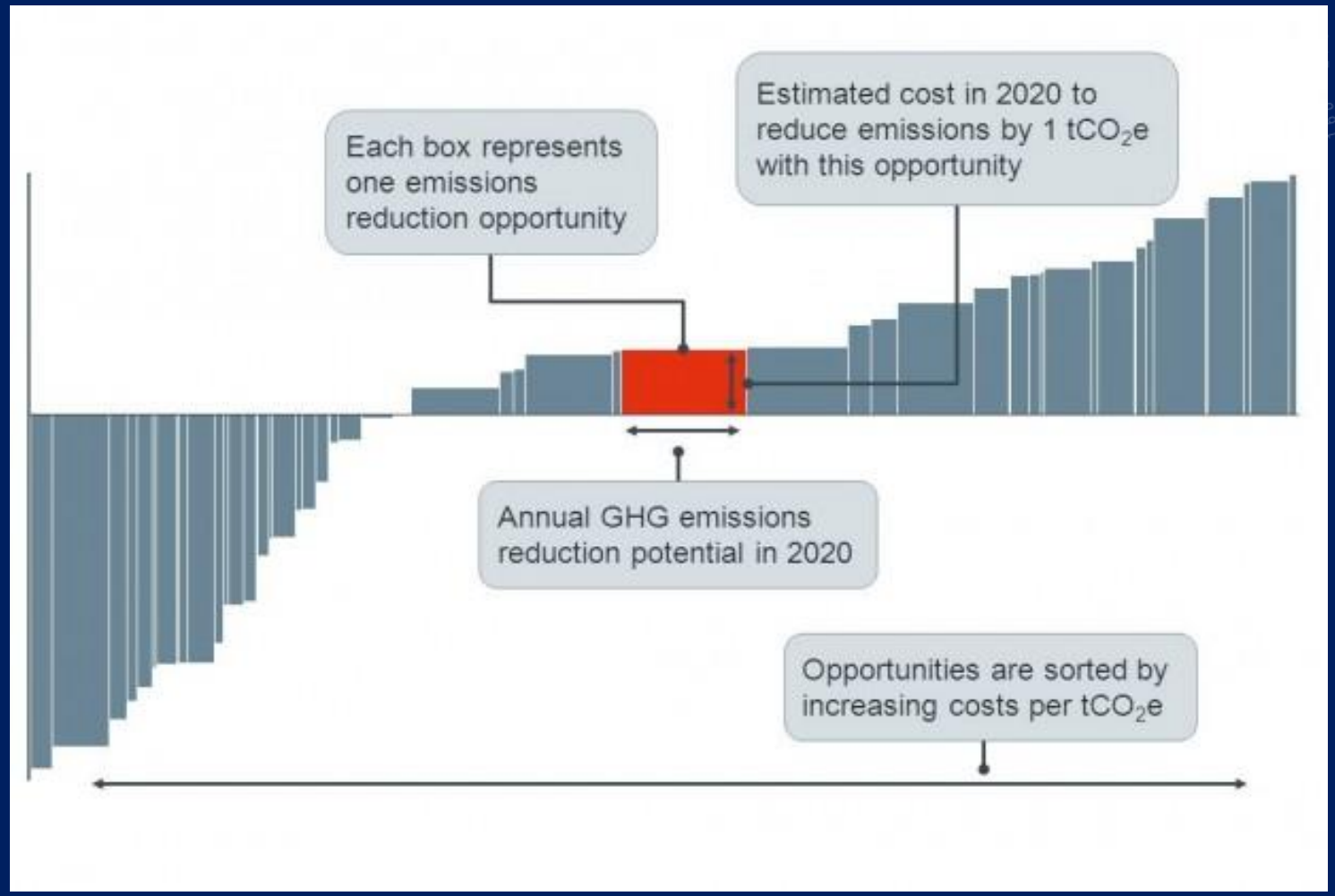
Economic indices

- SPP = 2.3 years
- NPV = 117, 895 Rs
- B/C ratio = 1.4
- IRR = 42.8%

Economic indices with tax saving

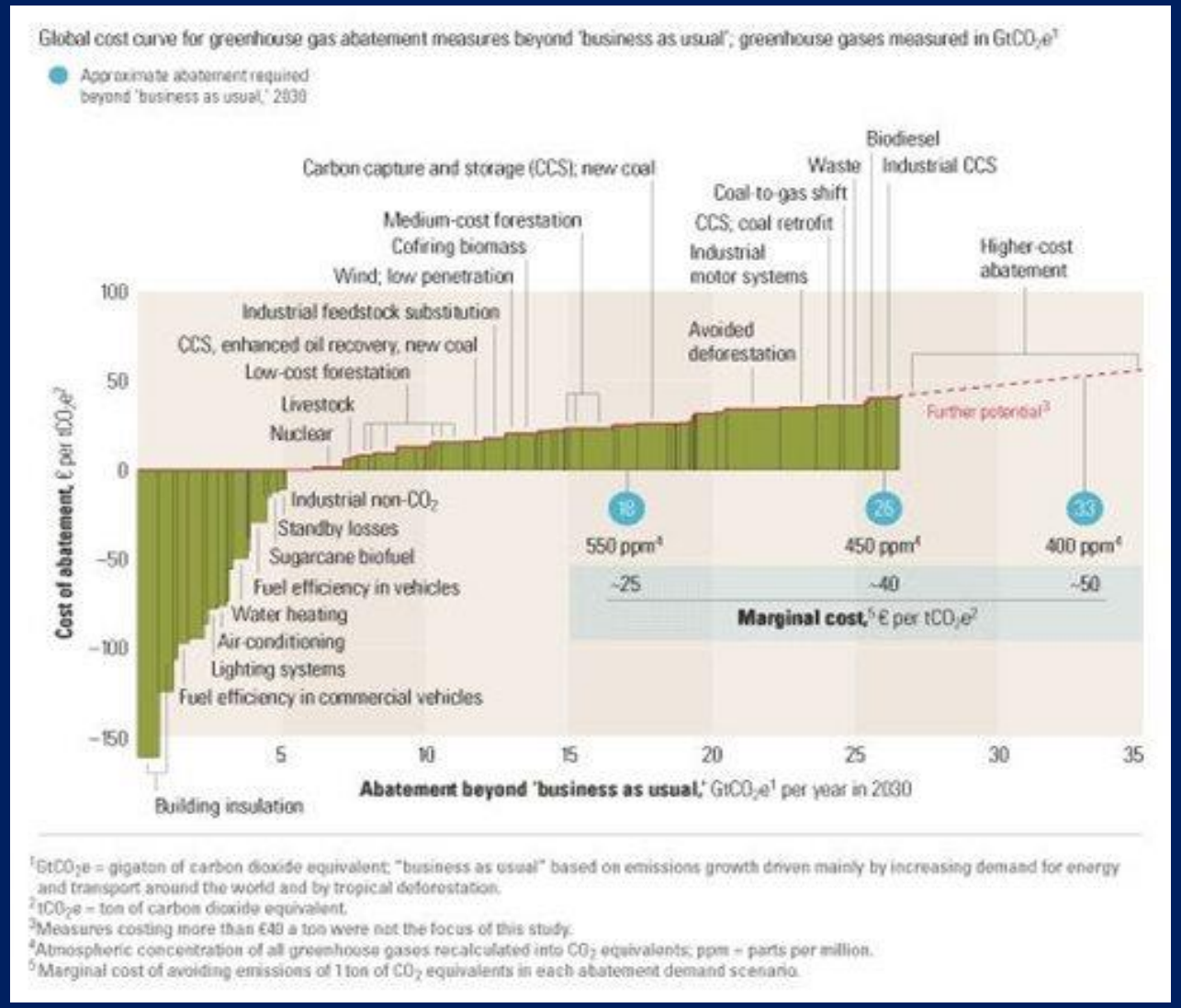
- SPP = 2.3 years
- NPV = 182,511 Rs
- B/C ratio = 1.7
- IRR =53.2%

Marginal Abatement Cost Curve



http://www.climateworksaustralia.org/project/national-plan/how-read-marginal-abatement-cost-curve

Global Cost Curve



Summing Up

- Economic criteria used as basis for decisions
- Discount rate- scarcity of capital
- Life Cycle costing, Marginal cost of carbon saved
- Taxes, Government Policies
- Sensitivity, Impact of variables

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