Hydropower Financing and Risk Management Nepal

SOME COST AND PRICING CONCEPTS

KATHMANDU
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ELECTRIC POWER: SOME CONCEPTS

- COST/COSTING REFER TO THE VALUE OF RESOURCES THAT GO INTO THE PRODUCTION AND SUPPLY OF ELECTRIC POWER
- THE VALUE OF RESOURCES IS CORRECTLY EXPRESSED IN TERMS OF OPPORTUNITY COST = THE VALUE OF THE RESOURCE IN ITS BEST ALTERNATIVE USE
- A ROLE OF COSTING IS TO PROVIDE A BENCHMARK FOR PRODUCTION AND PRICING DECISONS
- PRICING REFERS TO THE AMOUNT PAID FOR GOODS/SERVICES IN EXCHANGE
- THE FOCUS OF PRICING IS ON THE REVENUE RELATED TO EXCHANGE
- IN THE POWER SECTOR THE TERM PRICE OFTEN (BUT NOT ALWAYS) REFERS TO THE BULK PRICE OR WHOLESALE PRICE
- TARIFF MOSTLY REFERS TO WHAT END CONSUMERS PAY FOR ELECTRICITY (OFTEN NOT COST-BASED)
- WILLINGNESS-TO-PAY EXPRESSES WHAT PEOPLE ARE WILLING TO PAY FOR ELECTRICITY RATHER THAN GO WITHOUT IT (AS OPPOSED TO THE TARIFF THEY ACTUALLY PAY)

SOME POWER SECTOR COST/PRICE CONCEPTS

- **LEVELISED UNIT COST**
- **AVOIDED COST**
- **NETBACK PRICE**
- **MARKET PRICES**

- **COMMON TO ALL THESE CONCEPTS: EXPRESSED IN TERMS OF A COST OR A PRICE PER kWh: e.g. NPR/kWh, USc/kWh**

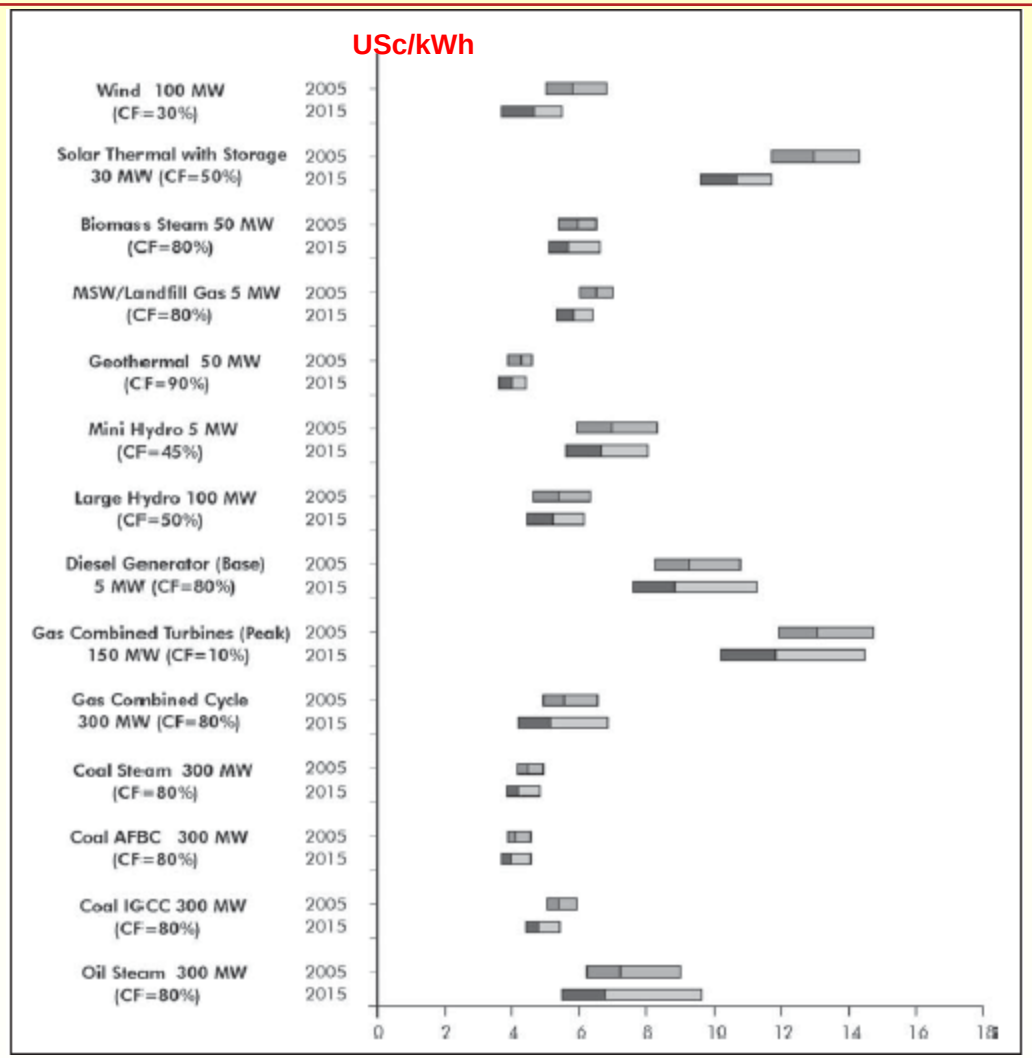
LEVELISED UNIT COST OF ENERGY

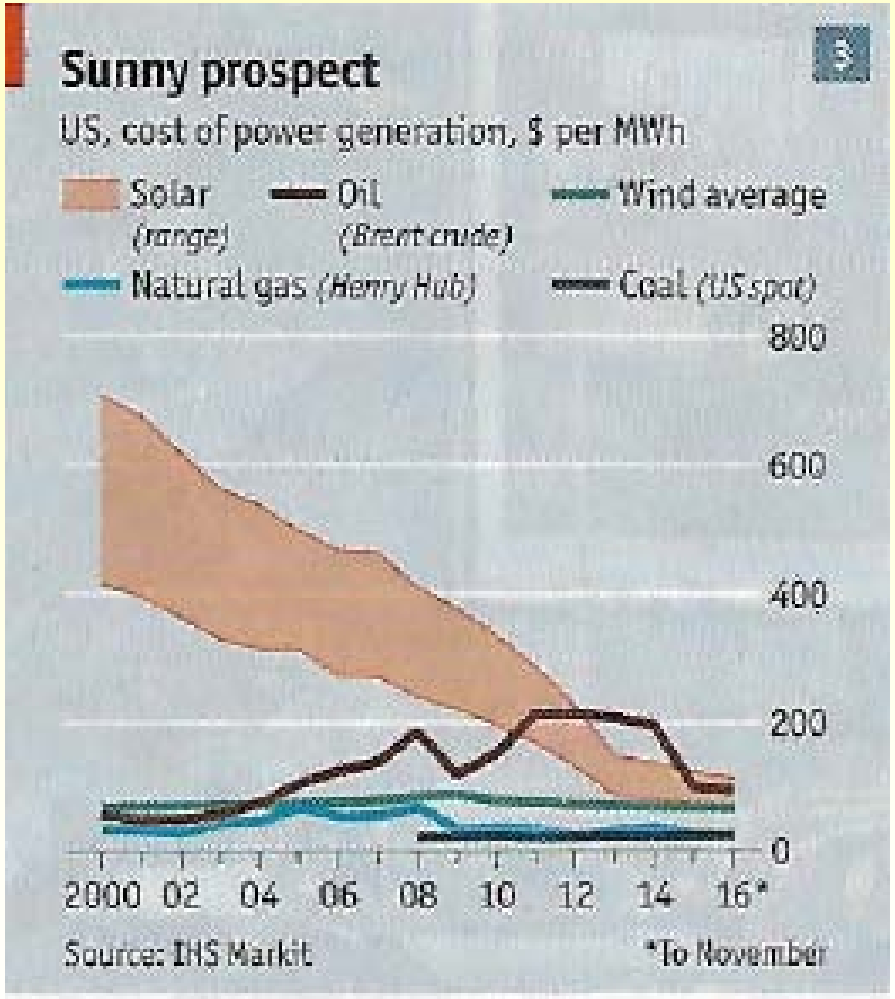
- **AN EXPRESSION OF UNIT ENERGY COST**
- **A STANDARDISED METHODOLOGY FOR COMPARING THE COSTS OF DIFFERENT TYPES OF POWER PLANTS PERFORMING SIMILAR FUNCTIONS**

USES OF LEVELISED COST

- **COMPARISON OF COST OF VARIOUS SOURCES OF SUPPLY**
- **OPTIMISATION OF A HYDROPOWER PLANT**
- **RANKING OF DOMESTIC HYDROPOWER PROJECTS**
- **BASIS FOR POWER TRADE NEGOTIATIONS**
- **IMPORTANT ELEMENT IN PPAs**
- **USER TARIFF SETTING**

USE OF LEVELISED COSTS
COMPARISON OF OFFGRID AND GRID CONNECTION OPTIONS





Source: ESMAP 2007: Technical and Economic Assessment of Off-grid, Mini-grid and Grid Electrification Technologies

Source: The Economist, Nov. 2016

LEVELISED COST: VARIATIONS

- NORMALLY REPRESENTED AS COST ON THE BASIS OF NET POWER SUPPLIED AT THE STATION BUSBAR
- BUT MAY ALSO REFER COSTS AND OUTPUT TO THE CONNECTING POINT TO THE GRID FOR THE RELEVANT PLANT
- MAY BE CALCULATED ON THE BASIS OF:
  - MEAN ANNUAL ENERGY (TOTAL ENERGY), OR
  - THE SUM OF FIRM ENERGY AND NON-FIRM ENERGY WHERE THE FORMER IS GIVEN A WEIGHT OF 1 AND THE LATTER A WEIGHT < 1

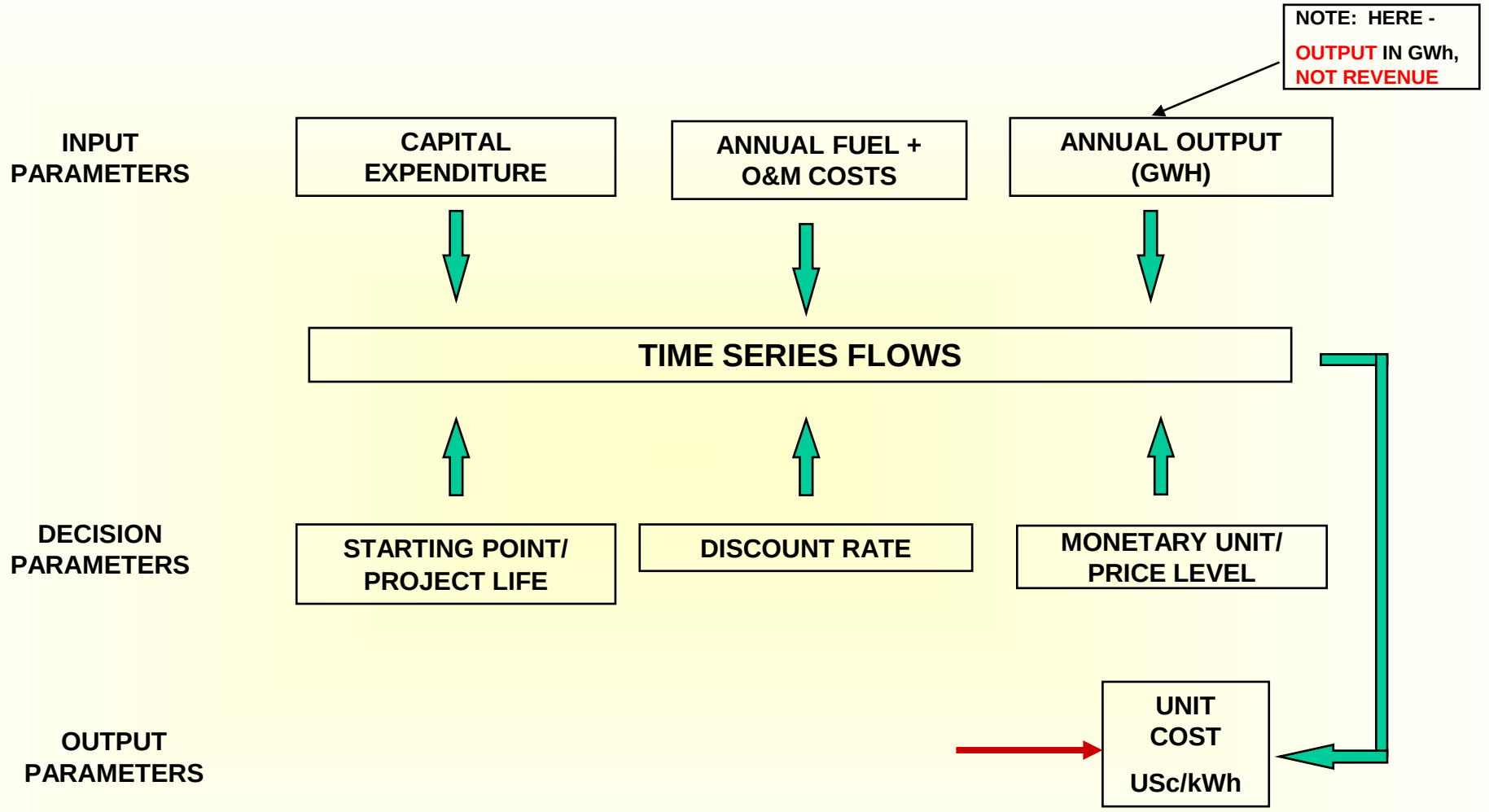
TYPE OF ENERY	OUTPUT	WEIGHT	ADJUSTED
FIRM ENERGY:	80 GWh	1	80 GWh
NON-FIRM ENERGY	40 GWh	0,6 (EXAMPLE)	24 GWh
TOTAL ANNUAL OUTPUT	120 GWh		104 GWh

- THE ADJUSTED FIGURE MAY BE RELEVANT WHEN COMPARING PROJECTS WITH WIDELY DIFFERENT SHARES OF FIRM/NON-FIRM ENERGY

LEVELISED COST: FURTHER CHARACTERISTICS

- COMPARED TO OTHER (ENGINEERING) METHODS OF UNIT COST CALCULATIONS, THE MAIN CHARACTERISTICS THAT DISTINGUISH THE LEVELISED COST METHOD ARE:
  - THE PROJECT LIFETIME PERSPECTIVE
  - ALL LIFETIME COSTS ACCOUNTED FOR
  - DISCOUNTING OF COSTS AND OUTPUT
- AS THE TERM INDICATES, THE LEVELISED COST IS “LEVEL” THROUGHOUT THE PROJECT LIFE (UNCHANGED)

PARAMETERS FOR LEVELISED COST CALCULATION



LEVELISED COSTS: TWO MAIN METHODS

METHOD 1:

- **DISCOUNTING ANNUAL COSTS AND ANNUAL OUTPUT OVER PROJECT LIFETIME BACK TO A COMMON BASE YEAR, ARRIVING AT PV COSTS AND PV OUTPUT**
- **LEVELISED UNIT COST= PV LIFETIME COSTS DIVIDED BY PV LIFETIME OUTPUT**

LEVELISED COST OF ENERGY: METHOD 1

$$\text{Unit energy cost (USc/kWh):} \quad \frac{\sum_{i=1}^{n} \frac{C_i}{(1+r)^i}}{\sum_{i=1}^{n} \frac{O_i}{(1+r)^i}}$$

where: C_i = investment, fuel and O&M costs for the project in year i
O_i = incremental output (kWh) from the scheme in year i
n = the project life in years
r = discount rate

HYDROPOWER: LEVELISED UNIT COST. METHOD 1

UPPER TAMAKOSHI

FINANCIAL EVALUATION - TOTAL INVESTMENT

SCENARIO: 1

Key Assumptions:

Discount rate: 12 %

Cash flows: In MUSD

Installed capacity (MW):	456	Incremental energy	Generation (GWh)	Tariff (USc/kWh)	**Price reference year:**	2014	
Capital cost power plant (MUSD):	455,00	Dry season	296,5	6,33	Fixed PP O&M (% p.a. of investment)	1,00 %	
Capital cost T&D (MUSD):	0,00	Wet season	1984,5	3,30	Variable PP O&M (USc/kWh):	0,00	
Total capital cost (MUSD):	455				T&D O&M (% p.a. of investment):		
Construction period (longest) (yrs.):	9	Total generation	2281,0		Fuel cost (USc/kWh):	0,0	
Project lifetime (yrs.):	50	Transm. losses:		0,0 %	Emission cost (USc/kWh):	0,0	
Wheeling costs (USc/kWh)	0,0				Carbon credit (USc/kWh):	0,0	

Sensitivities:

Investments		1,0
Firm and second. egy:		1,0
Dry season	296,5	
Wet season	1984,5	Fuel cost adjustm. for taxes/ levies
Capital cost MUSD	Power plant	T&D
	455,00	
	100 %	0 %

Cash flows:

	Costs									Revenues							
Year	Capital cost power plant	Cap cost T&D	Fixed PP O&M	Variable PP O&M	T&D O&M	Fuel cost	Emission costs	Wheeling cost	Total cost	Firm energy	Second. energy	Carbon credits	Total revenue	**Incremental net cash flow**	Tot costs excl emiss &wheeling	Mean ann. energy after tx losses	Investm. profile power pl. (%)	Investm. profile transm. (%)
1	22,75	0,00	0,00	0,00	0,00	0,00	0,00	0,00	22,75	0,00	0,00	0,00	0,00	-22,75	22,75	0,0	5 %	
2	45,50	0,00	0,00	0,00	0,00	0,00	0,00	0,00	45,50	0,00	0,00	0,00	0,00	-45,50	45,5	0,0	10 %	
3	45,50	0,00	0,00	0,00	0,00	0,00	0,00	0,00	45,50	0,00	0,00	0,00	0,00	-45,50	45,5	0,0	10 %	
4	45,50	0,00	0,00	0,00	0,00	0,00	0,00	0,00	45,50	0,00	0,00	0,00	0,00	-45,50	45,5	0,0	10 %	
5	68,25	0,00	0,00	0,00	0,00	0,00	0,00	0,00	68,25	0,00	0,00	0,00	0,00	-68,25	68,25	0,0	15 %	
6	68,25	0,00	0,00	0,00	0,00	0,00	0,00	0,00	68,25	0,00	0,00	0,00	0,00	-68,25	68,25	0,0	15 %	
7	68,25	0,00	0,00	0,00	0,00	0,00	0,00	0,00	68,25	0,00	0,00	0,00	0,00	-68,25	68,25	0,0	15 %	
8	68,25	0,00	0,00	0,00	0,00	0,00	0,00	0,00	68,25	0,00	0,00	0,00	0,00	-68,25	68,25	0,0	15 %	
9	22,75	0,00	0,00	0,00	0,00	0,00	0,00	0,00	22,75	0,00	0,00	0,00	0,00	-22,75	22,75	0,0	5 %	
10			4,55	0,00	0,00	0,00	0,00	0,00	4,55	18,77	65,49	0,00	84,26	79,71	4,55	2281,0		
46			4,55	0,00	0,00	0,00	0,00	0,00	4,55	18,77	65,49	0,00	84,26	79,71	4,55	2281,0		
47			4,55	0,00	0,00	0,00	0,00	0,00	4,55	18,77	65,49	0,00	84,26	79,71	4,55	2281,0		
48			4,55	0,00	0,00	0,00	0,00	0,00	4,55	18,77	65,49	0,00	84,26	79,71	4,55	2281,0		
49			4,55	0,00	0,00	0,00	0,00	0,00	4,55	18,77	65,49	0,00	84,26	79,71	4,55	2281,0		
50			4,55	0,00	0,00	0,00	0,00	0,00	4,55	18,77	65,49	0,00	84,26	79,71	4,55	2281,0		
51			4,55	0,00	0,00	0,00	0,00	0,00	4,55	18,77	65,49	0,00	84,26	79,71	4,55	2281,0		
52			4,55	0,00	0,00	0,00	0,00	0,00	4,55	18,77	65,49	0,00	84,26	79,71	4,55	2281,0		
53			4,55	0,00	0,00	0,00	0,00	0,00	4,55	18,77	65,49	0,00	84,26	79,71	4,55	2281,0		
54			4,55	0,00	0,00	0,00	0,00	0,00	4,55	18,77	65,49	0,00	84,26	79,71	4,55	2281,0		
55			4,55	0,00	0,00	0,00	0,00	0,00	4,55	18,77	65,49	0,00	84,26	79,71	4,55	2281,0		
56			4,55	0,00	0,00	0,00	0,00	0,00	4,55	18,77	65,49	0,00	84,26	79,71	4,55	2281,0		
57			4,55	0,00	0,00	0,00	0,00	0,00	4,55	18,77	65,49	0,00	84,26	79,71	4,55	2281,0		
58			4,55	0,00	0,00	0,00	0,00	0,00	4,55	18,77	65,49	0,00	84,26	79,71	4,55	2281,0		
59			4,55	0,00	0,00	0,00	0,00	0,00	4,55	18,77	65,49	0,00	84,26	79,71	4,55	2281,0		
Results:					**Generation: Unit cost (USc/kWh):**				3,97			**NPV (MUSD):**		-19,1	271,5	6830,9		
												FIRR:		11,4%	PV coststt	PV supply.		

	Supply	**PV GWh**	6831		Total cost	**PV (MUSD:**		271,5		Total rev	**PV (MUSD:**		252,3	

LEVELISED COSTS: TWO MAIN METHODS

METHOD 2:

- ANNUALISED CAPITAL COSTS PLUS ANNUAL FUEL + O&M COSTS TO ARRIVE AT A TOTAL ANNUAL COST
- LEVELISED UNIT COST: RATIO OF TOTAL ANNUAL COST TO ANNUAL OUTPUT

THE TWO METHODS GIVE IDENTICAL ANSWERS

- BOTH MEASURE EXPRESS COSTS DIVIDED BY OUTPUT
- CALCULATION OF METHOD 1 IS BASED ON COSTS OVER THE LIFETIME OF THE PROJECT
- CALCULATION OF METHOD 2 IS BASED ON COST IN ONE YEAR
  -- WITH CAPITAL EXPENDITURE SPREAD OVER PROJECT LIFETIME

LEVELISED COST OF ENERGY: METHOD 2

$$\text{Unit energy cost (USc/kWh):} \quad \frac{\text{(Annualised capital cost } (C_i + \text{IDC})) + \text{annual oper. cost (fuel + O\&M)}}{\text{Mean annual output (GWh)}}$$

where: C_i = investment in year i
IDC = interest during construction
Annualised (C + IDC) => transforming the discrete investment costs into an annual fixed payment over the lifetime of the project, accounting for interest over the same period

FORMULA FOR CALCULATING ANNUALISED CAPITAL COST

CAPITAL RECOVERY FACTOR =

$$\frac{i}{1-\frac{1}{(1+i)^n}}$$

- **CR FACTOR IS MULTIPLIED BY INITIAL INVESTMENT INCL. IDC**
- **IN EXCEL: AMORT-FUNCTION**
- **WITH CALCULATOR: PMT-FUNCTION**

HYDROPOWER: LEVELISED UNIT COST. METHOD 2

Unit energy cost											
Name /Type of Plant:	Upper Tamakoshi										
Assumptions:						Real terms		Price ref. yr:			2018
Installed capacity (MW):					456	Discount rate					12 %
FOR (%)					0,0 %	Replacement costs in year x (USD mill):					0
Maintenance time (%)					0,0 %	Fixed O&M + overhauls (USD million/yr.)					4,55
Max availability factor:					57,1 %	Limestone costs (USD/kWh)					0
Mean annual generation (GWh):					2 281	Variable O&M costs (USD/kWh)					0,0000
Operational life (years):					50	Heat rate (kj/kWh):					0
Construction costs (USD/kW installed):					998	Spinning reserve (%)					0 %
Construction period (yrs):					9	Fuel price (USD/GJ)					0,0
Auxiliary consumption (%):					0 %	Plant factor					57,1%

Distribution of Construction Cost By Construction Year (USD million):

	Construction Year										
	1	2	3	4	5	6	7	8	9	10	Total
Profile (%)	5 %	10 %	10 %	10 %	15 %	15,0 %	15,0 %	15 %	5 %		455,0
USD mill	22,8	45,5	45,5	45,5	68,3	68,3	68,3	68,3	22,8		455,0
											1,00

Calculation of Total Capital Expenditure (USD million):

Constr. Yr	Annual construction cost + compounded interest during the construction period.										Total
1	22,8										22,8
2	25,5	45,5									71,0
3	28,5	51,0	45,5								125,0
4	32,0	57,1	51,0	45,5							185,5
5	35,8	63,9	57,1	51,0	68,3						276,0
6	40,1	71,6	63,9	57,1	76,4	68,3					377,4
7	44,9	80,2	71,6	63,9	85,6	76,4	68,3				490,9
8	50,3	89,8	80,2	71,6	95,9	85,6	76,4	68,3			618,1
9	56,3	100,6	89,8	80,19	107,4	95,9	85,6	76,4	22,8		715,0
10											

Capital Expenditure incl. IDC			
	Investment cost:	455,00	USD million
	Interest during construction:	259,99	USD million
	Capital cost incl. IDC	714,99	USD million
Fixed Annual Costs			
	Annualised capital cost incl. IDC	86,10	USD million
	Annualised replacement costs	0,00	USD million
	Fixed O&M + annualised overhauls	4,55	USD million
	Total fixed annual costs	90,65	USD million
Variable Annual Costs @ Plant Factor			57 %
	Annual fuel costs	0,00	USD million
	Annual variable O&M costs	0,00	USD million
	Total variable annual costs	0,00	USD million
Cost Per kWh Generated @ Plant Factor			57 %
	Total fixed annual costs	90,65	USD million
	Total variable annual costs	0,00	USD million
	Total annual costs	90,65	USD million
	Mean annual supply	2 281,0	GWh
	Levelised unit cost	**3,97**	USc/kWh

MODEL INPUTS

CALCULATIONS

RESULTS

SAME ANSWER AS METHOD 1

GAS FIRED CCGT: LEVELISED UNIT COST. METHOD 2

Levelised Unit Cost

Type of Plant: CCGT

Assumptions:		**Real terms**	**Price ref. yr:**	**2013**
Installed capacity (MW):	500	Discount rate		10 %
FOR (%)	4,6 %	Replacement costs in year x (USD mill):		0
Maintenance (%)	6,9 %	Fixed O&M costs (USD/kW/yr)		28
Max availability factor:	88,8 %	Limestone costs (USc/kWh)		0
Mean annual generation (GWh):	2 190	Variable O&M costs (USD/kWh)		0,0020
Operational life (years):	25	Heat rate (kj/ kW)		6435
Construction costs (USDlkW installed):	910	Spinning reserve (%)		0 %
Construction period (yrs.):	3	Gas price (USD/GJ)		10,00
Auxiliary consumption (%):	0 %	Plant factor		50%

Distribution of Construction Cost By Construction Year (USD million):

	Construction Year										
	1	2	3	4	5	6	7	8	9	10	Total
Profile	40 %	50 %	10 %								455,0
USD mill	182,0	227,5	45,5								455,0
											1,00

Calculation of Total Capital Expenditure (USD million):

Constr. Yr	Annual construction cost + compounded interest during the construction period.										Total
1	182,0										182,0
2	200,2	227,5									427,7
3	220,2	250,3	45,5								516,0
4											
5											
6											
7											
8											
9											
10											

Capital Expenditure incl. IDC						
	Investment cost:	455,0	USD million			
	Interest during construction:	61,0	USD million		CCGT	
	Capital cost incl. IDC	516,0	USD million	Plant factor	Levelised unit cost	
Fixed Annual Costs				%	USc/kWh	
	Annualised capital cost incl. IDC	56,8	USD million	10 %	22,81	
	Annualised replacement costs	0,0	USD million	20 %	14,72	
	Fixed O&M costs	14,0	USD million	30 %	12,03	
	Total fixed annual costs	70,8	USD million	40 %	10,68	
				50 %	9,87	
Variable Annual Costs @ Plant Factor			50 %	60 %	9,33	
	Annual fuel costs	140,9	USD million	70 %	8,95	
	Annual variable O&M costs	4,4	USD million	80 %	8,66	
	Total variable annual costs	145,3	USD million	90 %	8,43	
				100 %	8,25	
Cost Per kWh Generated @ Plant Factor			50 %			9,870
	Total fixed annual costs	70,8	USD million			
	Total variable annual costs	145,3	USD million			
	Total annual costs	216,1	USD million			
	Mean annual supply	2 190	GWh			
	Levelised unit cost	**9,9**	USc/kWh			

PLANT FACTOR INFLUENCES UNIT COST HEAVILY

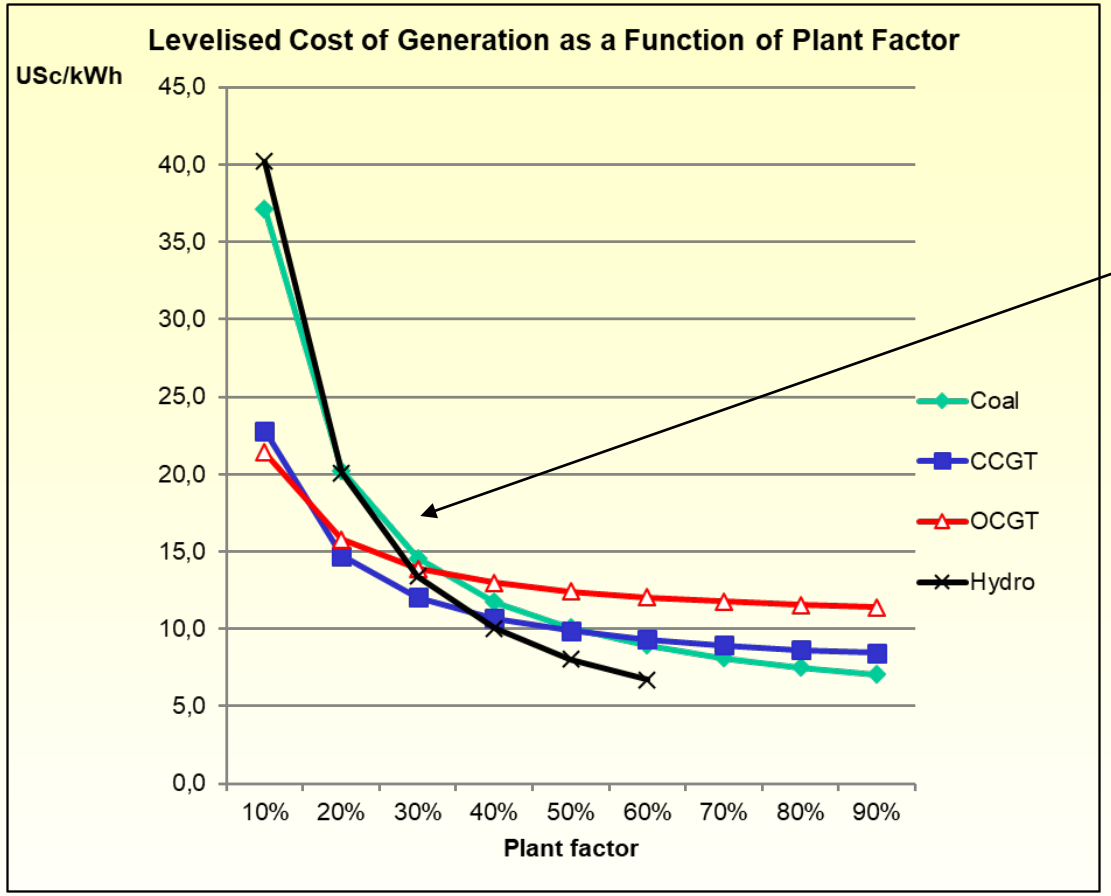
FUEL AND VARIABLE O&M ARE ADDITIONAL AND SIGNIFICANT ELEMENTS COMPARED TO HYDROPOWER

IMPORTANT ELEMENTS INFLUENCING THE LEVELISED COST

- **IN ADDITION TO THE BASIC COST OF CONSTRUCTION AND OPERATION, THE FOLLOWING FACTORS ARE IMPORTANT:**
  - **PLANT FACTOR**
  - **INTEREST (DISCOUNT) RATE**
- **THE IMPACT OF THESE ELEMENTS ON THE UNIT COST WORK IN OPPOSITE DIRECTIONS**

SCREENING CURVES

ILLUSTRATIONS FOR VARIOUS TYPES OF PLANTS AND PLANT FACTORS



UNIT COST AT VARYING PLANT FACTORS FOR DIFFERENT TYPES OF POWER PLANT

- HIGHER PLANT FACTOR MEANS LOWER UNIT COST
- THE UNIT COST OF SOME TYPES OF PLANTS ARE MORE SENSITIVE TO PLANT FACTOR THAN OTHERS

CHARACTERISTICS OF HYDROPOWER VS THERMAL COSTS

EXAMPLES OF LIFETIME COSTS OF BASE LOAD OPERATIONS

TYPICAL COST STRUCTURE USD/MWh	HYDROPOWER		CCGT (US)		COAL (US)	
CAPITAL	32.5	95%	10.5	24%	22.0	45%
FUEL	0		30.5	69%	19.0	39%
0&M	2.0	5%	3.0	7%	8.0	16%
TOTAL (per MWh)	34.5		44		49	

LEVELISED UNIT COST AS A FUNCTION OF DISCOUNT RATE
(SOURCE OF FUNDING / OWNERSHIP)

PROJECT COMPANY:
PRIVATE/PUBLIC

AVERAGE INTEREST RATE: 10% p.a.	RETURN ON EQUITY: 17%
DEBT 70%	EQUITY 30%

WACC: 12% = DISCOUNT RATE

UTK HPP: PRE-TAX LEVELISED UNIT COST = USc 4,0/kWh

PROJECT: OWNED BY
PUBLIC UTILITY

AVERAGE INTEREST RATE: 3,5% p.a.	RETURN ON EQUITY: 12%
DEBT 70%	%EQUITY 30%

WACC: 6% = DISCOUNT RATE

UTK HPP : PRE-TAX LEVELISED UNIT COST = USc 1,8/kWh

- THE COMPARISON ILLUSTRATES THE IMPORTANCE OF FINANCING OF POWER PROJECTS AND THE ADVANTAGE OF CONCESSIONARY FUNDING
- HOWEVER, THIS IS ONLY ONE DIMENSION OF PRIVATE VS. PUBLIC PROJECT DEVELOPMENT
  - POSSIBLE EFFICIENCY GAINS FROM PRIVATE DEVELOPMENT ARE NOT ACCOUNTED FOR HERE
  - COST OF RISK OFTEN LESS CLEARLY ADDRESSED IN PUBLIC FINANCED PROJECTS

LEVELISED COST: SUMMARY

- CONSTITUTES A CORRECT METHOD IN ECONOMIC AND FINANCIAL TERMS FOR EXPRESSING THE UNIT COST OF GENERATION
- THE METHODOLOGY APPLIES BOTH TO HYDROPOWER AND THERMAL GENERATION OPTIONS
- EQUIVALENT TO THE AVERAGE PRICE TO BE PAID BY CONSUMERS FOR GENERATION, TO REPAY EXACTLY THE INVESTOR/UTILITY FOR:
  - CAPITAL INVESTMENT, FUEL AND 0&M COSTS FOR GENERATION
  - PLUS A RETURN (INTEREST) ON CAPITAL INVESTMENT
- BUT - THE LEVELISED COST NORMALLY EXCLUDES TRANSMISSION AND DISTRIBUTION COSTS
- IN ORDER TO COMPARE A UNIT COST WITH THE AVERAGE TARIFF: ADD UNIT T&D COSTS

USES OF LEVELISED COST

- COMPARISON OF COST OF VARIOUS SOURCES OF SUPPLY
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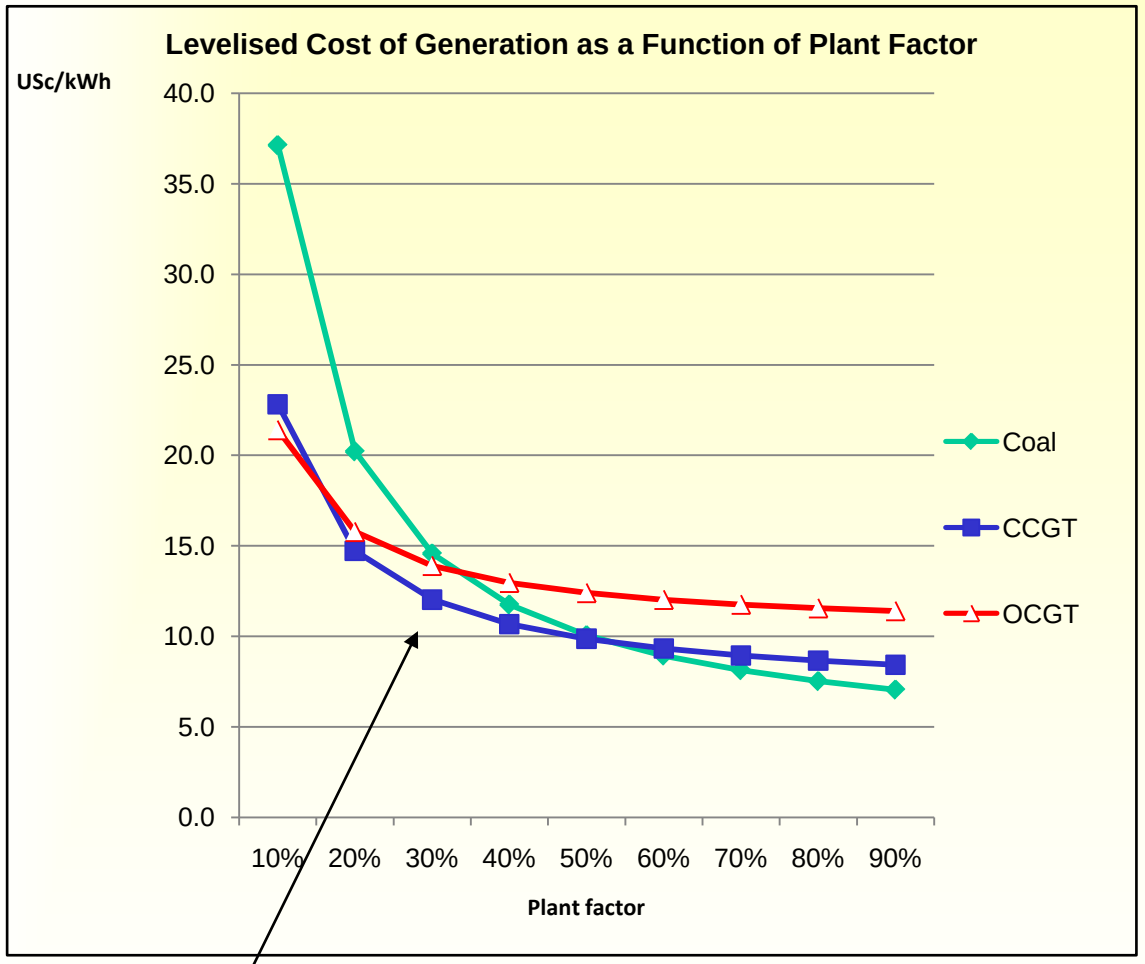
UNIT COST FOR OPTIMISATION OF A HYDROPOWER PLANT



UNIT COST AT VARYING PLANT FACTORS FOR DIFFERENT THERMAL PLANTS

- ESTABLISH OPERATION MODE OF HPP (BASE LOAD, SHOULDER LOAD, PEAKING) BASED ON PLANT AND RIVER CHARACTERISTICS
- IDENTIFY THERMAL PLANT ALTERNATIVE THAT THE HPP WILL COMPETE WITH
- CALCULATE LEVELISED COST AND PREPARE SCREENING DIAGRAM FOR RELEVANT THERMAL PLANT
- SIMULATE ENERGY PRODUCTION FOR VARYING HPP INSTALLED CAPACITIES
- ESTIMATE CORRESPONDING UNIT HPP COSTS FOR COMPARISON WITH UNIT THERMAL PLANT COST
- DETERMINE OPTIMAL HPP SIZE, BASED ON A COMPARISON OF UNIT COSTS (AND OTHER RELEVANT ELEMENTS)

RANKING OF HYDRO PROJECTS BASED ON LEVELISED COST

USES OF LEVELISED COST

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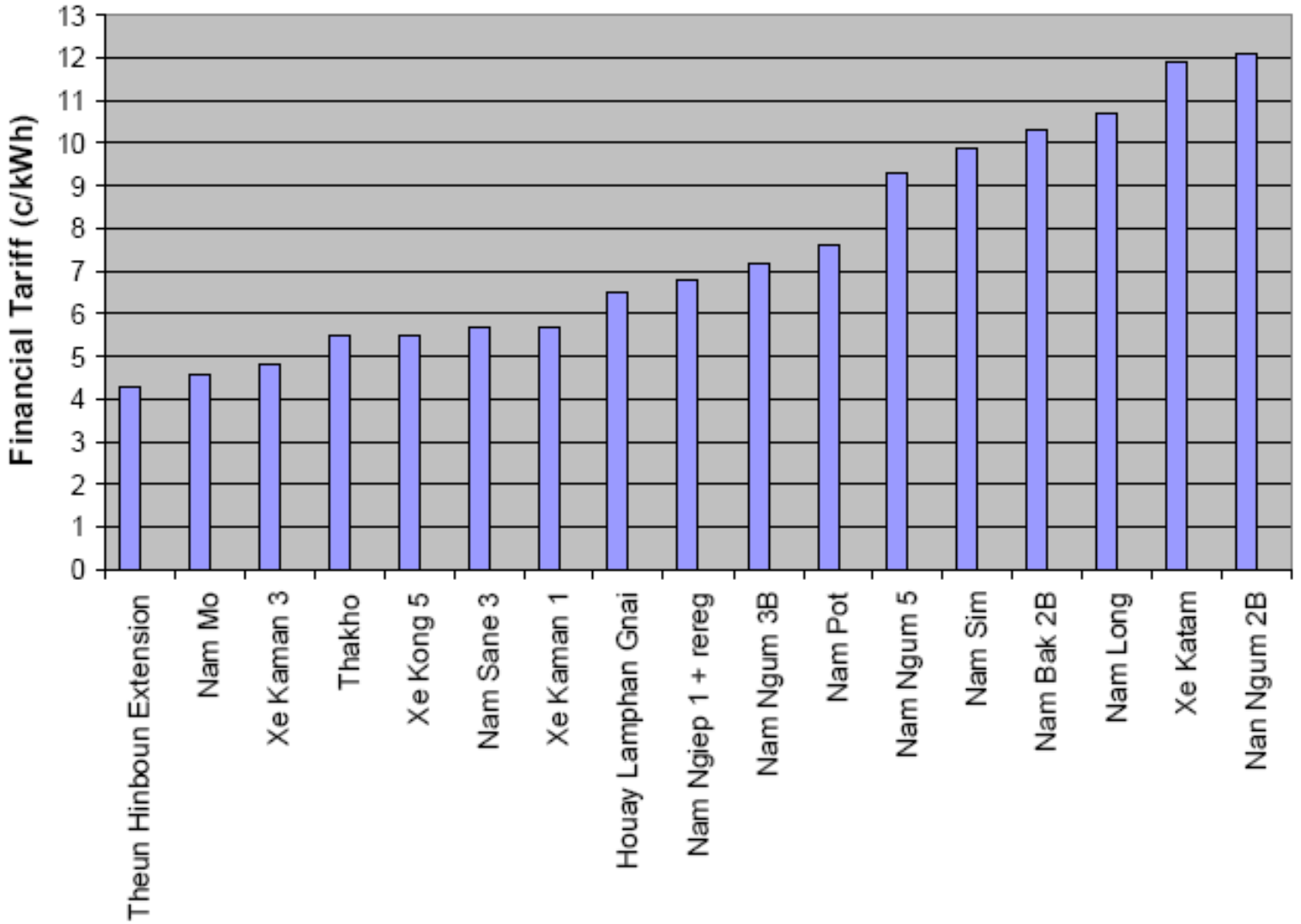


PRICING BASIS FOR POWER TRADE

USES OF LEVELISED COST

- COMPARISON OF COST OF VARIOUS SOURCES OF SUPPLY
- OPTIMISATION OF A HYDROPOWER PLANT
- RANKING OF DOMESTIC HYDROPOWER PROJECTS
- BASIS FOR POWER TRADE NEGOTIATIONS
- IMPORTANT ELEMENT IN PPAs
- USER TARIFF SETTING

ALTERNATIVE PRINCIPLES:

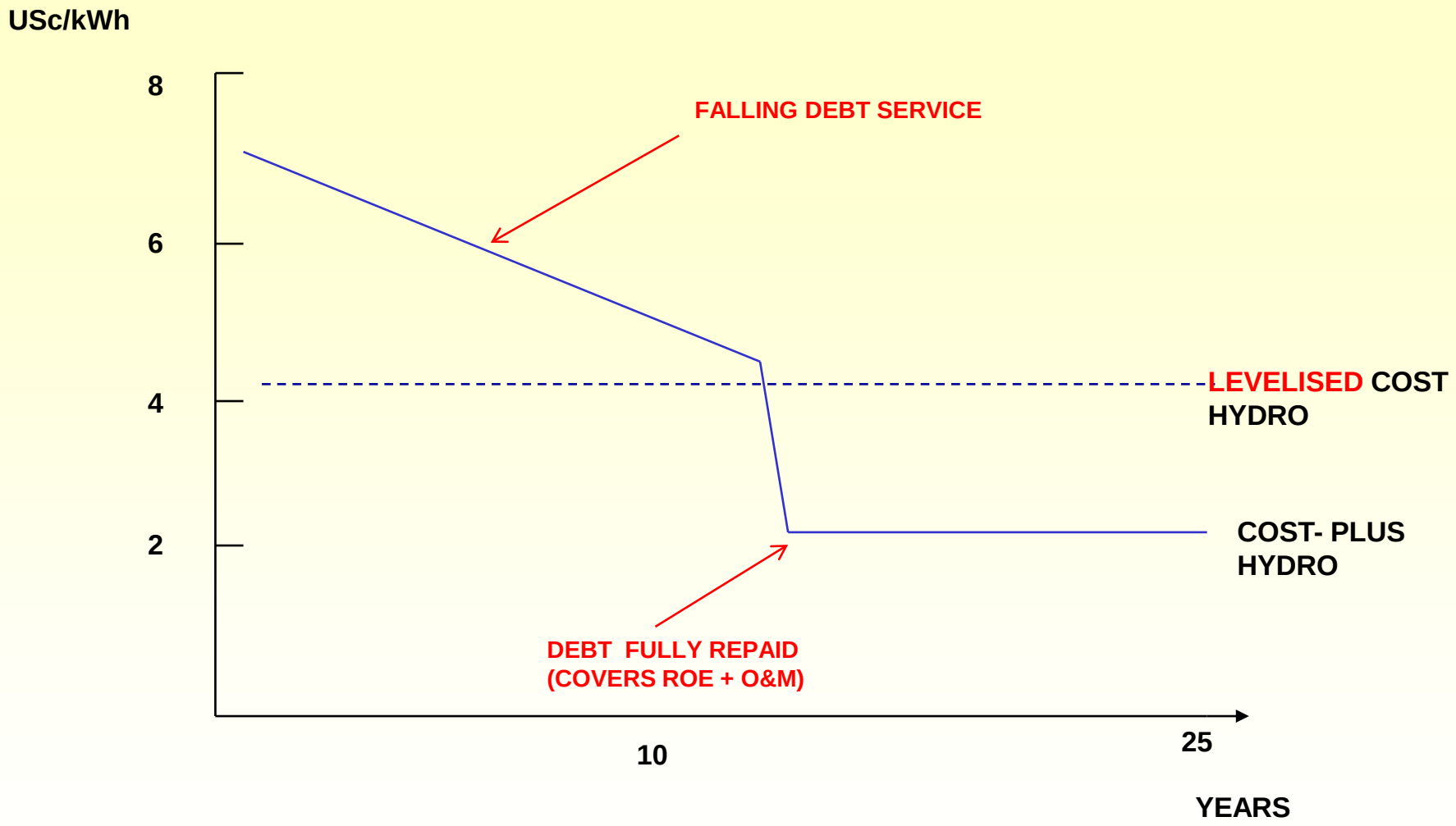
- COST – PLUS CALCULATION
- AVOIDED COST
- BENEFIT SHARING
- MARKET BASED PRICE

COST- PLUS CALCULATION (1)

- **A CALCULATION OF PRICE OF ELECTRICITY TO HYDROPOWER BASED ON:**
  - **OPERATION AND MAINTENANCE COSTS**
  - **SERVICING OF DEBT TO FINANCE PROJECT**
  - **YIELDING A ”REASONABLE” RATE OF RETURN ON INVESTMENT**

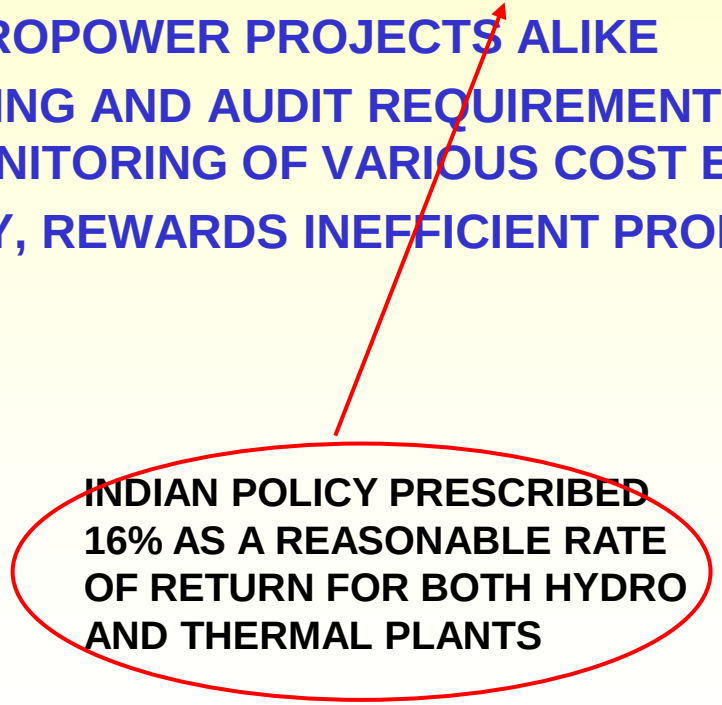
- **PROPOSED BY SOME COUNTRIES TO DOMESTIC IPPs AND FOREIGN EXPORTERS**

COST- PLUS TARIFF (illustr.)



COST- PLUS CALCULATION 2

- **ARGUMENTS AGAINST COST-PLUS CALCULATIONS AS BASIS FOR POWER EXPORTS PRICING:**
  - **DOES NOT RECOGNISE THE PRINCIPLE OF SHARING FAIRLY THE BENEFITS OF TRADE**
  - **LITTLE RECOGNITION OF RELATIONSHIP: RISK – REWARD IF APPLIED TO THERMAL AND HYDROPOWER PROJECTS ALIKE**
  - **BURDENSOME REPORTING AND AUDIT REQUIREMENTS (VERIFICATION AND MONITORING OF VARIOUS COST ELEMENTS)**
  - **AND, MORE GENERALLY, REWARDS INEFFICIENT PRODUCTION MANAGEMENT**



AVOIDED COST (1)

- A CONCEPT NORMALLY USED IN THE CONTEXT OF A UTILITY THAT MAY:
  - IMPORT ELECTRICITY FROM A NEIGHBOURING COUNTRY
  - PURCHASE ELECTRICITY FROM DOMESTIC IPPs
- THE AVOIDED COST IS IN THIS CASE THE UTILITY'S OWN LEAST-COST SOURCE OF GENERATION THAT CAN BE POSTPONED - OR AVOIDED IF THE ALTERNATIVE (IMPORT OR IPP GENERATION) IS LESS COSTLY
- WHEN COMPARING COSTS THE ASSUMPTION IS THAT THE OUTPUT FROM THE ALTERNATIVE SHOULD BE OF THE SAME:
  - TYPE OF POWER (PEAKING, SHOULDER, BASE LOAD)
  - RELIABILITY

  AS THAT OF ITS OWN GENERATION

AVOIDED COST (2)

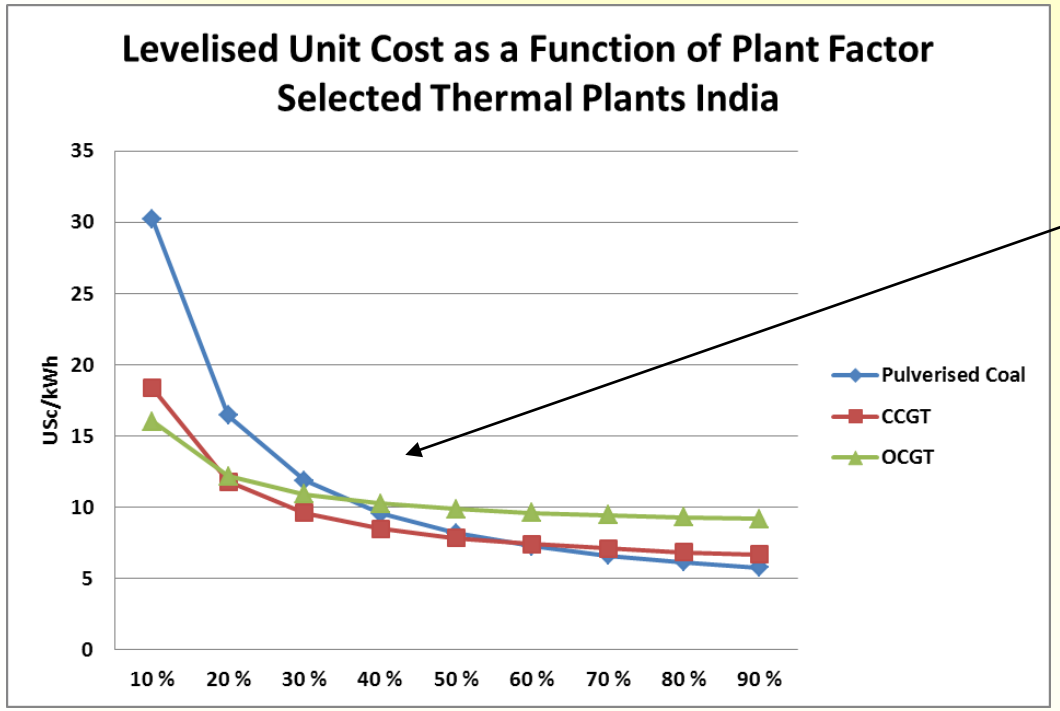
- THE UTILITY'S OWN SOURCE OF SUPPLY MAY BE A THERMAL OR A HYDROPOWER PLANT, BUT WILL NORMALLY BE A THERMAL PLANT
- THE COST OF THE (THERMAL) PLANT CONSISTS OF SUM OF LIFETIME:
  - INVESTMENT COSTS
  - FUEL COSTS
  - FIXED AND VARIABLE O&M COSTS
  - THE TOTAL IS NORMALLY EXPRESSED AS A UNIT COST: USc/kWh
- THUS THE AVOIDED COST IS EXPRESSED IN TERMS OF LEVELISED COST

AVOIDED COST
IN A DOMESTIC CONTEXT

ILLUSTRATION: NEPAL ELECTRICITY ACT 1992

- **PARAGRAPH 21:**
  - *(1) IF ANY PERSON DESIRES TO SELL IN BULK THE ELECTRICITY GENERATED PURSUANT TO THIS ACT, GOVERNMENT OF NEPAL MAY PURCHASE OR CAUSE TO PURCHASE SUCH ELECTRICITY TO THE NATIONAL GRID.*
  - *(2) THE RATE OF ELECTRICITY PURCHASED PURSUANT TO SUB-SECTION (1) SHALL BE DETERMINED ON THE BASIS OF FIXED PERCENTAGE OF AVOIDED COST OR AN ADDITION TO THE GENERATION COST OR FIXED PERCENTAGE OF AVERAGE TARIFF OF NEA.*

AVOIDED THERMAL COSTS
IN THE CONTEXT OF POWER TRADE



- **AVOIDED COST IS BASED ON:**
  - THE TYPE OF POWER NEEDED BY THE IMPORTING COUNTRY (BASE LOAD, SHOULDER LOAD, PEAKING POWER)
  - THE TYPE OF PLANTS IN THE IMPORTING COUNTRY'S GENERATION EXPANSION PLAN
  - THE LEVELISED COST OF THESE PLANTS AT RELEVANT PLANT FACTORS
- **THE AVOIDED COST IN THE IMPORTING COUNTRY:**
  - FORMS ONE BASIS FOR TARIFF NEGOTIATIONS WITH THE HYDROPOWER EXPORTING COUNTRY
  - BUT IT MAY NOT BE READILY AVAILABLE FOR COMMERCIAL REASONS
  - THEREFORE – THE HP EXPORTING COUNTRY SHOULD MAKE ITS OWN ESTIMATES (BASED ON GENERIC CAPITAL COSTS + LOCAL FUEL & O&M COSTS) AS PART OF PREPARATIONS FOR NEGOTIATIONS

FROM DISCUSSIONS BETWEEN NEPAL AND INDIA ON AVOIDED COSTS
(WITH REFERENCE TO PANCHESHWAR PROJECT)

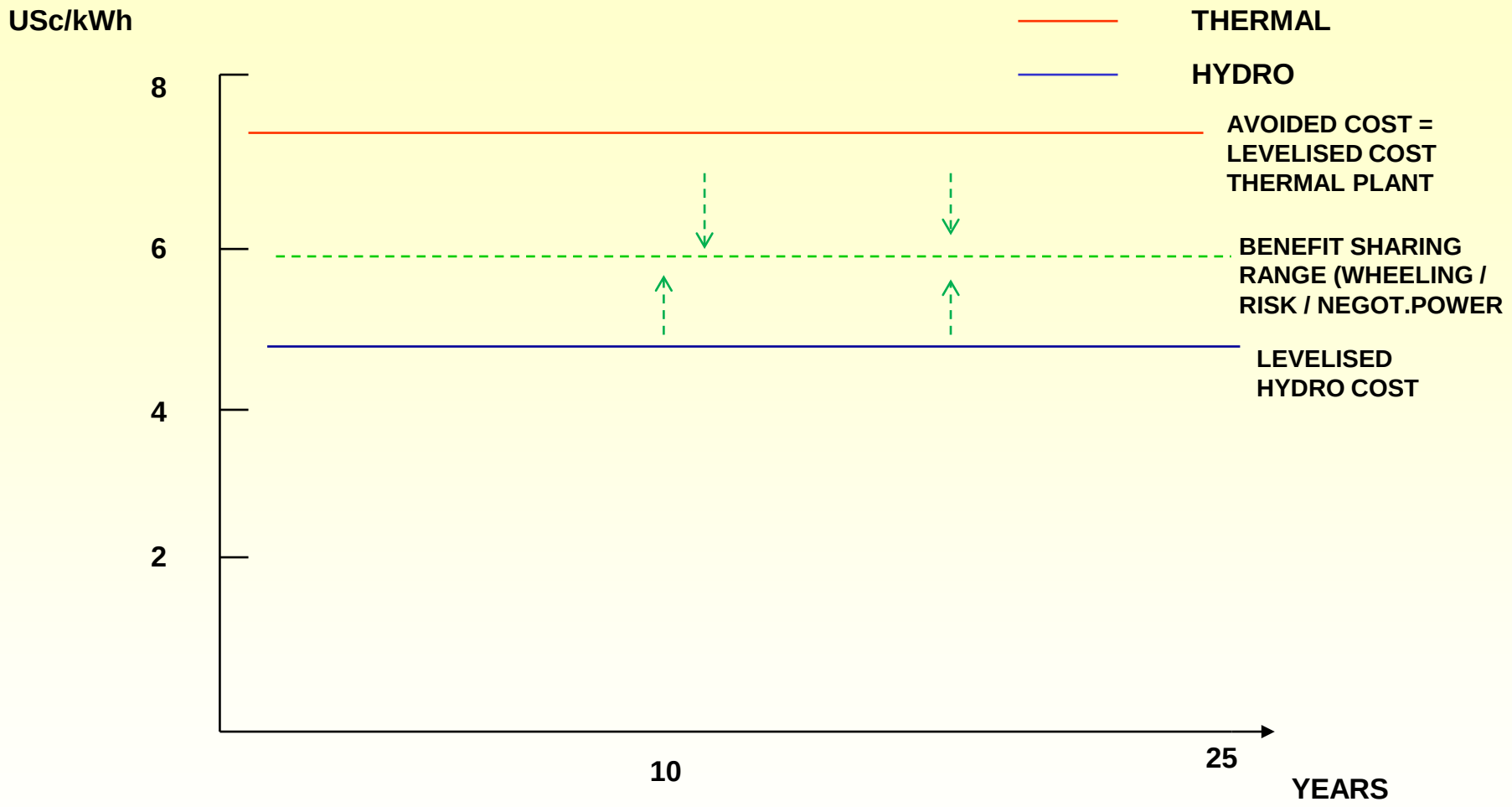
- THE WATER RESOURCES MINISTER OF NEPAL AT THAT TIME CLAIMED THAT THE PRINCIPLE OF DISPLACED COST OF ALTERNATIVES SHOULD BE APPLIED IN THE EVALUATION OF BENEFITS
- INDIA COUNTERED THE RELEVANT ALTERNATIVES AVAILABLE IN INDIA COULD WELL MEAN OTHER HYDROPOWER OPTIONS, NUCLEAR, GAS, ETC., AND NOT NECESSARILY COAL FIRED PLANTS THAT THE NEPALI MINISTER HAD IN MIND
- INDIA'S ANSWER IMPLIES AN ACCEPTANCE OF THE PRINCIPLE OF AVOIDED COSTS AS ONE ELEMENT IN PRICE DISCUSSIONS

BENEFIT SHARING IN POWER TRADE

(THERE IS MORE TO IT THAN COST PLUS OR AVOIDED COST ALONE)

- THE IMPORTER'S AVOIDED COST (USc/kWh) WOULD REPRESENT THE CEILING IN THE PRICE NEGOTIATIONS BETWEEN SELLER AND IMPORTER
- THE COST- PLUS FIGURE OF THE HYDROPOWER SCHEME WOULD REPRESENT THE FLOOR IN THE NEGOTIATIONS
- THE FINAL PRICE SHOULD LIE BETWEEN THE CEILING AND THE FLOOR ALLOWING
  - FOR TRANSMISSION COSTS
  - FOR RISKS FROM IMPORTER'S PERSPECTIVE
  - THE PARTIES TO SHARE THE BENEFITS OF TRADE
- SALES AGREEMENTS WHERE AVOIDED COST HAS PLAYED A ROLE:
  - LAOS/THAILAND
  - CANADA/US

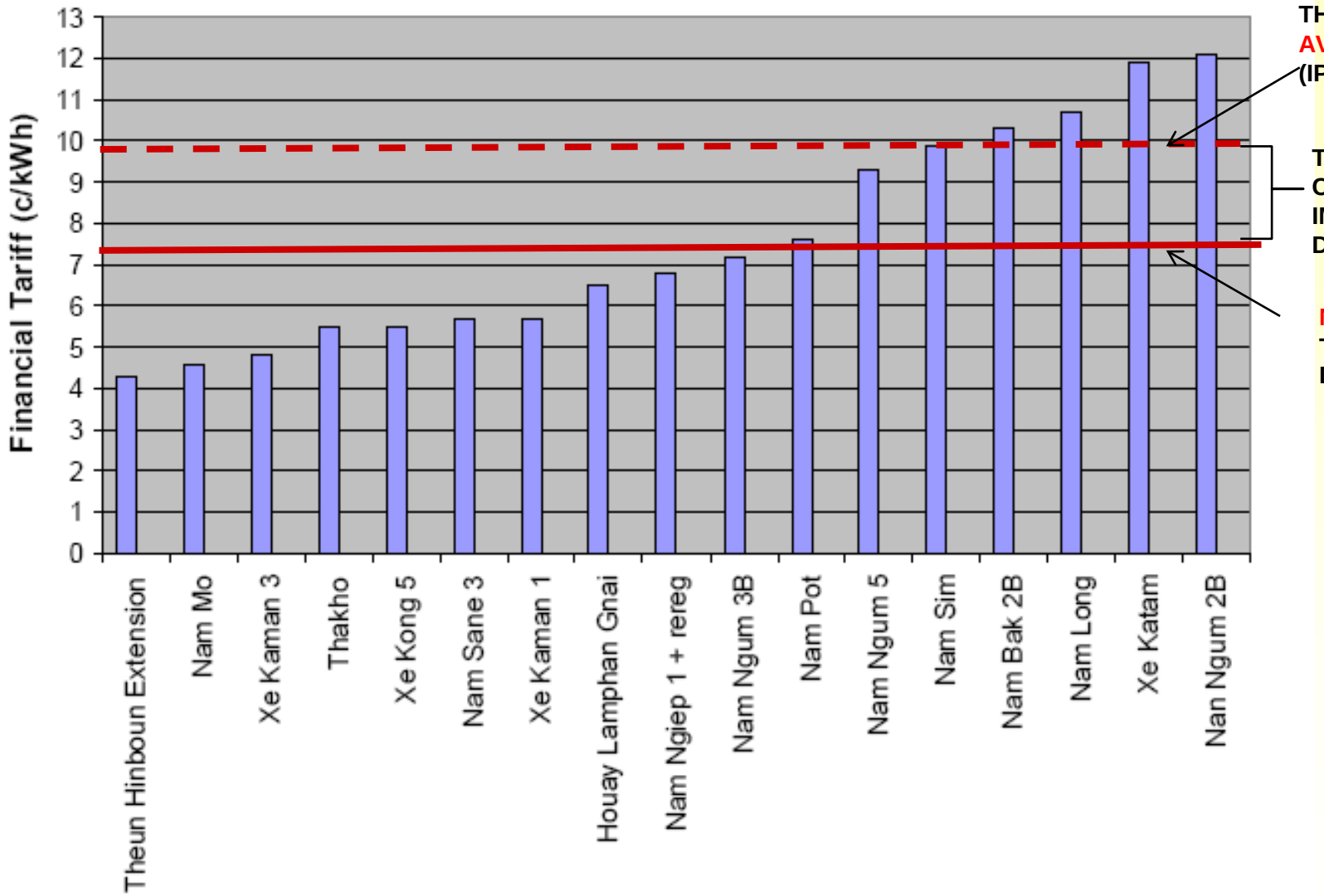
BENEFIT SHARING: ILLUSTRATION



NETBACK PRICES
IN A POWER SECTOR CONTEXT

- NETBACK PRICING REFERS TO THE PROCESS OF EQUALIZING THE COST OF THERMAL ENERGY TO THE COST OF HYDROPOWER
  - BY ADJUSTING FOR TRANSMISSION COSTS, EXPORT TAXES AND TRADE DISCOUNT, COMBINED ALSO KNOWN AS TRADE COST BARRIERS
- NETBACK PRICE = THE PRICE FACING, SAY, AN EXPORTER'S HYDROPOWER PROJECT, AFTER EXPLICITLY TAKING INTO ACCOUNT TRADE COST BARRIERS BETWEEN EXPORTING AND IMPORTING COUNTRY
- THUS, IT CAN BE SEEN AS EQUAL TO THE AVOIDED COST OF A POWER IMPORTING COUNTRY MINUS THE TRADE COST BARRIERS
- NETBACK PRICE IS IN REALITY JUST ANOTHER TERM FOR AVOIDED COST

ILLUSTRATION OF TWO LEVELISED COST TERMS



NETBACK PRICES FACING A HYDROPOWER PROJECT
(CASE: NEPAL I HPP)

FOR A HPP TO BE COMPETITIVE, ITS TOTAL UNIT COST MUST BE LESS THAN THE NETBACK PRICES OF THE THERMAL OPTIONS

		@ economic prices	
		OCCT	CCCT
Cost item		**3**	**4**
Hours per day	Hours	8	8
Plant factor	%	0,33	0,33
Fuel: Imported LNG, border price	US$/mmBTU	5,00	5,00
Landfall price	Rs/1000 CM	7 310	7 310
Transportation	Rs/1000 CM	1 150	1 150
Royalty	Rs/1000 CM	n.a.	n.a.
Delivered fuel price	Rs/1000 CM	8 460	8 460
Calorific value	KCal/CM	8 500	8 500
Burner tip price	Rs/millionKCal	995	995
Heat rate	KCal/kWh	2 900	2 000
Fuel cost	Rs/kWh	2,89	1,99
Investment cost	Rs/kW	17 200	28 900
Investment cost	US$/kW	400	672
Discount rate	%	12 %	12 %
Economic life	Years	20	20
Annualised capital cost	Rs/kW/year	2 303	3 869
Operating hours	Hours per year	2 920	2 920
Capital cost	Rs/kWh	0,79	1,33
Fixed operating cost	Rs/kW/year		
Fixed operating cost	Rs/kWh	0,06	0,32
Variable operating cost	Rs/kWh	0,12	
Total cost/kWh	Rs/kWh	3,85	3,64
Total cost/kWh	USc/kWh	8,97	8,45
Transmission loss	%	2	2
Transmission cost	US$/kW	190	190
Transmission cost	Rs/kW	8 170	8 170
Annualised transmission cost	Rs/kWh	0,37	0,37
Annualised transmission cost	USc/kWh	0,87	0,87
Total cost (netback) @ Upper K.	Rs/kWh	3,41	3,20
Total cost (netback) @ Upper K.	USc/kWh	7,93	7,43

← **INDIAN THERMAL ALTERNATIVES**

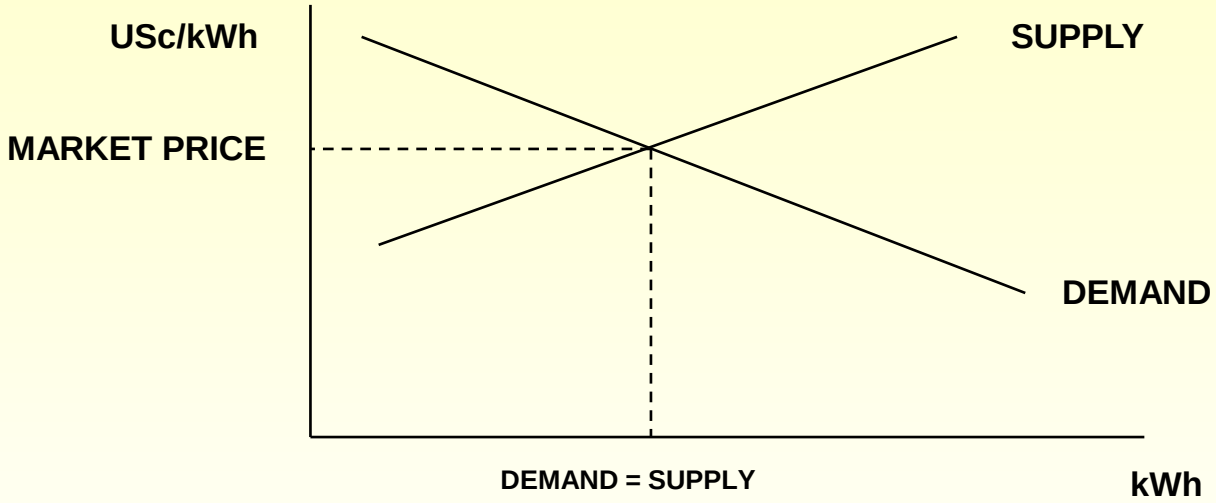
← **TOTAL UNIT COST OF THERMAL ALTERNATIVES**

← **TRANSMISSION COSTS**

← **NETBACK UNIT PRICE FACING HPP**

MARKET BASED PRICE

- IN A DEREGULATED MARKET WITH SEVERAL BUYERS AND SELLERS, THE PRICE OF ELECTRICITY WILL BE DETERMINED ON THE BASIS OF SUPPLY AND DEMAND
- NO PPA



- MARKET BASED PRICING
  - RISKY FROM INVESTOR'S POINT OF VIEW
  - DIFFICULT TO FINANCE ON A PROJECT FINANCE BASIS
  - FOUND MAINLY IN MATURE POWER SYSTEMS, E.G. TRADE BETWEEN SCANDINAVIAN COUNTRIES AND IN SOME LATIN AMERICAN COUNTRIES (BUT WITH SIGNIFICANT ELEMENTS OF PPAs)

COST ELEMENTS IN USER TARIFF SETTING

USES OF LEVELISED COST

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- **ENERGY COST**
- **CAPACITY COST**
- **THESE COSTS APPLY TO**
  - **POWER GENERATION**
  - **TRANSMISSION AND DISTRIBUTION (T&D)**
- **ENERGY AND CAPACITY COSTS MAY IN THE TARIFF BE EXPRESSED AS A SINGLE NPR/kWh FIGURE, CALCULATED IN TERMS OF LEVELISED COST**
- **OR AS COMBINATION OF A kWh FIGURE PLUS A FIXED MONTHLY CHARGE**

NEPAL: SELECTED UNIT ELECTRICITY COSTS, PRICES, TARIFFS

USES OF LEVELISED COST

- COMPARISON OF COST OF VARIOUS SOURCES OF SUPPLY
- OPTIMISATION OF A HYDROPOWER PLANT
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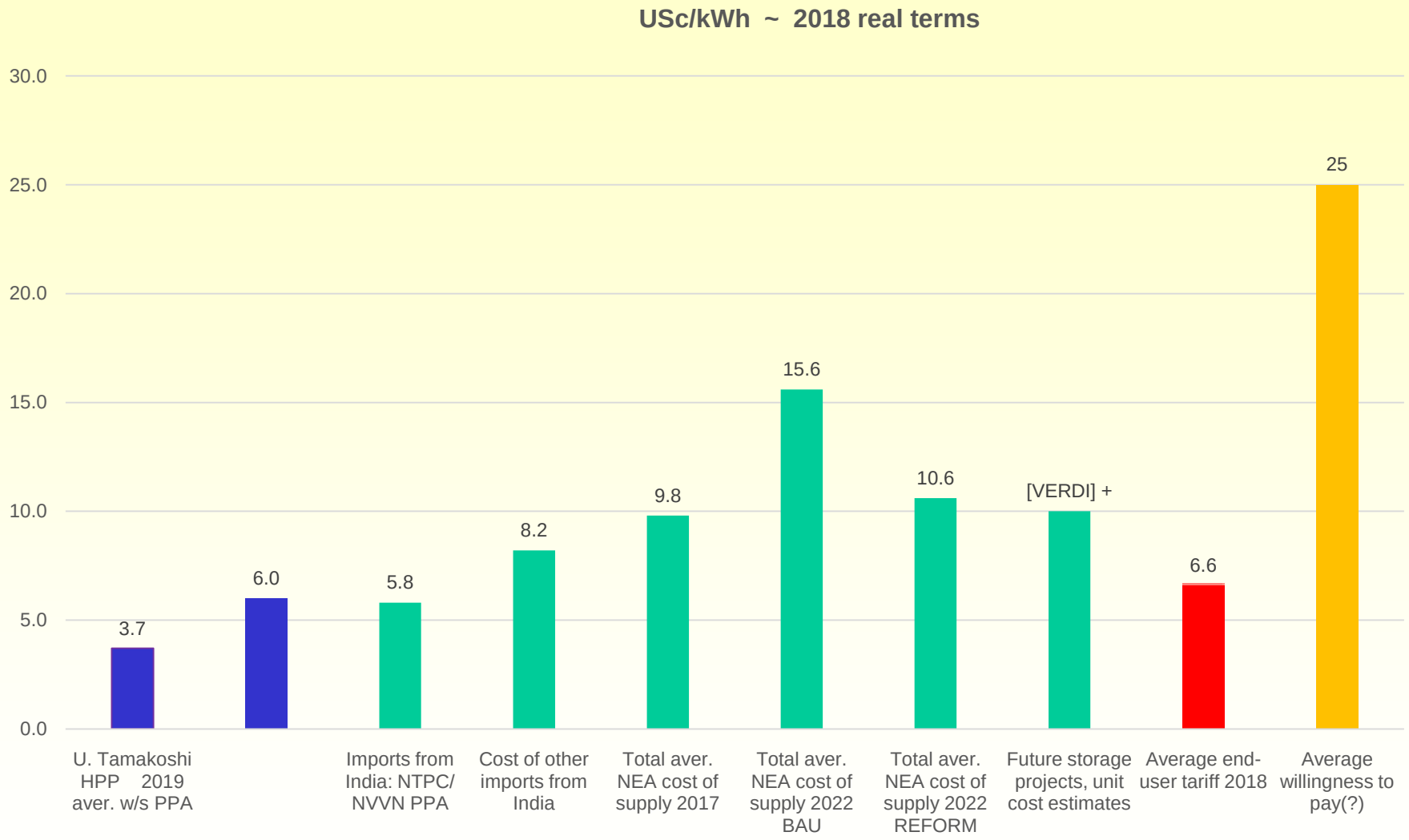

WILLING TO PAY BUT UNWILLING TO CHARGE
EVIDENCE FROM SOME OTHER COUNTRIES

- **UGANDA: SURVEY SHOWED THE FOLLOWING**
  - AVERAGE UGANDAN HOUSEHOLD SPENDS US$ 72/YEAR ON DRY CELL BATTERIES (USED IN 94% OF HOUSEHOLDS)
  - DRY CELL BATTERY COST WORKS OUT AT: US$ 400/KWh
  - CAR BATTERIES, USED BY 5% OF HOUSEHOLDS: US$ 3/KWh
  - SMALL DIESEL GENERATORS OWNED BUSINESSES AND WEALTHIER HOUSEHOLDS: USc 25/KWh
  - 5% OF HOUSEHOLDS SERVED BY GRID ELECTRICITY (1997)
  - HOUSEHOLD TARIFFS: USc 6-12/KWh
- **LAOS:**
  - SURVEY SHOWED PEOPLE WILL PAY UP TO 10% OF INCOME ON ENERGY SERVICES
- **NUMEROUS SURVEYS:**
  - PEOPLE ARE WILLING TO PAY MORE IF QUALITY AND RELIABILITY IMPROVE, BUT OBJECT TO PRICE INCREASES FOR POOR QUALITY
- **CONCLUSION: EVIDENCE OF WILLINGNESS TO PAY (CUSTOMERS)**

  - BUT UNWILLINGNESS TO CHARGE (POLITICIANS)