Hydropower Financing and Risk Management Nepal

ECONOMICS: SOME KEY CONCEPTS

KATHMANDU

NOVEMBER 2018

TRULS HOLTEDAHL

TOPICS MENU

1. **HYDROPOWER IN A CONTEXT**
2. **SOME ASPECTS OF FINANCIAL & ECONOMIC ANALYSES**
3. **SOME COST & PRICING CONCEPTS**
4. **ENVIRONMENTAL IMPACTS IN ECONOMIC ANALYSIS OF HPPs**
5. **FINANCIAL & ECONOMIC ANALYSES: PROCEDURES IN FEASIBILITY STUDIES**

"Economics is extremely useful as a form of employment for economists."

J.K. Galbraith
Canadian/American economist

TEN PRINCIPLES OF ECONOMICS
(from an introductory textbook in economics)

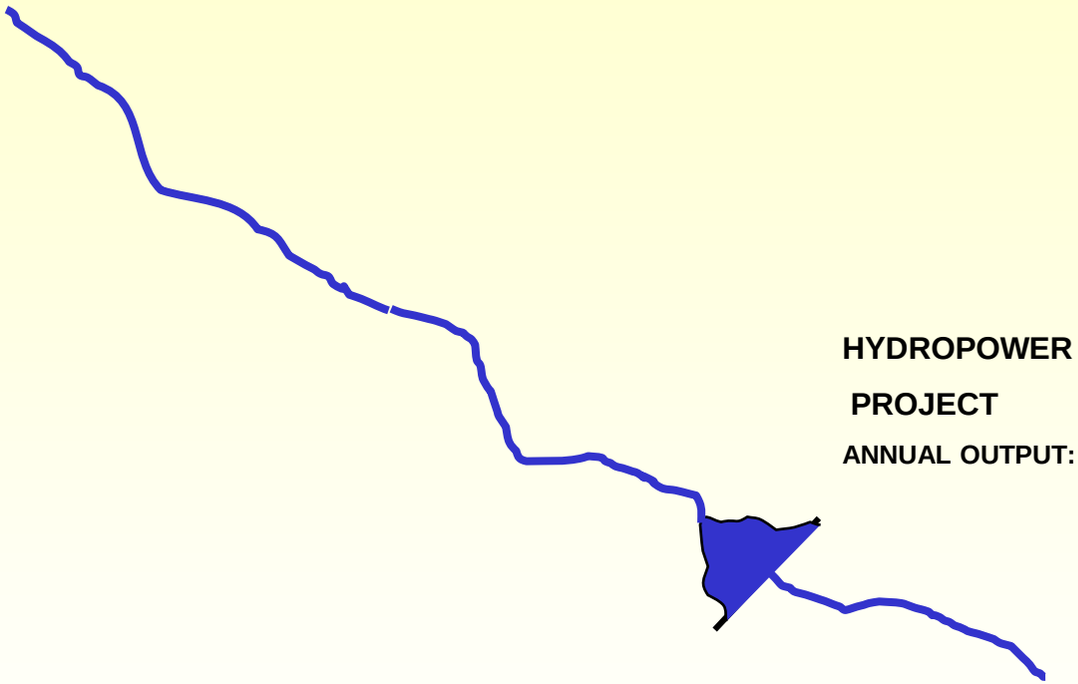
- **HOW PEOPLE MAKE DECISIONS**
- **HOW PEOPLE INTERACT**
- **HOW THE ECONOMY AS A WHOLE WORKS**

1. **PEOPLE FACE TRADE-OFFS**
2. **THE COST OF SOMETHING IS WHAT YOU GIVE UP TO GET IT**
3. **RATIONAL PEOPLE THINK AT THE MARGIN**
4. **PEOPLE RESPOND TO INCENTIVES**
5. **TRADE CAN MAKE EVERYBODY BETTER OFF**
6. **MARKETS ARE USUALLY A GOOD WAY TO ORGANISE ECONOMIC ACTIVITY**
7. **GOVERNMENTS CAN SOMETIMES IMPROVE MARKET OUTCOMES**
8. **A COUNTRY'S LIVING STANDARD DEPENDS ON ITS ABILITY TO PRODUCE GOODS AND SERVICES**
9. **PRICES RISE WHEN GOVERNMENT PRINTS TOO MUCH MONEY**
10. **SOCIETY FACES A SHORT-RUN TRADE-OFF BETWEEN INFLATION AND UNEMPLOYMENT**

TRADE-OFF AND OPPORTUNITY COST

- **TRADE-OFF:**
  - **OCCURS WHEN HAVING TO CHOOSE BETWEEN ALTERNATIVES**
  - **INVOLVES A SACRIFICE THAT MUST BE MADE IN ORDER TO OBTAIN SOMETHING ELSE**
- **IN ECONOMIC JARGON TRADE-OFF IS EXPRESSED IN TERMS OF OPPORTUNITY COST**
- **OPPORTUNITY COST:**
  - **THE COST OF SOMETHING IS WHAT YOU GIVE UP BY USING IT**
  - **= THE VALUE OF SOMETHING IN ITS BEST ALTERNATIVE USE**
- **EXAMPLE: IF ONE USES A RESOURCE - SAY, WATER - FOR ONE PURPOSE - SAY, IRRIGATION, ONE MAY HAVE TO GIVE UP THE VALUE OF USING THE WATER FOR ANOTHER PURPOSE - SAY, HYDROPOWER GENERATION**

OPPORTUNITY COST: ILLUSTRATION

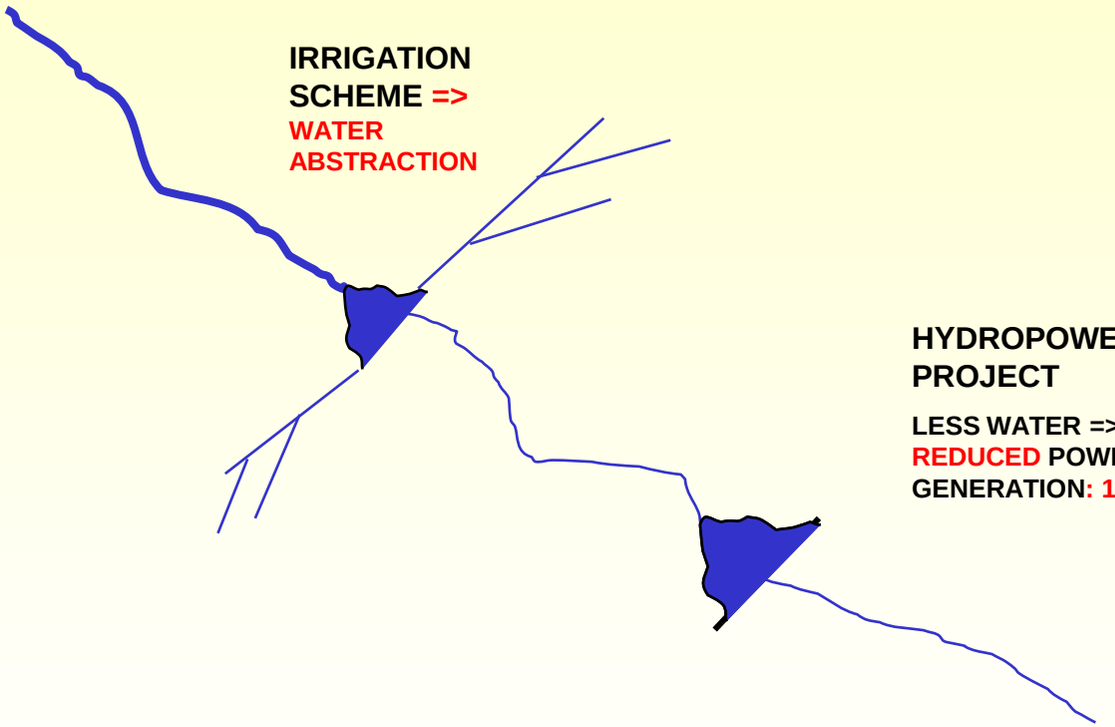


HYDROPOWER

PROJECT

ANNUAL OUTPUT: 2,400 MWh

OPPORTUNITY COST: ILLUSTRATION



IRRIGATION SCHEME => WATER ABSTRACTION

HYDROPOWER PROJECT

LESS WATER => REDUCED POWER GENERATION: 1,400 MWh

OPPORTUNITY COST = VALUE OF LOST 1,000 MWh

USE OF OPPORTUNITY COST: ILLUSTRATION

IRRIGATION SCHEME REDUCING QUANTITY OF WATER FOR A HPP

	1,000 USD
• LIFETIME BENEFIT OF IRRIGATION SCHEME	
• PV OF FUTURE *INCREMENTAL* CROP PRODUCTION	2,200
• LIFETIME COSTS OF IRRIGATION SCHEME	
• PV CAPEX OF IRRIGATION DAM + CANALS	1,100
• PV FUTURE O&M COSTS OF IRRIGATION SCHEME	300
• TOTAL DIRECT COSTS IRRIGATION	1,400
• LIFETIME DIRECT BENEFIT FROM IRRIGATION PROJECT	800
• LIFETIME VALUE OF LOST HP OUTPUT (1000 MWh/yr)	
= OPPORTUNITY COST	550
• NET LIFETIME BENEFIT OF IRRIGATION SCHEME	250

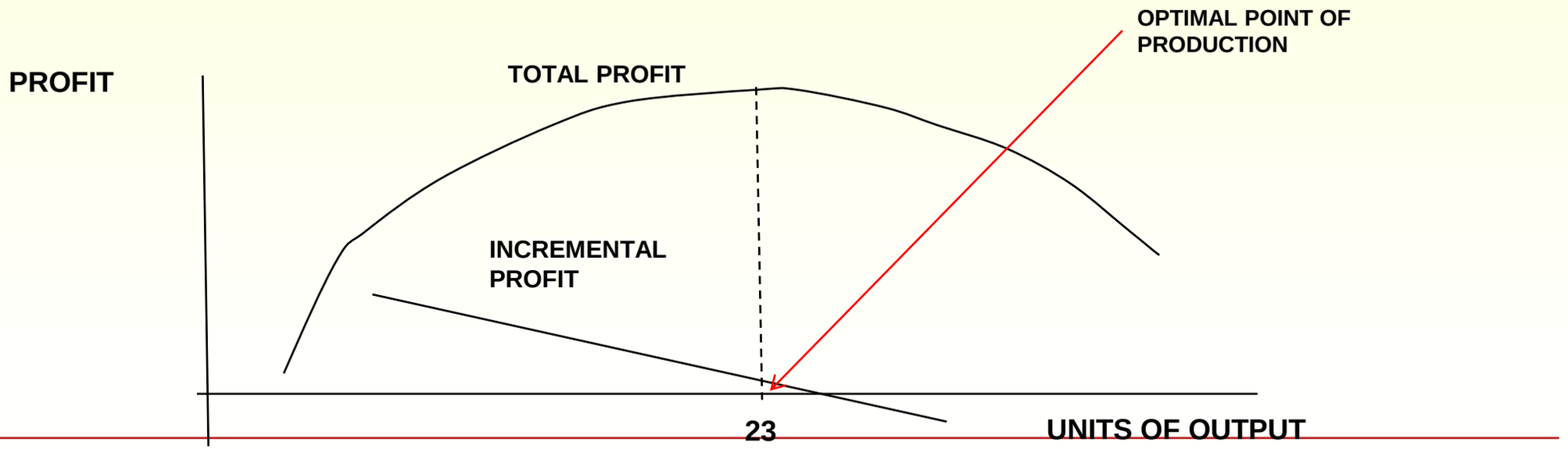
- FROM THE COUNTRY POINT OF VIEW, THE VALUE OF THE LOSS OF HP ENERGY OUTPUT IS A COST, AN OPPORTUNITY COST
- THIS APPLIES EVEN IF THE IRRIGATION PROJECT PRECEDES THE HPP: LOSS OF A FUTURE OPPORTUNITY

PEOPLE/FIRMS MAKE DECISIONS ”AT THE MARGIN”

UNIT OF OUTPUT 1 2 3 …….	20	21	22	23	24	25	26
SALES REVENUE PER UNIT	15	15	15	15	15	15	15
COSTS PER UNIT	11	12	13	14	15	16	17
PROFIT PER UNIT	4	3	2	1	0	-1	-2

OBSERVATION: PEOPLE TRY TO BALANCE OUT COSTS AND BENEFITS OF GOING ONE STEP FURTHER

- BY INCREASING INPUT BY ONE UNIT AT A TIME AND OBSERVING HOW PROFIT IS AFFECTED
- THIS IS KNOWN AS MARGINAL ANALYSIS
- THE OWNER THEREBY MAXIMISES PROFIT
- THIS LINE OF THINKING CAN BE APPLIED TO EVERYDAY LIFE, IF PEOPLE TRY TO MAXIMIZE THEIR WELL-BEING



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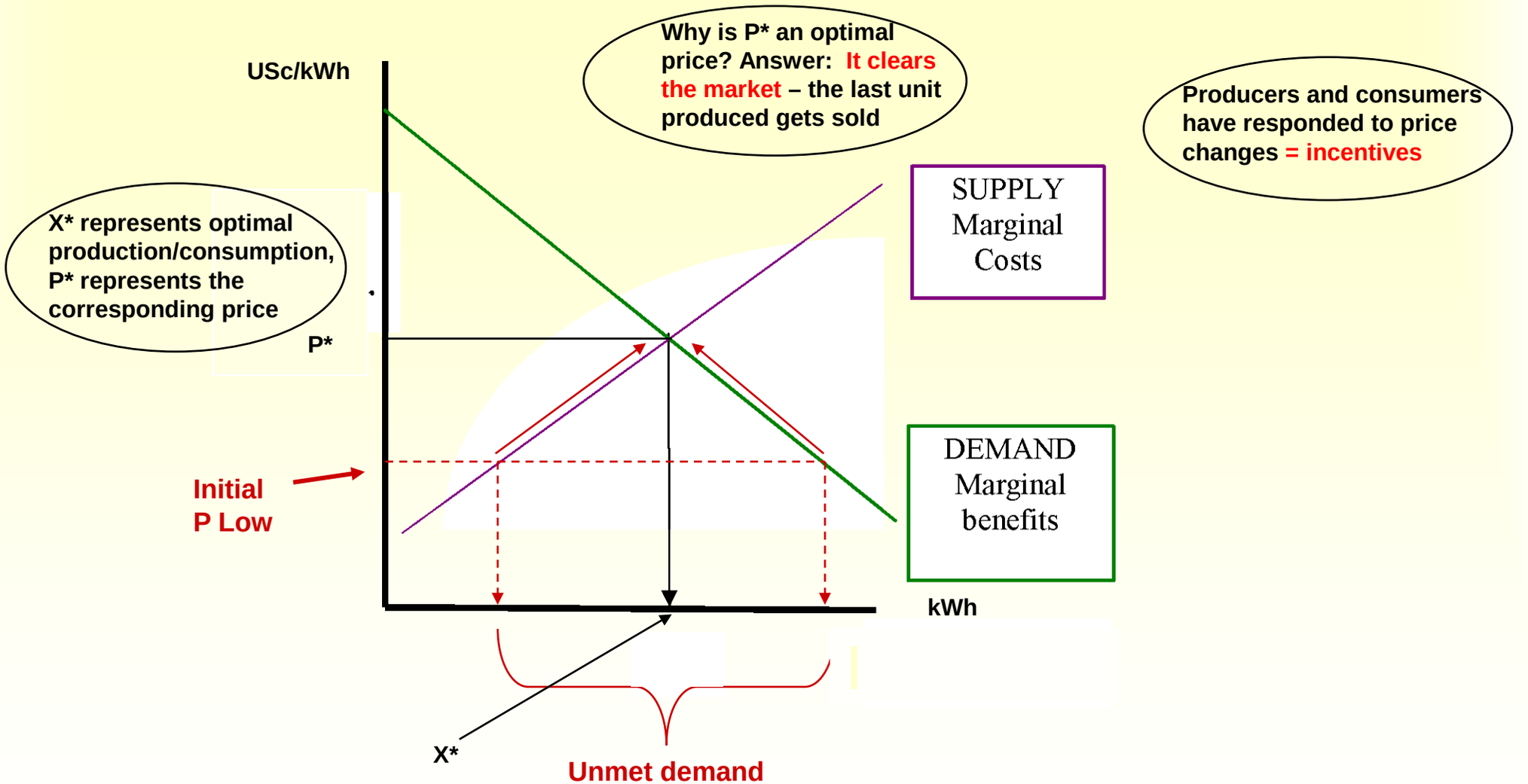
INCENTIVES: FIRMS/ PEOPLE RESPOND TO PRICES

CASE: INITIAL POWER SUPPLY IMBALANCE



SUMMARY OF SOME KEY ECONOMIC CONCEPTS

- **TRADE-OFF AND OPPORTUNITY COST**
- **MARGINAL ANALYSIS**
- **MARKETS AND INCENTIVES**

Hydropower Financing and Risk Management Nepal
HYDROPOWER IN A CONTEXT

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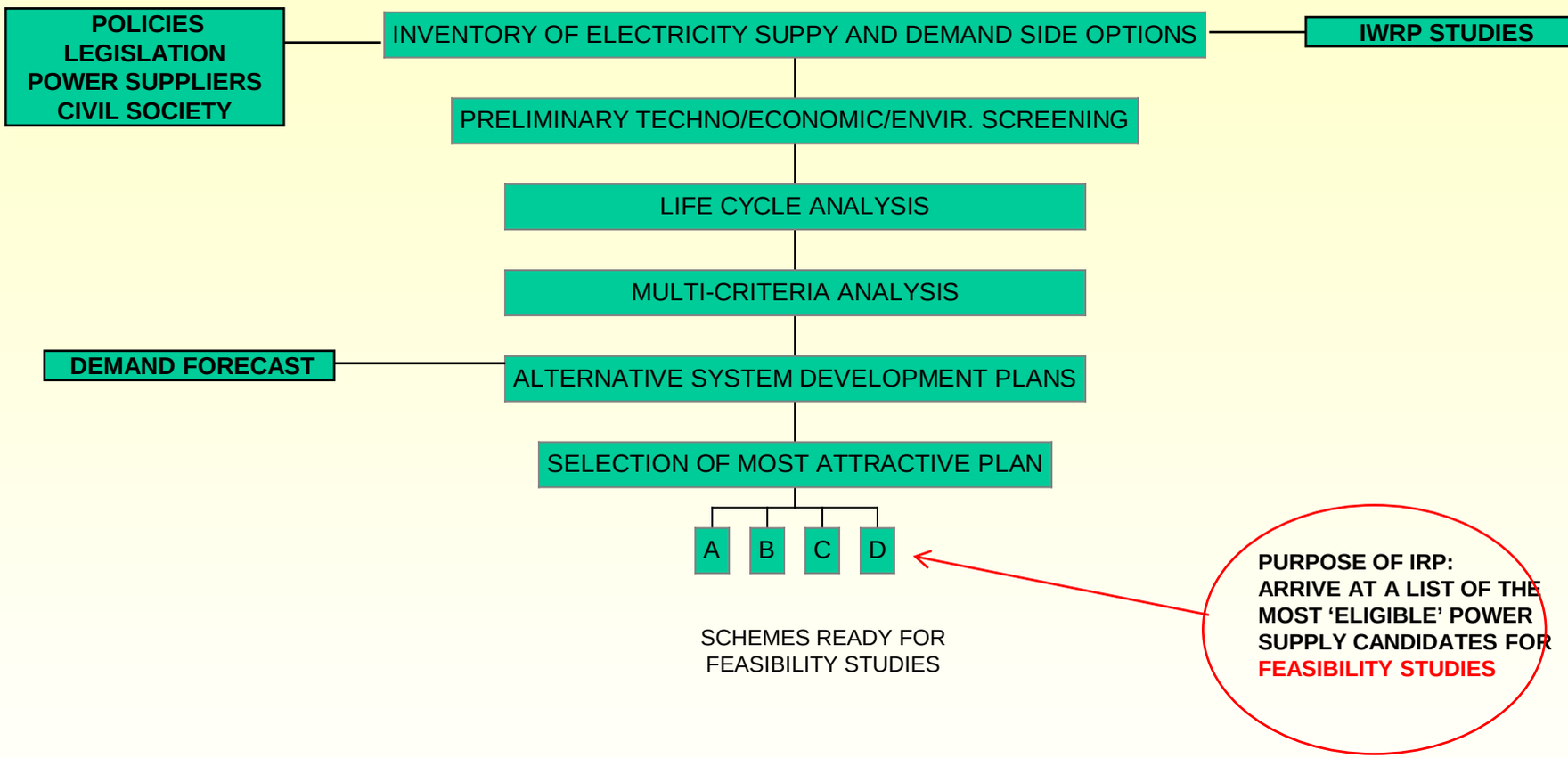
POWER SECTOR & INTEGRATED RESOURCE PLANNING (IRP)

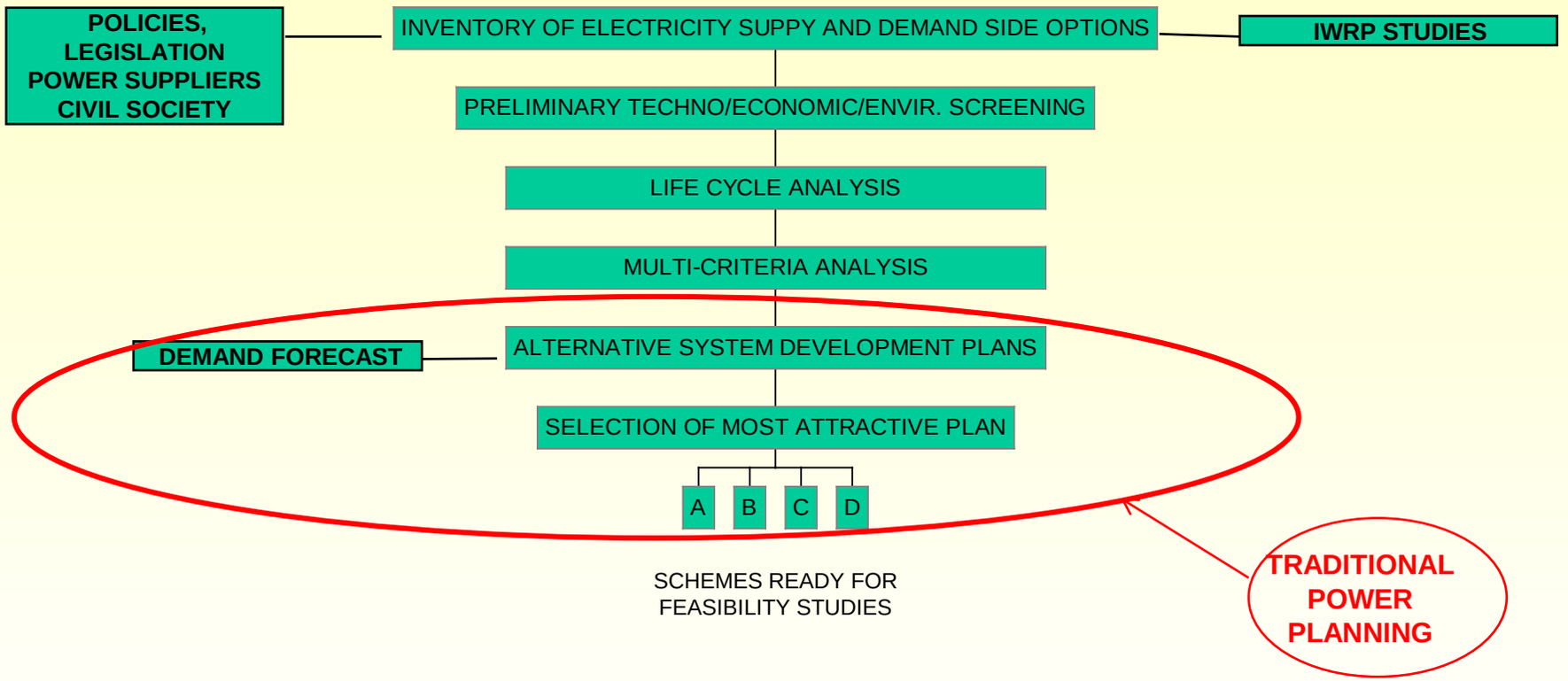
- **TRADITIONAL POWER PLANNING:**
  - **CAPACITY EXPANSION TO MEET PROJECTED DEMAND**
  - **ECONOMIC LEAST-COST SOLUTIONS THROUGH SYSTEM ANALYSIS**
  - **LIMITED / NO INTEGRATION WITH WATER RESOURCE PLANNING**
  - ***NARROW APPROACH***

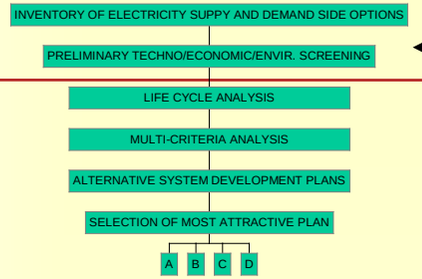
- **IRP AND POWER SECTOR PLANNING (WORLD COMMISSION ON DAMS - WCD):**
  - **FULL INCLUSION AND EQUAL TREATMENT OF ALL OPTIONS – SUPPLY & DEMAND**
  - **HYDROPOWER SEEN AS PART OF WATER RESOURCES PLANNING**
  - **EMPHASIS ON ENVIRONMENTAL AND SOCIAL IMPACTS, NOT ONLY TECHNICAL AND ECONOMIC ASPECTS**
  - **PARTICIPATORY APPROACH**
  - **VALUE OF WATER RECOGNISED**
  - ***BROAD APPROACH***

INTEGRATED RESOURCE PLANNING FOR POWER
(AS PROPOSED BY THE WORLD COMMISSION OF DAMS)



STEPS IN IRP FOR POWER





INVENTORY OF OPTIONS

IWRP STUDIES

- **NEW GENERATION**
  - **HYDROPOWER**
  - **THERMAL POWER**
  - **OTHER RENEWABLE OPTIONS (WIND, SOLAR)**
- **REHABILITATION OF EXISTING GENERATING FACILITIES**
- **DEMAND SIDE MANAGEMENT**
  - **PRICING POLICY**
  - **PROMOTION OF ENERGY SAVING TECHNOLOGIES**
  - **EDUCATION AND CAMPAIGNS**

GVT. POLICIES
LEGISLATION
POWER SUPPLIERS
CIVIL SOCIETY

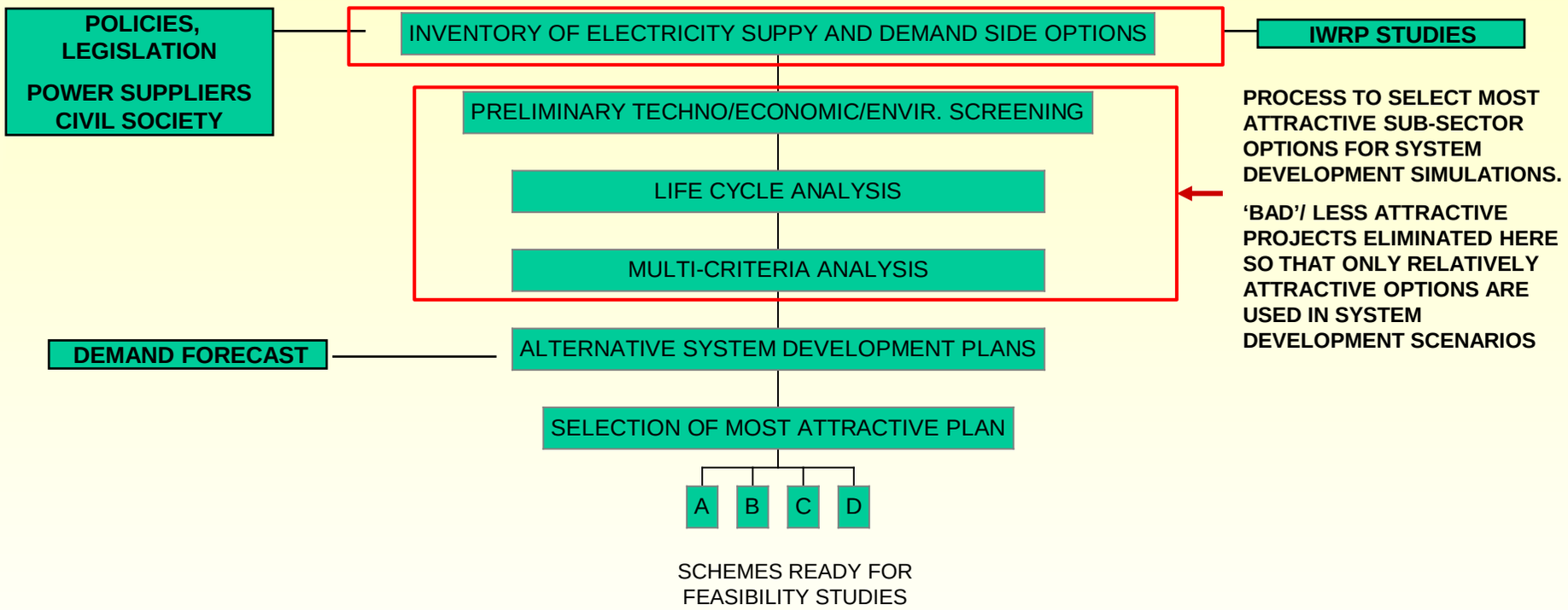
IWRP AND POWER

- IWRP ADOPTS THE RIVER BASIN OR CATCHMENT AREA AS THE BASIC PLANNING UNIT
- ALL COMPETING USES OF WATER TO BE CONSIDERED
- HYDROPOWER IS ONE OF SEVERAL, COMPETING USERS OF WATER
- HYDROPOWER IS SUBORDINATE TO OVERALL WATER RESOURCE PLANNING
- HYDROPOWER OPTIONS ARE IDENTIFIED FOR INCLUSION IN A POWER SECTOR PLANNING PROCESS

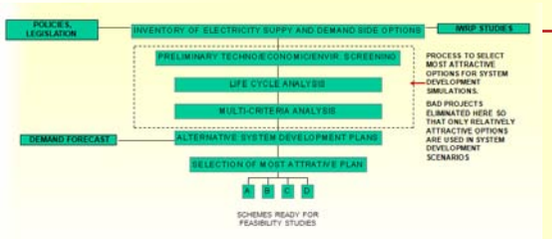
INTEGRATED WATER RESOURCE PLANNING
ILLUSTRATIONS FROM BHUTAN AND NEPAL

- **NEPAL HYDROPOWER DEVELOPMENT POLICY, 2001**
  - ***MAKE THE RIVER BASINS .... ..THE BASIS OF DEVELOPMENT AND MANAGEMENT OF WATER RESOURCES IN ORDER TO ACHIEVE MAXIMUM BENEFITS FROM THE UTILIZATION OF WATER RESOURCES OF NEPAL***
  - ***ADOPT A BROADER PERSPECTIVE ON NATONAL DEVELOPMENT IN THE CONTEXT OF MACRO-ECONOMY IN DEVELOPING AND MANAGING HYDROPOWER IN LINE WITH THE CONCEPT OF DEVELOPING WATER RESOURCES IN AN INTEGRATED MANNER***
- **BHUTAN HYDROPOWER POLICY, 2008**
  - ***MOA PLAYS AN IMPORTANT ROLE IN ENSURING SUSTAINABLE WATERSHED MANAGEMENT THROUGH CATCHMENT PROTECTION AND OTHER NATURE CONSERVATION WORKS IN ORDER TO SUPPORT THE AVAILABILITY OF WATER FOR HYDROPOWER GENERATION***
  - ***MOA IN COLLABORATION WITH MOEA SHALL WORK OUT THE MODALITIES FOR INTEGRATED SUSTAINABLE WATER RESOURCES MANAGEMENT***

INTEGRATED RESOURCE PLANNING FOR POWER

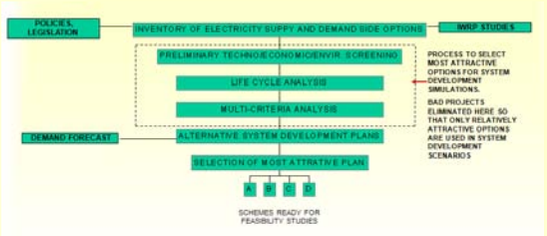


PRELIMINARY (ROUGH) SCREENING



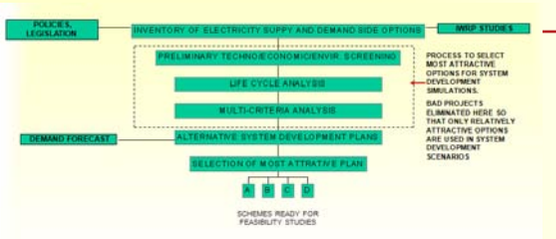
- **CONSIDERS MAIN FEATURES OF PROJECT ALTERNATIVES**
  - **TECHNICAL**
  - **ENVIRONMENT/SOCIAL**
  - **ECONOMIC**
- **A ROUGH ANALYSIS WITHOUT IN-DEPTH INFORMATION/DATA**
- **SEEKS TO ELIMINATE OBVIOUS UNDESIRABLE PROJECTS**

LIFE CYCLE ANALYSIS (LCA)



- **A TECHNIQUE TO ASSESS ENVIRONMENTAL IMPACTS ASSOCIATED WITH ALL THE STAGES OF AN ENERGY OPTION'S LIFE "FROM-CRADLE-TO-GRAVE"**
  - **FROM RAW MATERIAL EXTRACTION THROUGH MATERIALS PROCESSING, MANUFACTURE, DISTRIBUTION, USE, REPAIR AND MAINTENANCE, AND DECOMMISSIONING**
- **COMPREHENSIVELY COMPARES ENERGY AND MATERIAL FLOWS AND ENVIRONMENTAL RELEASES OF ALTERNATIVE ENERGY SUPPLY OPTION**
- **OPTIONS WHICH ARE CLEARLY INFERIOR WILL BE DISCARDED**
- **LCA NOT COMMONLY CARRIED OUT IN IRPs**

MULTI-CRITERIA ANALYSIS

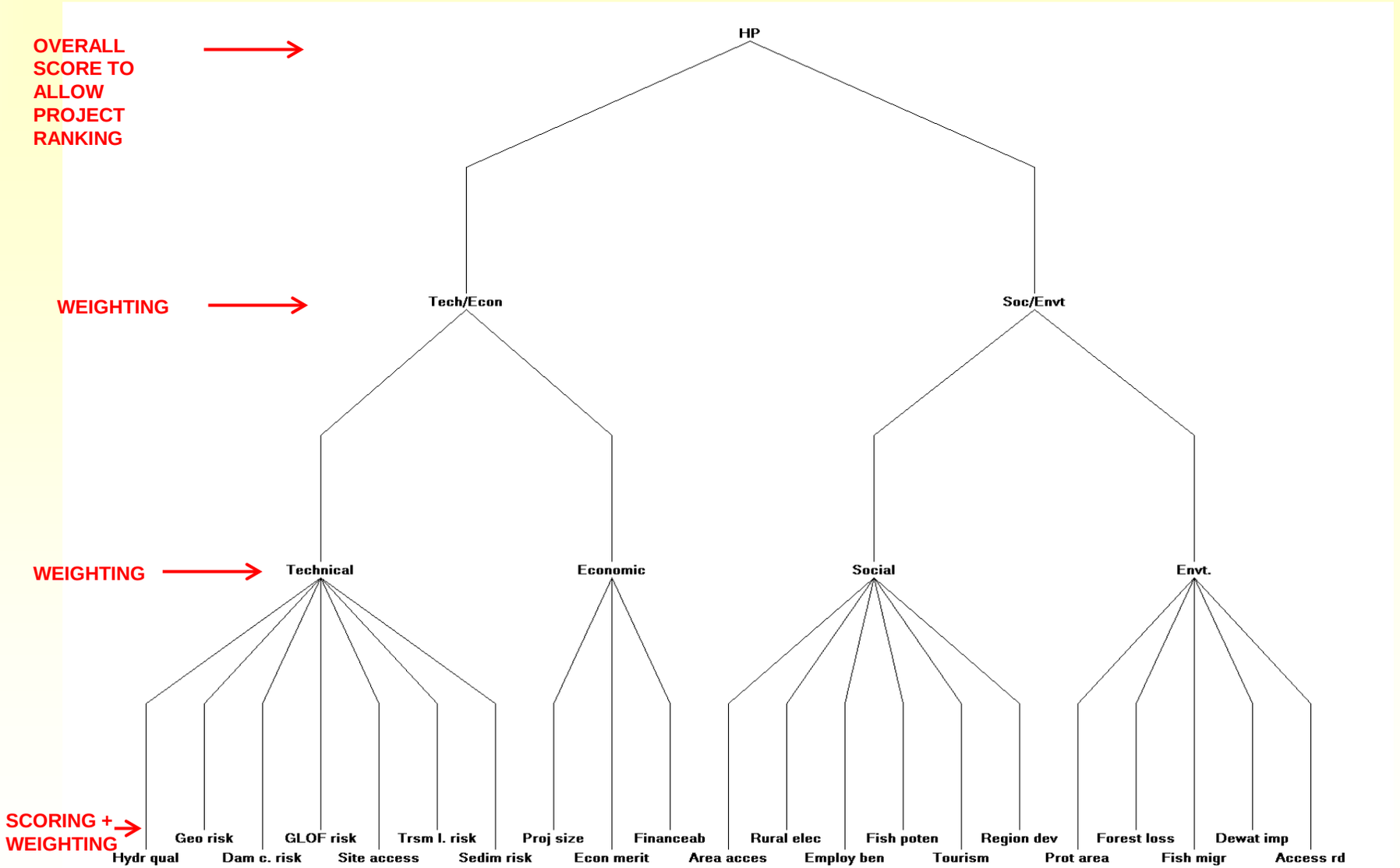


- **MCA IS A TECHNIQUE THAT**
  - **ALLOWS COMPARISON OF DIFFERENT PROJECTS OF A CERTAIN TYPE (E.G. HYDROPOWER)**
  - **ACCOUNTS FOR THE HIGHLY VARYING IMPACTS OF THESE PROJECTS**
  - **MAY BE USED FOR COMPARISON OF DIFFERENT SITES OR DESIGN OF A SINGLE PROJECT**
- **IMPACTS OFTEN EXPRESSED IN VERY DIFFERENT SETS OF UNITS**
  - **COSTS: USc/kWh**
  - **RISKS OF VARYING TYPES**
  - **HA OF LAND INUNDATED/NUMBER OF PEOPLE TO BE RESETTLED**
  - **BIOLOGICAL IMPACTS**
  - **OPPORTUNITY FOR RURAL ELECTRIFICATION, ETC.**

DIFFERENT TYPES OF IMPACT REPRESENT A CHALLENGE WITH RESPECT TO COMPARISON AND IMPORTANCE

- **THE IMPACTS ARE**
  - **EXPRESSED IN TERMS OF SCORES (WHICH ARE NORMALIZED)**
  - **GIVEN WEIGHTS (DEGREE OF IMPORTANCE)**
  - **TRANSFORMED INTO A COMMON YARDSTICK TO ALLOW RANKING OF OPTIONS**
- **THE RANKED OPTIONS: A BASIS FOR NEXT STEP: FEASIBILITY STUDIES**

MCA ILLUSTRATION: IMPACTS AND CRITERIA OVERVIEW



MCA: SCORING AND WEIGHTING OF IMPACTS

IMPACTS →

PROJECTS →

BHUTAN WRMP & PSMP

Input Values

Criteria:	Technical							Economic			Social						Environmental				
Sub-criteria:	Hydrologi-cal Quality	Geological Risk	Dam Cost Risk	GLOF Risk	Site Acces-sibility	Transmis-sion Line Risk	Reservoir Sedimenta-tion	Size of Project	Economic Merit	Finance-ability	Improved Access	Rural Electrifi-cation	Employ-ment Benefits	Fishery Potential	Tourism	Balanced Regional Developm.	Intrusion Protected Areas	Loss of Primary Forest	Dewatering Impacts	Access Road Erosion	Fish Migration
Unit	Index (0=best, 100=worst)	Tunnel excav. vol. (m3 x aver. support %)	Concrete volume (m3^0.5)	Index (0=best, 100=worst)	Distance to border (km)	Distance to Siliguri (km)	Index (0=best, 1=worst)	Mean annual energy (GWh/ year)	Unit energy cost (USc/kWh)	Investment cost (MUSD)	Index (100=best, 0=worst)	Index (100=best, 0=worst)	Index (100=best, 0=worst)	Index (100=best, 0=worst)	Index (100=best, 0=worst)	Index (100=best, 0=worst)	Index (0=best, 100=worst)	Total land lost (ha)	Mitigated inflow (higher % = better)	Total road length (km)	Index (0=best, 100=worst)
Project ID																					
11.030	80	1 077 909	412	30	24	99	0,3	2 210	7,26	507	100	100	100	0	10	95	0	45,7	24,7	47,9	60
12.082	20	77 573	1871	10	39	159	1,0	893	11,43	475	20	10	10	50	10	50	0	316,6	100,0	2,2	0
13.120	30	1 535 771	608	70	76	296	0,2	4 770	6,31	900	0	10	10	0	10	65	0	104,1	27,8	0,0	0
13.230B	30	3 065 635	474	65	61	281	0,3	4 667	6,95	968	0	10	10	0	10	65	0	94,8	31,3	0,0	25
14.010	90	131 714	265	0	84	339	0,1	1 642	8,81	275	5	10	10	0	10	85	100	101,8	24,1	9,2	0
14.020	40	775 720	361	70	79	334	0,2	2 909	7,44	631	5	10	10	0	10	85	70	101,8	58,3	13,8	0
15.110	60	914 557	290	10	72	327	0,2	3 207	6,87	617	100	100	70	0	0	100	70	134,3	32,4	73,8	40
15.150B	60	692 452	214	15	92	347	0,1	2 714	8,03	550	100	100	70	0	0	100	70	154,1	28,6	82,3	10
16.010	80	205 948	130	5	144	504	0,1	1 507	8,90	371	80	10	10	0	0	90	30	136,6	78,6	16,5	0
16.030	80	725 931	346	70	110	470	0,3	1 883	8,94	486	0	10	10	0	0	75	30	61,9	28,0	0,0	25
17.150B	80	742 784	235	30	80	440	0,2	2 207	7,20	464	0	10	10	0	0	90	0	75,3	21,6	1,0	0

SCORE EVERY IMPACT

BHUTAN WRMP & PSMP

	Input Values	Normalised Score
Criteria:	Technical	
Sub-criteria:	Hydrological Quality	Hydrological Quality
Unit	Index (0=best, 100=worst)	Normalised score (100 = best, 0 = worst)
Project ID		
11.030	80	14
12.082	20	100
13.120	30	86
13.230B	30	86
14.010	90	0
14.020	40	71
15.110	60	43
15.150B	60	43
16.010	80	14
16.030	80	14
17.150B	80	14

NORMALISE EACH SCORE

WEIGHT EACH IMPACT

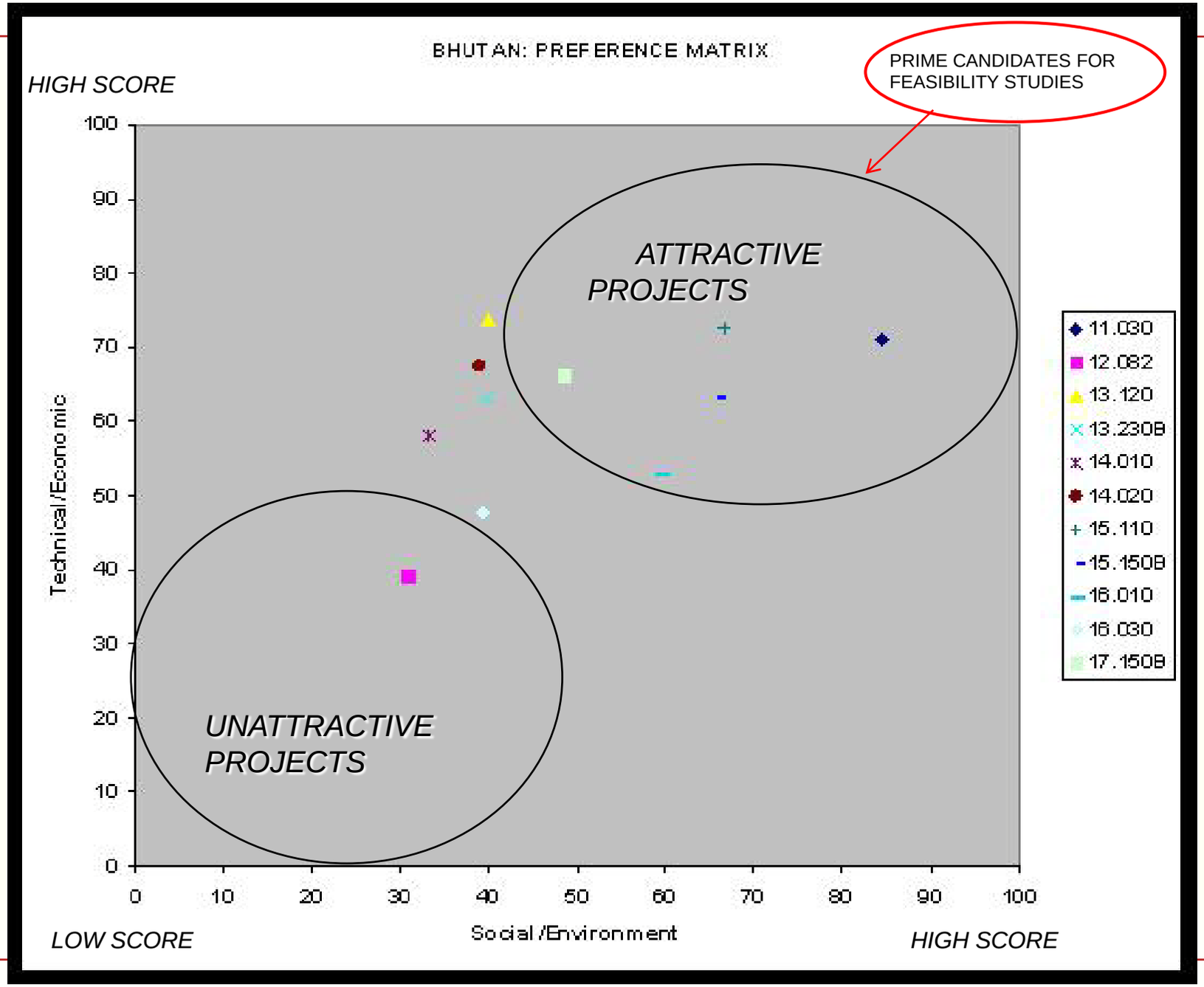
BHUTAN WRMP & PSMP: CONSULTANT'S ADDITIONAL MCA

Criteria and Weights

Criteria	Sub-criteria	Weights 1)	Weights	Weights
Social	Improved access	22 %		
	Rural electrification	17 %		
	Employment benefits	10 %		
	Fishery potential	3 %		
	Tourism	8 %		
	Balanced regional development	40 %		
	Sub-total	100 %	50 %	
Environmental	Intrusion into protected areas	35 %		
	Loss of primary forest	40 %		
	Dewatering impacts	10 %		
	Access road erosion	10 %		
	Fish migration	5 %		
	Sub-total	100 %	50 %	
Total Social and Environmental			100 %	30 %
Technical	Hydrological quality	22 %		
	Geological risk	25 %		
	Dam cost risk	15 %		
	GLOF risk	6 %		
	Site accessibility	10 %		
	Transmission line risk	18 %		
	Reservoir sedimentation	4 %		
	Sub-total	100 %	40 %	
Economic	Size of project	0 %		
	Economic merit	80 %		
	Financeability	20 %		
	Sub-total	100 %	60 %	
Total Technical and Economic			100 %	70 %
Total Overall				100 %

1) Weights to add up to 100% for all the sub-criteria within a (main) criterion

- **FOR EACH PROJECT**
  - **COMBINE THE NORMALISED SCORE AND WEIGHT FOR EVERY IMPACT**
  - **ADD ALL WEIGHTED NORMALISED SCORES TO DERIVE AN OVERALL PROJECT SCORE**


BHUTAN: PREFERENCE MATRIX
PRIME CANDIDATES FOR FEASIBILITY STUDIES
HIGH SCORE
ATTRACTIVE PROJECTS
UNATTRACTIVE PROJECTS
Technical/Economic
Social/Environment
LOW SCORE
HIGH SCORE
0
10
20
30
40
50
60
70
80
90
100
11.030
12.082
13.120
13.230B
14.010
14.020
15.110
15.150B
16.010
16.030
17.150B

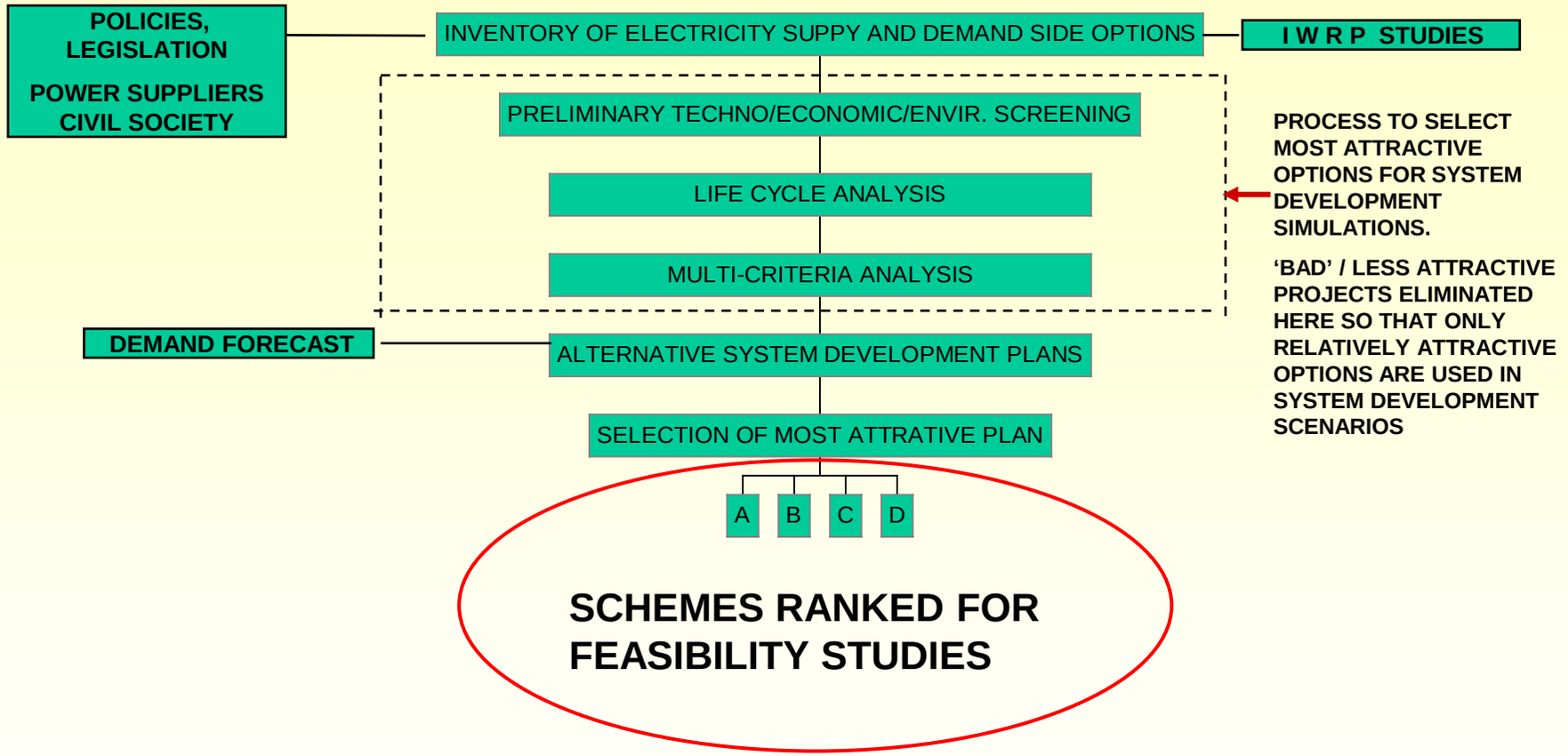
MCA: OVERALL SCORE AND RANKING

BHUTAN WRMP & PSMP

Ranked Order of Preference

Criteria:	Tech./Econ	Soc/Envt	Overall	Ranking as per MCA	Ranking as per FPCE
Weights	70 %	30 %	100 %		
Project ID					
13.120	52	15	**66**	1	1
11.030	40	25	**65**	2	5
15.110	44	18	**62**	3	2
13.230B	40	15	**55**	4	3
17.150B	36	18	**54**	5	4
15.150B	35	18	**53**	6	7
14.020	38	14	**52**	7	6
16.010	29	19	**49**	8	9
14.010	34	12	**46**	9	8
16.030	25	14	**40**	10	10
12.082	27	10	**38**	11	11

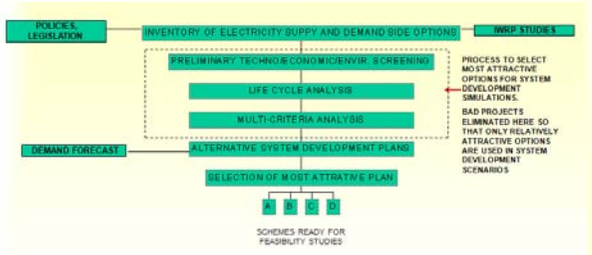
STEPS IN IRP FOR POWER



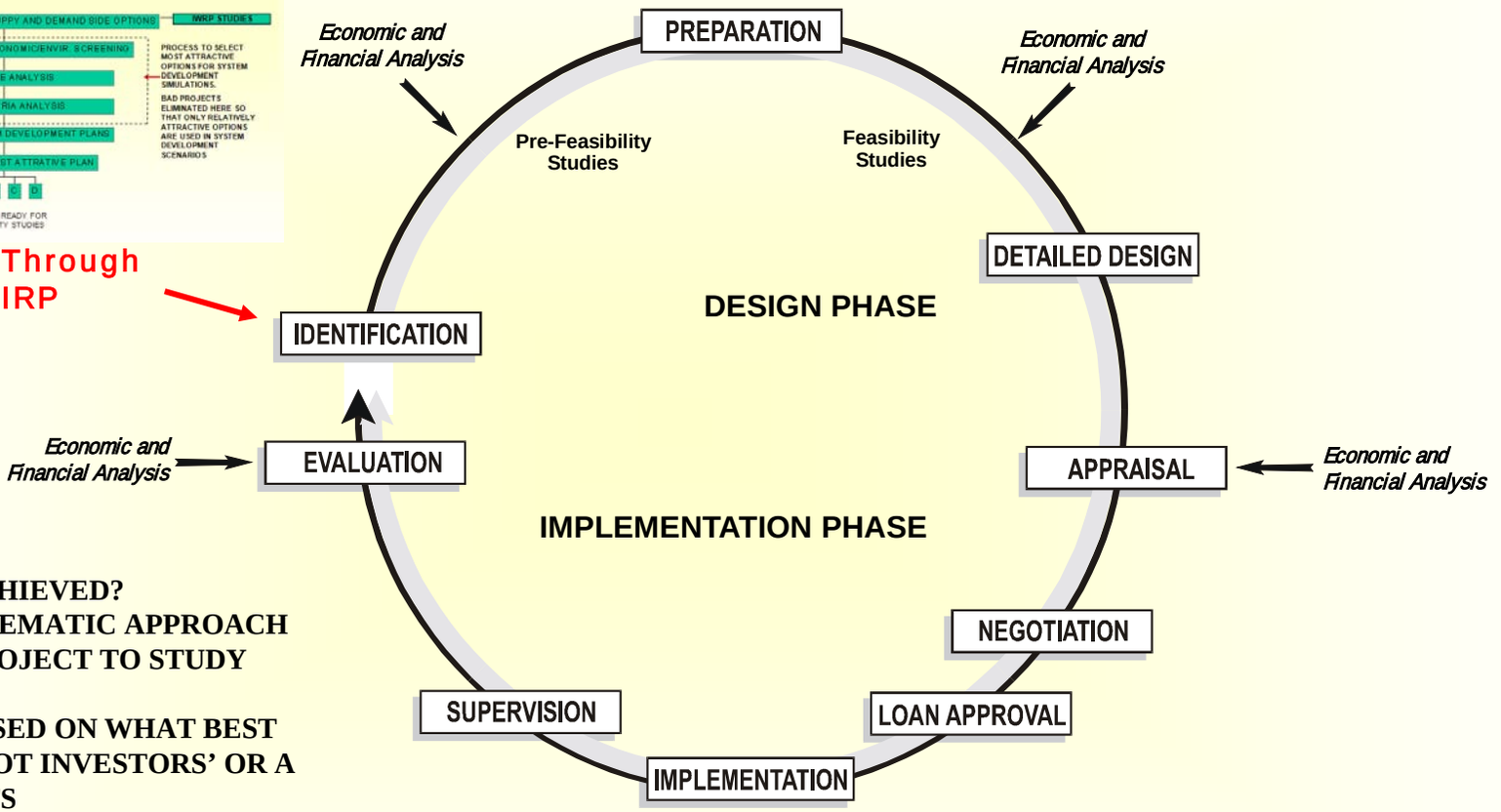
PRESENT APPLICATION OF IRP IN POWER SECTOR

- COMPLETE IRPs ARE TIME CONSUMING AND COSTLY
- LIMITED NUMBER OF EXAMPLES OF FULL IRP EXERCISE IMPLEMENTED
- MORE COMMONLY, SOME PARTS OF IRP CARRIED OUT
- COUNTRIES WHERE PART OF PLANNING PROCESS CARRIED OUT: NEPAL, LAOS, VIETNAM, NORWAY, BHUTAN, OTHERS?
  - NORWAY 1984-92
    - "SAMLET PLAN FOR VASSDRAG"
  - NEPAL 1997-98
    - PRELIMINARY SCREENING
    - MULTI-CRITERIA ANALYSIS OF MEDIUM SIZED HYDROPOWER PROJECTS
    - EXPANSION PLAN FOR MEDIUM SIZED HPP
  - BHUTAN 2002/03:
    - WATER RESOURCE MANAGEMENT PLAN
    - PRELIMINARY SCREENING
    - MULTI-CRITERIA ANALYSIS
    - POWER EXPORT MASTER PLAN
    - A LIST OF CANDIDATE PROJECTS READY FOR FEASIBILITY STUDY

THE PROJECT CYCLE



Through IRP



IRP WITH MCA: WHAT IS ACHIEVED?

- **A STRUCTURED AND SYSTEMATIC APPROACH FOR DECIDING WHICH PROJECT TO STUDY AND IN WHICH ORDER**
- **THE PRIORITY LIST IS BASED ON WHAT BEST SERVES THE COUNTRY, NOT INVESTORS' OR A MINISTER'S PET PROJECTS**

WORLD BANK REPORT, AUGUST 2018
NEPAL: FIRST PROGRAMMATIC ENERGY SECTOR DEVELOPMENT POLICY CREDIT

"Investment decisions in the sector are not sufficiently informed by a formal planning process

- *Investments in the sector are guided by the periodic plans of the National Planning Commission, which lay out the three-year targets for various sectors including the power sector.*
- *Investments to meet these targets are **selected on a project-by-project basis** without adequate consideration of technical and economic merits of the projects and without sufficient coordination with other investment decisions.*
- *The use of formal sector plans (covering, load demand, generation, transmission, and distribution) and river basin plans to inform the priority order of investments is absent.*
- *There is no coordination between access efforts through grid extension and off-grid renewable energy technologies.*
- *There is a need to strengthen the hydropower licensing process **by moving from a developer-driven approach** to an open, transparent, and efficient licensing process **based on basin-wide hydropower development planning**."*