Hydropower Financing and Risk Management Nepal

ECONOMICS: SOME KEY CONCEPTS

KATHMANDU
NOVEMBER 2018

TRULS HOLTEDAHL
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
  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

• HOW PEOPLE INTERACT

• HOW THE ECONOMY AS A WHOLE WORKS
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

- 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"

<table>
<thead>
<tr>
<th>UNIT OF OUTPUT</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>......</th>
<th>20</th>
<th>21</th>
<th>22</th>
<th>23</th>
<th>24</th>
<th>25</th>
<th>26</th>
</tr>
</thead>
<tbody>
<tr>
<td>SALES REVENUE PER UNIT</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>COSTS PER UNIT</td>
<td>11</td>
<td>12</td>
<td>13</td>
<td>14</td>
<td>15</td>
<td>16</td>
<td>17</td>
<td>17</td>
<td>17</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>PROFIT PER UNIT</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>-1</td>
<td>-2</td>
<td>-2</td>
<td>-2</td>
<td>-2</td>
<td>-2</td>
</tr>
</tbody>
</table>

**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

![Graph showing Profit, Total Profit, Incremental Profit, and the Optimal Point of Production](image)

**OPTIMAL POINT OF PRODUCTION**
TEN PRINCIPLES OF ECONOMICS
(from an introductory textbook in economics)

• HOW PEOPLE MAKE DECISIONS
  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

• HOW PEOPLE INTERACT
  7. GOVERNMENTS CAN SOMETIMES IMPROVE MARKET OUTCOMES
  8. A COUNTRY’S LIVING STANDARD DEPENDS ON ITS ABILITY TO PRODUCE GOODS AND SERVICES

• HOW THE ECONOMY AS A WHOLE WORKS
  9. PRICES RISE WHEN GOVERNMENT PRINTS TOO MUCH MONEY
  10. SOCIETY FACES A SHORT-RUN TRADE-OFF BETWEEN INFLATION AND UNEMPLOYMENT
INCENTIVES: FIRMS/ PEOPLE RESPOND TO PRICES

CASE: INITIAL POWER SUPPLY IMBALANCE

$X^*$ represents optimal production/consumption, $P^*$ represents the corresponding price

Why is $P^*$ an optimal price? Answer: It clears the market – the last unit produced gets sold

Producers and consumers have responded to price changes = incentives

Initial P Low

Unmet demand

SUPPLY Marginal Costs

DEMAND Marginal benefits
SUMMARY OF SOME KEY ECONOMIC CONCEPTS

• TRADE-OFF AND OPPORTUNITY COST
• MARGINAL ANALYSIS
• MARKETS AND INCENTIVES
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)

PURPOSE OF IRP:
ARRIVE AT A LIST OF THE MOST ‘ELIGIBLE’ POWER SUPPLY CANDIDATES FOR FEASIBILITY STUDIES

POLICIES
LEGISLATION
POWER SUPPLIERS
CIVIL SOCIETY

INVENTORY OF ELECTRICITY SUPPLY AND DEMAND SIDE OPTIONS
PRELIMINARY TECHNO/ECONOMIC/ENVIR. SCREENING
LIFE CYCLE ANALYSIS
MULTI-CRITERIA ANALYSIS

ALTERNATIVE SYSTEM DEVELOPMENT PLANS

SELECTION OF MOST ATTRACTIVE PLAN

SCHEMES READY FOR FEASIBILITY STUDIES
STEPS IN IRP FOR POWER

1. POLICIES, LEGISLATION, POWER SUPPLIERS, CIVIL SOCIETY
2. INVENTORY OF ELECTRICITY SUPPLY AND DEMAND SIDE OPTIONS
3. PRELIMINARY TECHNO/ECONOMIC/ENVIR. SCREENING
4. LIFE CYCLE ANALYSIS
5. MULTI-CRITERIA ANALYSIS
6. ALTERNATIVE SYSTEM DEVELOPMENT PLANS
7. SELECTION OF MOST ATTRACTIVE PLAN
8. SCHEMES READY FOR FEASIBILITY STUDIES
9. TRADITIONAL POWER PLANNING
INVENTORY OF OPTIONS

- 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
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 NATIONAL 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

- Policies, Legislation
- Power Suppliers
- Civil Society

Inventory of Electricity Supply and Demand Side Options

- Preliminary Techno/Economic/Envir. Screening
- Life Cycle Analysis
- Multi-Criteria Analysis

Alternative System Development Plans

Selection of Most Attractive Plan

A: B: C: D:

Schemes Ready for Feasibility Studies

IWRP Studies

Process to select most attractive sub-sector options for system development simulations. ‘Bad’/ Less attractive projects eliminated here so that only relatively attractive options are used in system development scenarios.
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.

- 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: SCORING AND WEIGHTING OF IMPACTS**

**IMPACTS**

**PROJECTS**

**SCORE EVERY IMPACT**

**NORMALISE EACH SCORE**

**WEIGHT EACH IMPACT**

**FOR EACH PROJECT**

- **COMBINE** the normalised score and weight for every impact
- **ADD** all weighted normalised scores to derive an overall project score
UNATTRACTIVE PROJECTS

ATTRACTIVE PROJECTS

PRIME CANDIDATES FOR FEASIBILITY STUDIES
## BHUTAN WRMP & PSMP

### Ranked Order of Preference

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

POLICIES, LEGISLATION
POWER SUPPLIERS
CIVIL SOCIETY

INVENTORY OF ELECTRICITY SUPPLY AND DEMAND SIDE OPTIONS

PRELIMINARY TECHNO/ECONOMIC/ENVIR. SCREENING

LIFE CYCLE ANALYSIS

MULTI-CRITERIA ANALYSIS

ALTERNATIVE SYSTEM DEVELOPMENT PLANS

SELECTION OF MOST ATTRACTIVE PLAN

A B C D

SCHEMES RANKED FOR FEASIBILITY STUDIES

I W R P STUDIES

PROCESS TO SELECT MOST ATTRACTIVE OPTIONS FOR SYSTEM DEVELOPMENT SIMULATIONS. ‘BAD’ / LESS ATTRACTIVE PROJECTS ELIMINATED HERE SO THAT ONLY RELATIVELY ATTRACTIVE OPTIONS ARE USED IN SYSTEM DEVELOPMENT SCENARIOS
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
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
“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.”