PN-ACE-899
10127 #6

Task Order No 804
Contract No PCE-1-00-96-00002-00

Power Projects Survey and Analysis

Prepared By
Asia Consulting Group

June 19, 1998

For
USAID/India
Mr N V Seshadri

Environmental Policy and Institutional Strengthening Indefinite Quantity Contract (EPIQ)
Partners International Resources Group, Winrock International
and Harvard Institute for International Development

Subcontractors PADCO Management Systems International and Development Alternatives Inc

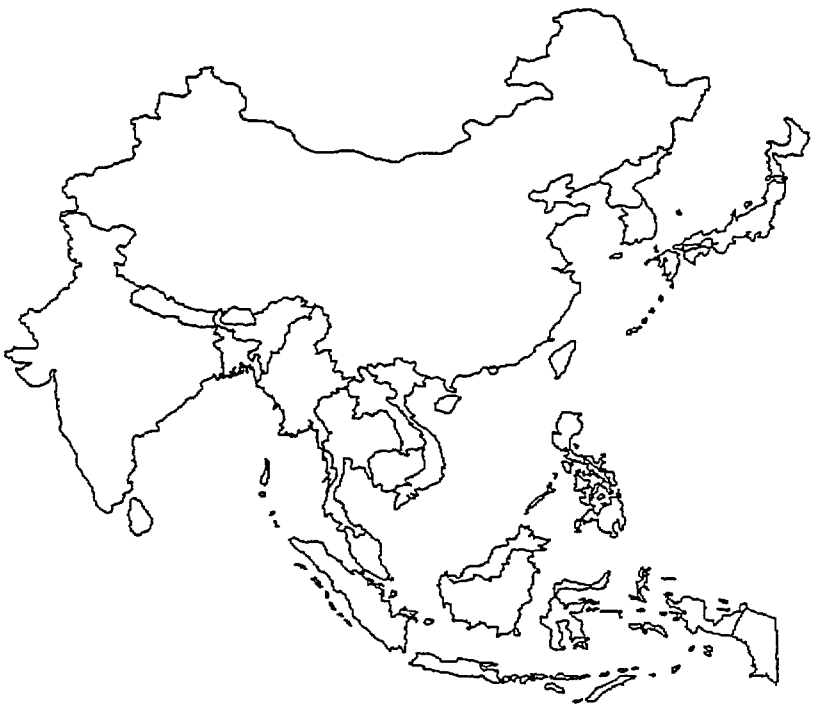
Collaborating Institutions Center for Naval Analysis Corporation Conservation International KNB Engineering and Applied Sciences Inc Keller-Bliesner Engineering Resource Management International, Inc , Tellus Institute Urban Institute and World Resources Institute

ASIA CONSULTING GROUP

USAID-EMCAT-R^3 10
POWER PROJECTS
SURVEY & ANALYSIS
BY ASIA CONSULTING GROUP

Bangkok • Hong Kong • Jakarta • Kuala Lumpur • Manila • New Delhi • Seoul • Shanghai • Singapore • Sydney • Taipei • Tokyo

2



USAID - EMCAT - R^3

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POWER PROJECTS
SURVEY & ANALYSIS
BY ASIA CONSULTING GROUP

19TH JUNE 1998

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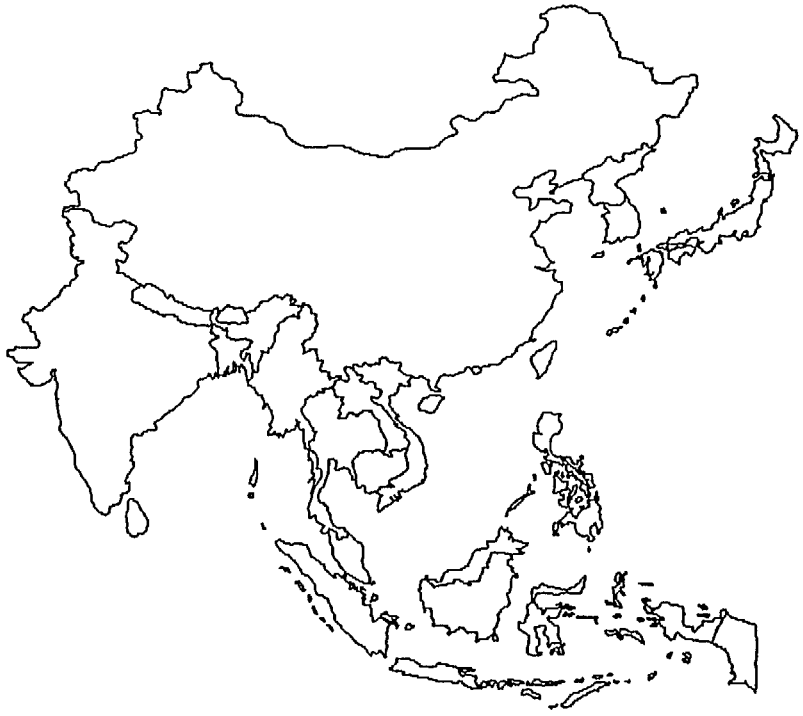
3



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SECTION I INTRODUCTION

SECTION II METHODOLOGY

SECTION III POWER PROJECTS STUDY

SECTION IV CONCLUSIONS

SECTION V APPENDIX I

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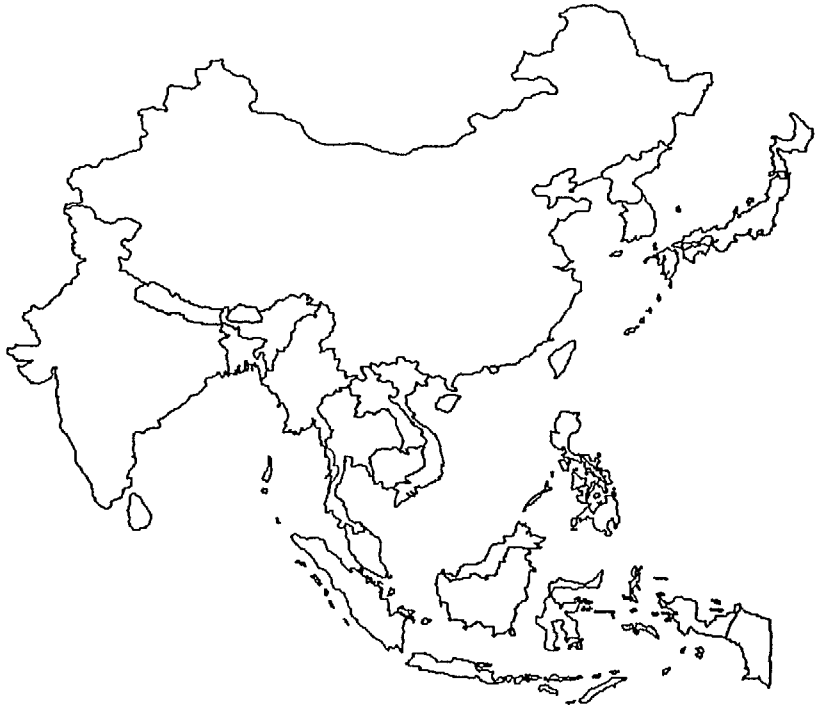


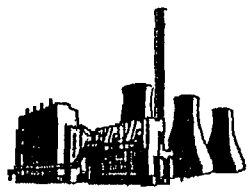
INTRODUCTION

- STUDY I SURVEY OF POWER PROJECTS
- STUDY I (PROJECTS) PROJECT TEAM
- PROJECT I SURVEY OF POWER PROJECT (GANTT CHART)

1 2 3 4 5

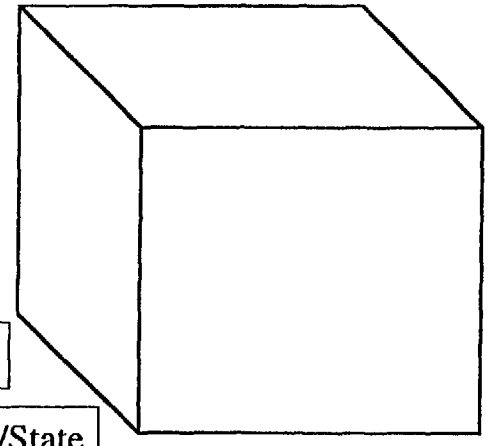
Deliverables

5 Year Forecast by Three Key Axis



Differentiators

- Technology & Fuel
- Project Type IPP/Captive/State



- # Projects
- MW

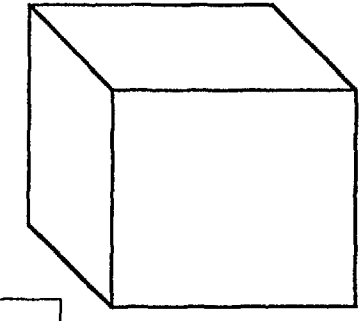
Quantum

- National Forecast
- Regional Forecast

Geographic Scope

Projected Reliance on Clean Technology for Power Generation

Analysis of Top 10 Industries by



- MW
- Generation
- Historical
- Projected
- Captive
- SEB

Source Client Briefing, ACG Methodology ACG Analysis

STUDY I (PROJECTS) PROJECT TEAM

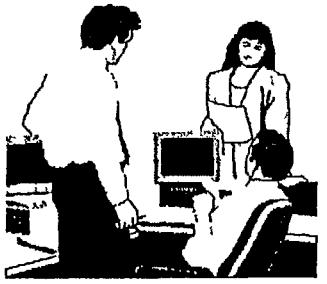
USAID (United States Agency for International Development)

Mr N V Seshadri, Program Specialist (Energy)
Ms Kavita Sinha, Project Specialist

Mr Dick Goldman, Director

IRG (International Resources Group)

Mr Ronald Leasburg, Director Energy Group



ACG Project Team

Mr V Kanwarpal Project Manager
Mr J Anand, Senior Analyst
Mr G Lal, Analyst

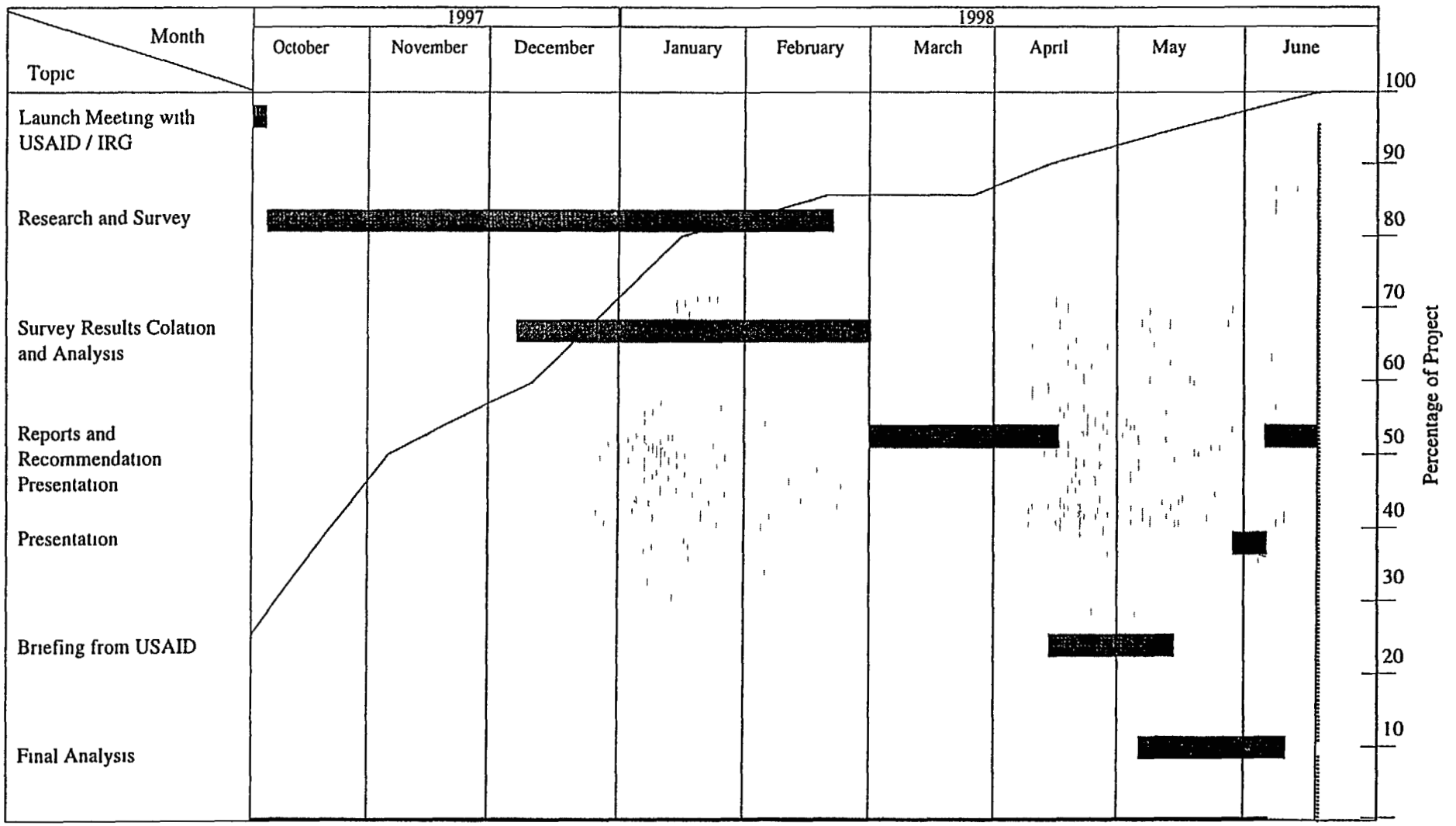
ACG Advisors

Mr Bhardwaj, Senior Advisor
(Former Chairman, NJPC)

Source ACG Models & Databases

90% of the project is completed as of March 1998

PROJECT I SURVEY OF POWER PROJECTS (GANTT CHART)



Source ACG Models & Databases, ACG Analysis

SOURCES OF INFORMATION

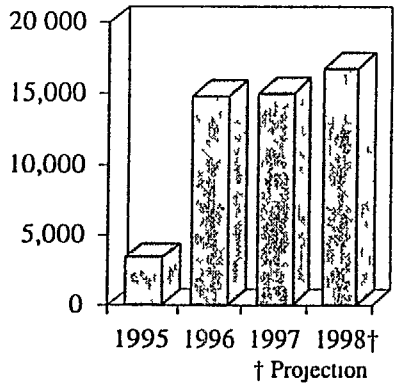
ACG Proprietary Resources

- Business Journals Database™ (1995, 1996, 1997, 1998)
- Captive Power Project Track™
- National Project Track™
- State Database™
- Transmission and Distribution Database™
- Electricity Intensity Analysis

Government Reports and Publications

- Annual Report on the working of SEB s (1990 1994, 1997)
- Census Of India - 1991
- Compendium of Thermal Power Stations in India, Central Board of Irrigation and Power
- Fifteenth Electric Power Survey of India, Central Electricity Authority
- Fourteenth Electric Power Survey of India, Central Electricity Authority
- Profiles of Power Utilities and non Utilities in India - 1997 Council Of Power Utilities of India
- CEA General Review
- Power Pool Arrangements and Economic Load Despatch
- Power Gen Asia Report, 1995, 1996 & 1997
- Power Gen Americas 1994 Conference Papers
- Indian Electricity Act, 1910
- The Electricity (Supply) Act 1948

Records in Business Journals Database™



Periodicals and Magazines

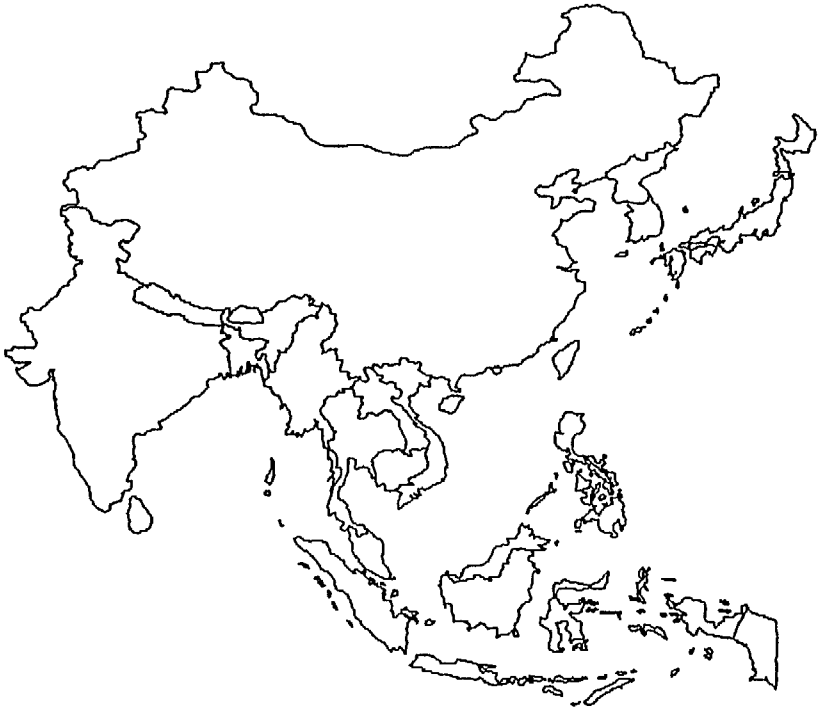
- Business India
- Business Standard
- Business Today
- Business World
- Manorama Year Book 1996,1998
- Power Line
- The Economic Times
- The Financial Express
- The Observer

Directories and Miscellaneous Publications

- Commercial and Industrial Guide, 1996
- Directory of Key Personnel in the Power Supply Industry - 1997
- Kothari's Industrial Directory of India 1996- 97 Kothari Enterprise
- Power Pool Arrangements and Economical Load Despatch

Source Industry & Government Reports ACG Models & Databases

SECTION TITLE METHODOLOGY



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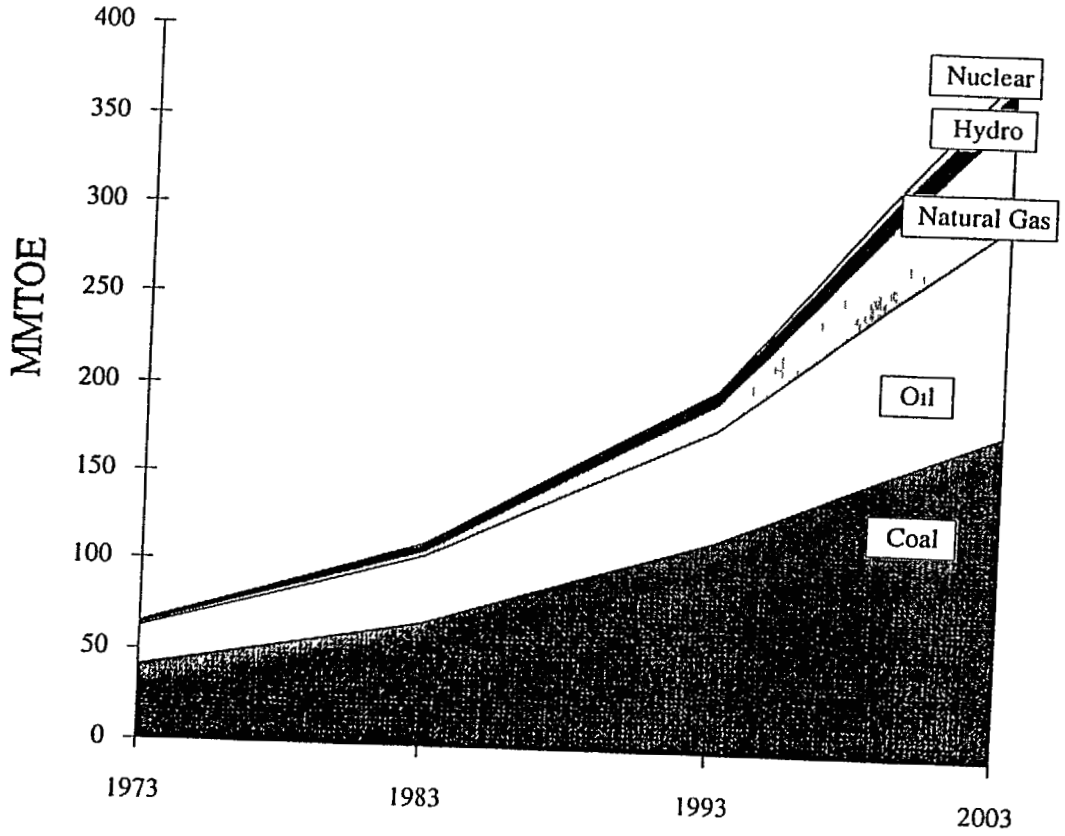
INDIA POWER & ENERGY DEMAND
INDIA RENEWABLE ENERGY POTENTIAL
FRAMEWORK USAID-ACG PROJECT & POLICY STUDIES

1 2 3 4 5

Source

India Primary Energy Consumption & Projection



Source BP Statistical Review (1996) & MoP&NG

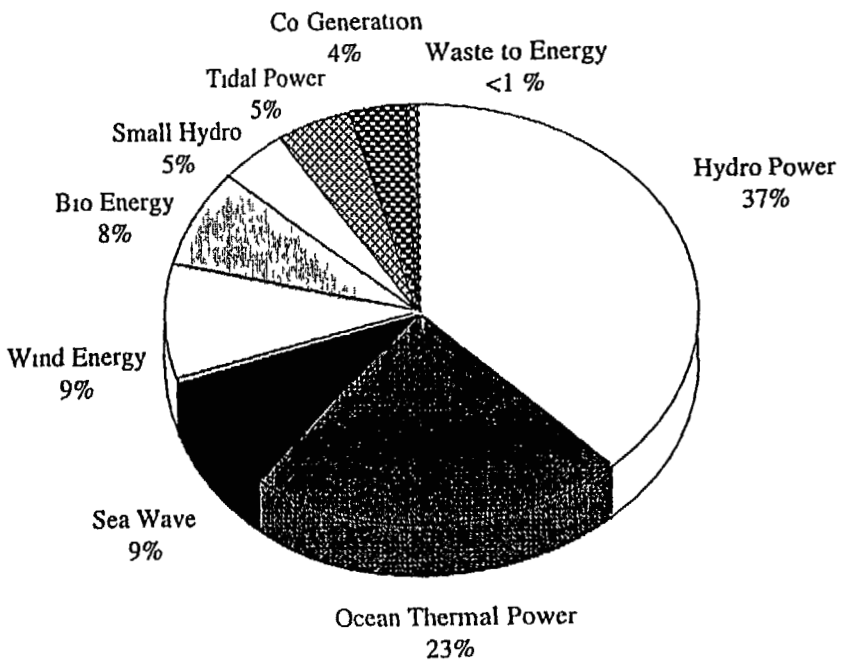
- India's power & energy demand are expected to grow rapidly with continued economic growth
- The nation is projected to continue its heavy reliance on coal and oil as the primary sources of energy
- Gas usage and demand are projected to grow substantially over the next decade
- Renewable sources of energy are plentiful but remain untapped due to a range of considerations

Source Industry & Government Reports ACG Analysis

INDIA RENEWABLE ENERGY POTENTIAL

While India possesses tremendous renewable energy potential

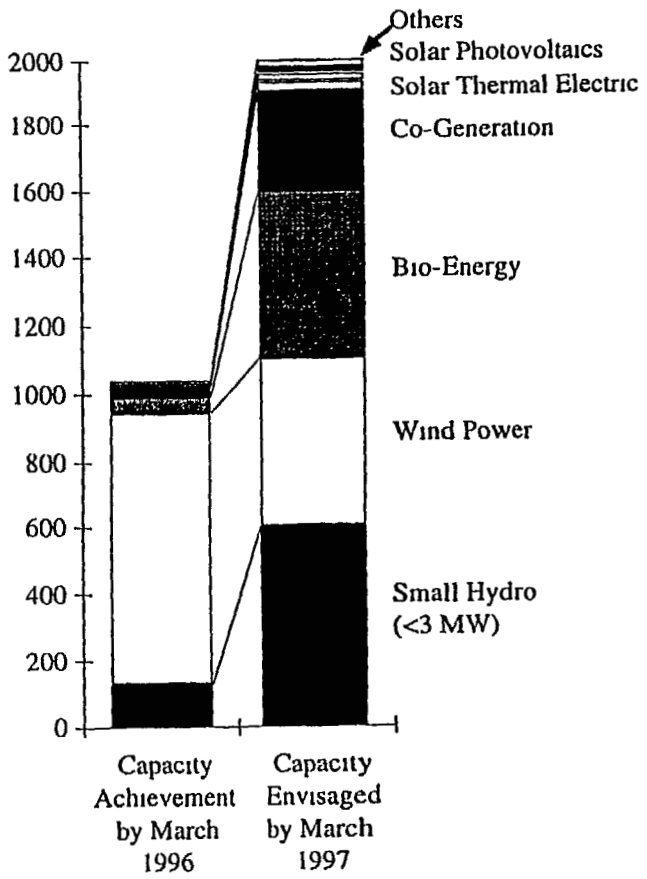
Renewable Energy Potential by Source



Total = 220,000 MW

Capacity addition reflects a limited impact

8th Five Year Plan Programme of Renewable Energy Development



Note Does not include estimated 30,000 MW potential based on Draught Animal Power' & 5×10^5 KWhr/Year of Solar Energy Potential

Source Industry & Government Reports, ACG Analysis

12

FRAMEWORK USAID - ACG PROJECT & POLICY STUDIES

- ACG will conduct the two studies synchronously for maximum analytical value

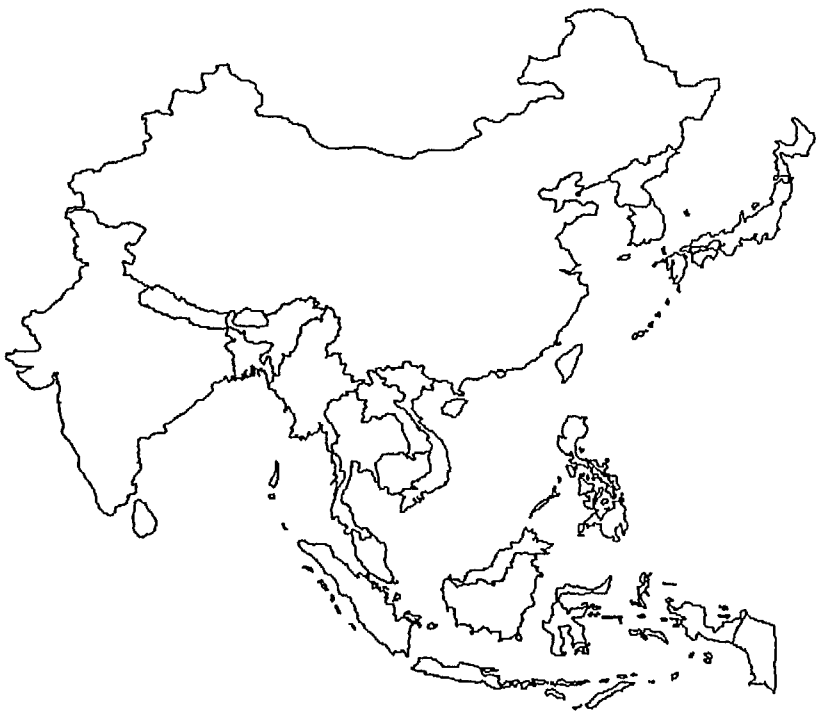
	Fundamental Analysis	Dynamics of Deliverables
Project I Power Project Study	• Analysis of Dynamics of Power Project Development • Analysis of Key Drivers of Capacity Addition	Impact of Capacity Addition on • Power & Energy Dependence • Environmental Impact ***Focus of ACG Study*** • *Capacity Forecast* - *Technology & Fuel* - *Type (IPP vs Captive)* - *Industry*
Project II Power Policy Study	• Analysis of Dynamics of Policy Evolution • Analysis of Key Drivers of Policy	Policy Impact on Power Projects & Capacity Addition ***Focus of ACG Study*** • *Regulatory Reform* • *Utility System Restructuring* • *Power Generation†* • *Power Transmission†* • *R& M of Plants †* • *Financial Resources for Restructuring & Expansion* *† Private Sector*
USAID Program	• Detailed Study of USAID Program EMCAT-R[3]	USAID Program Impact on Policy
Other Agencies Programs	• Study of Programs of World Bank, ADB, IFC, OECF	Impact of Initiatives on Policy

1991 ←→ 1995 (Compressed Focus) 1996 1997 Projections

Timeline

Source Client briefing, ACG Methodology & ACG Analysis

SECTION TITLE. POWER PROJECT STUDY



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POWER PROJECT DEVELOPMENT IN INDIA 1991-1997
POWER PROJECT 17 STEP CLEARANCE PROCESS
ACG POWER PROJECT SUCCESS RATING METHODOLOGY
NPT™-TRACKING & RATING 2,400 POWER PROJECTS IN INDIA
ACG POWER PROJECT & ELECTRICITY SUPPLY PROJECTION METHOD
ELECTRICITY DEMAND PROJECTIONS-CEA XVTH SURVEY
INSTALLED & NEW PROJECTS BY FUEL CATEGORY
NPT™ NEW PROJECTS BY TYPE
INSTALLED GENERATION BY PRIME MOVER TYPE
INTEGRATED ASSESSMENT BY ALL TECHNOLOGIES (METHODOLOGY)
CATEGORY OF ANALYSIS
CLEAN TECHNOLOGY FUEL IDENTIFICATION & CATEGORIZATION
POWER GENERATION BY TECHNOLOGY
RENEWABLE ENERGY GROWTH IN INSTALLED CAPACITY
RENEWABLE SOURCE OF ENERGY PROFILES
SMALL HYDRO PROJECTS DEFINITIONS
CAPTIVE/COGENERATION INSTALLED BASE BY INDUSTRY & TECHNOLOGY
HISTORICAL CAPTIVE/COGENERATION CAPACITY BY INDUSTRY (1973-1993)
INDIA BY ELECTRICITY REGIONS
INDIA ELECTRICITY REGIONS OVERVIEW
REGIONAL PERFORMANCE & PLANS
REGIONAL ANALYSIS OF DEMAND VS SUPPLY POTENTIAL
REGIONAL LOAD DESPATCH CENTER OVERVIEW
METHODOLOGY REGIONAL NPT™ STATUS CLEAN TECHNOLOGIES
NPT™ STATUS CLEAN TECHNOLOGIES BY REGION
NEW CAPACITY ADDITION FORECAST
CLEAN TECHNOLOGY SUMMARY

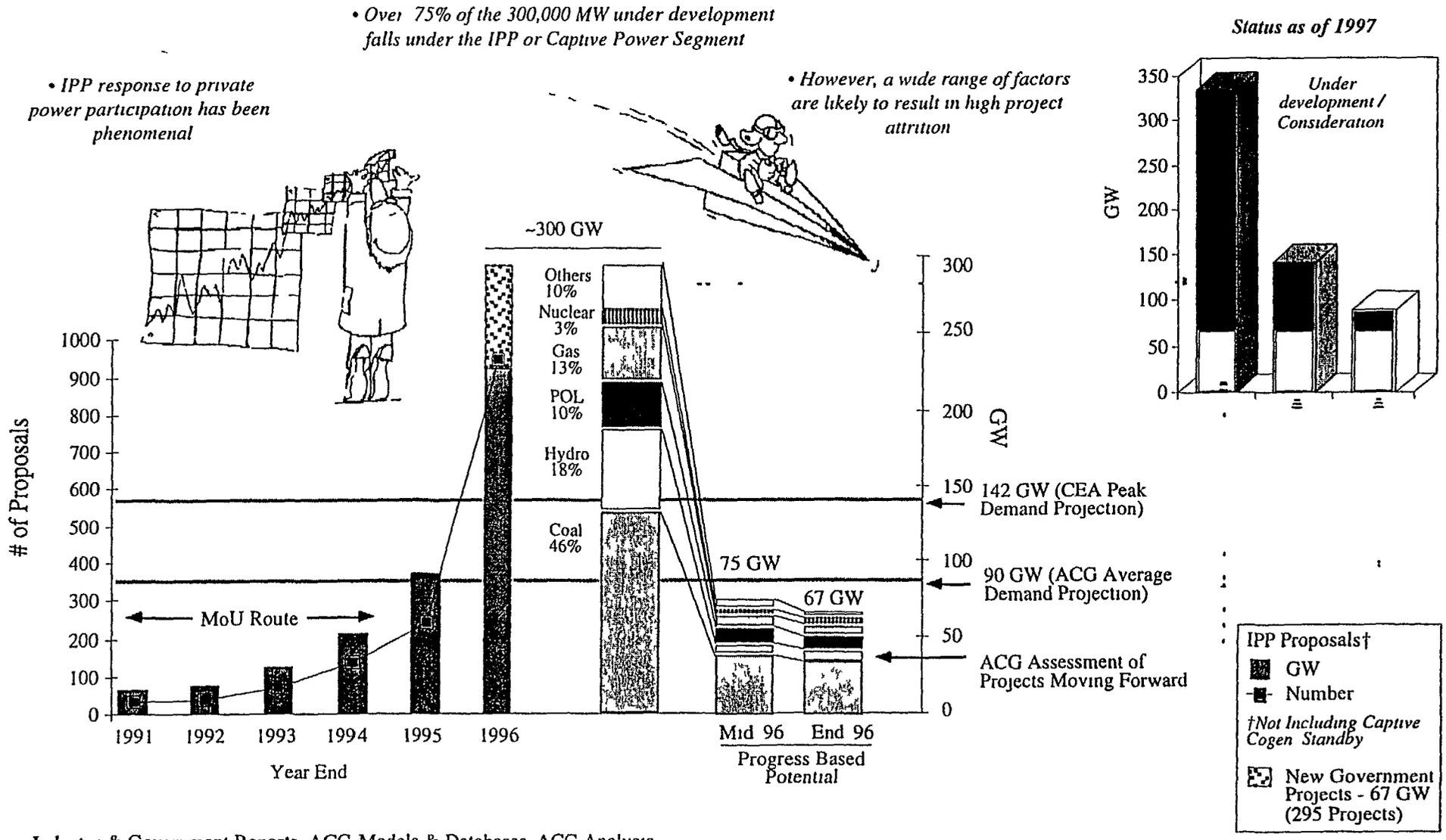
1 2 3 4 5

Source

Making sense of the callosal development of projects is an imperative

POWER PROJECT DEVELOPMENT IN INDIA 1991 - 1997

Power project development in India has followed a tumultuous path in the past six years While there is tremendous apparent activity and pronouncements, it is daunting challenge to ascertain the status of power projects in the country Lack of a clear understanding of project development status is giant hurdle for policy makers and industry strategists alike



Source Industry & Government Reports, ACG Models & Databases ACG Analysis

Developers need to follow variations of the 17 step clearance process to develop a power project in India

POWER PROJECTS 17 STEP CLEARANCE PROCESS

No	Item	Agency	Remarks
1	COST ESTIMATES †1	CEA	Required under Section 29 of Electricity (Supply) Act, 1948 (E/S)Act, 1948
2	TECHNO-ECONOMIC CLEARANCE/ CONCURRENCE OF CEA †2	CEA	Under section 30 of Electricity (Supply) Act of 1948 SEBs State Governments, Concerned Ministries of Coal Petroleum & Natural Gas Railways Surface Transport involved
3	PUBLICATION †3	State Governments	Section 29 clause (2),(3) (4) and (6) ES Act 1948 • State Governments
4	WATER AVAILABILITY	1 State Governments 2 CWC	• Interaction between State Government departments & CWC required • Relevant Irrigation Act of the State & Central/ Water Commission
5	SEB CLEARANCE	1 SEB 2 State Government	Sec 44 E/S Act, 1948
6	POLLUTION CLEARANCE WATER AND AIR	State & Central Pollution Control Board	Water Prevention & Control Pollution Act 1974 Air/Prevention & Control of Pollution Act 1981
7	FOREST CLEARANCE	1 State Government 2 Min of E&F	Coordination with state Forest Department Ministry of Environment & Forest (MOE & F) regarding Forest Conservation Act 1980
8	ENVIRONMENT & FOREST CLEARANCE	1 State Government 2 Min of E&F	As per item 6& 7 & Government Policy in Force
9	CIVIL AVIATION CLEARANCE †4	National Airport Authority	
10	REGISTRATION OF COMPANY	Registrar of Companies	Under Indian Companies Act 1956
11	REHABILITATION & RESETTLEMENT (Of displaced families by land acquisitions)	1 Ministry of E&F 2 State Government	- -
12	HYDRO PROJECTS (MINI MICRO)	1 Ministry of Water Resources	Under relevant Acts
13	EQUIPMENT PROCUREMENT	DFTD, CCI&SE*	Import & Export Acts
14	LAND AVAILABILITY	State Government	- -
15	FUEL LINKAGE	Department of Coal • Dept of Petroleum & Natural Gas	
16	FINANCING	• CEA, Department of Power, Dept of Economic Affairs Financial Institutions	-
17	TRANSPORTATION OF FUEL	Department of Coal Ministry of Petroleum & Natural Ga Ministry of Railways, Shipping & Surface Transport	

† 1 Any Power project involving capital expenditure exceeding the limit by Government needs to be scrutinized by CEA for examination of salient features and benefits which may accrue therefrom
† 2 By CEA after examination of (i) River works/dams to be put up for hydro and for water availability for thermal plants (ii) Greatest possible economic output of electric power (iii) Transmission lines and Systems (iv) Reasonableness of the Scheme (v) Site location for optimum utilization of fuel resources, distance from load centers, transportation facilities, water availability and environmental considerations
† 3 Schemes to be published in the Official Gazette/ local newspapers as the generating company may consider necessary along with a notice for at least two months and modification if any consequent to public representation
†4 For Chimney Height

Note 14 17 are NON Statutory Clearances

CEA
State Government
Environment Related Agencies / Ministry
SEB
Central Government

Source Government reports, ACG Analysis

Rating of a project takes into account all aspects associated with a project development from the project initiation stage to the final stage of commissioning

ASIA CONSULTING GROUP POWER PROJECT SUCCESS RATING METHODOLOGY

Rating	*Criteria*
■ High ▩ Medium	• Project with 2 or more factors
□ Low □ Unknown	• Retarded Progress
□ Nil	• Scrapped

Financial & Investment
- ▩ • FIPB Clearance (+)
- ■ • Financial Closure Achieved (+++)
- • Tied finance (++)
- • Short-listed for Finance (+)
- • Financial Partner Backed Out (- -)
- ▩ • Finance Sought (+)

Project Partners
- • Looking for partners (-)
- • Developer Backing Out (- -)
- □ • Problem with Vendors (-)

□ • Pessimistic Developer (-)

17 Transportation of Fuel

16 Financing

15 Fuel Linkage

14 Land Availability

13 Equipment Procurement

12 Hydro Projects

Power Purchase
- ■ • PPA Initialled (+)
- ■ • PPA Signed (++)
- ▩ • PPA Under Revision (-)

Payment Guarantees
- ■ • Escrow Mechanism (++)
- • Letters of Guarantee (+)
- • LCs / LoIs (+)

11 Rehabilitation & Resettlement

10 Registration of Company

Fuel Supply
- ■ • FSA Signed (++)
- ▩ • Liquid fuel Linkage Finalized (+)
- □ • Facing Fuel Supply Problems (-)

9 Civil Aviation Clearance

Project Development
- □ • Planning Stage (-)
- • DPR Considered (+)
- • Bidding On (+)
- • EPC bid process on (+)
- ▩ • EPC Contractor Finalized (++)
- ■ • Construction On (++)
- • Commissioning Soon (+++)

■ 8 Environment & Forest Clearance

□ • Bureaucratic hurdles ( )

7 Forest Clearance

6 Pollution Clearance (Water & Air)

Opposition
- • Environmental Opposition ( )
- □ • Local Resistance (-)
- □ • Tussle with SEB (-)

5 SEB Clearance

4 Water Availability

3 Publication

2 CEA Techno-Economic Clearance

1 Cost Estimates

Clearances
- ■ • In-Principle TEC Clearance (+)
- • TEC Clearance (++)

General Progress
- □ • Very New Project (-)
- □ • Not much Development (- -)
- □ • No Report (- - -)
- • Project Cancelled (- - -)

Source Industry & Government Reports, ACG Models & Databases, ACG Analysis

NATIONAL PROJECT TRACK - TRACKING & RATING 2400+ POWER PROJECTS IN INDIA

Database Updates (2)

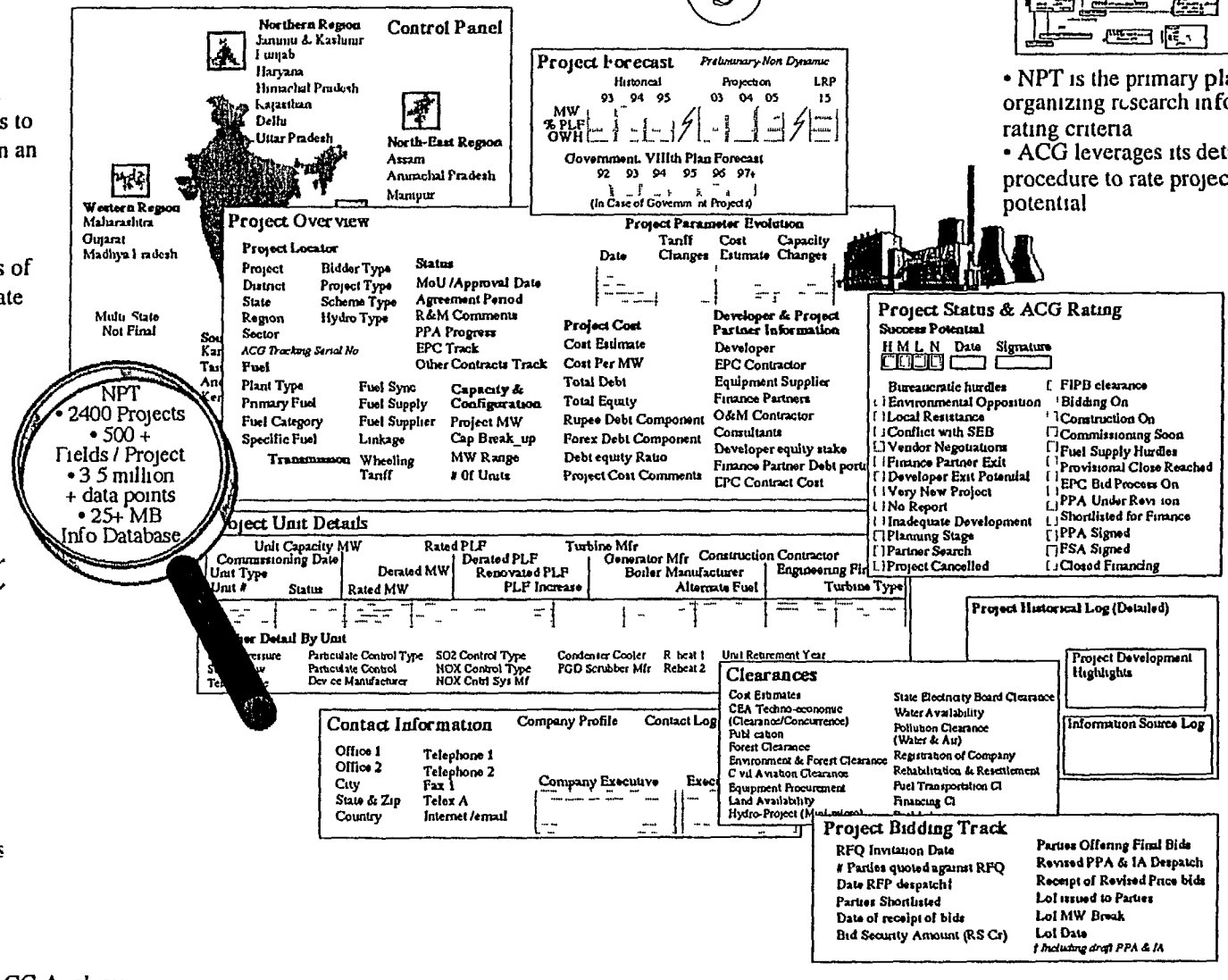
Primary Research

- ACG conducts interviews with Developers, SEBs and Ministries to ascertain the status of projects on an ongoing basis

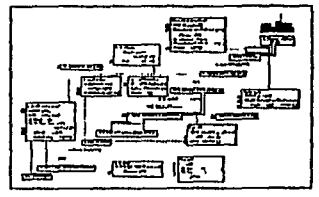
Secondary Research

- NPT relies on over 100 sources of information that are used to update the database at the average frequency of 50 updates per day

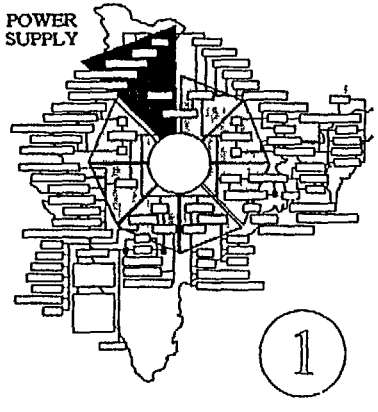
NATIONAL PROJECT TRACK DATABASE OUTLINE (3)



Role in Rating Projects (4)



- NPT is the primary platform for organizing research information in to rating criteria
- ACG leverages its detailed rating procedure to rate projects for success potential



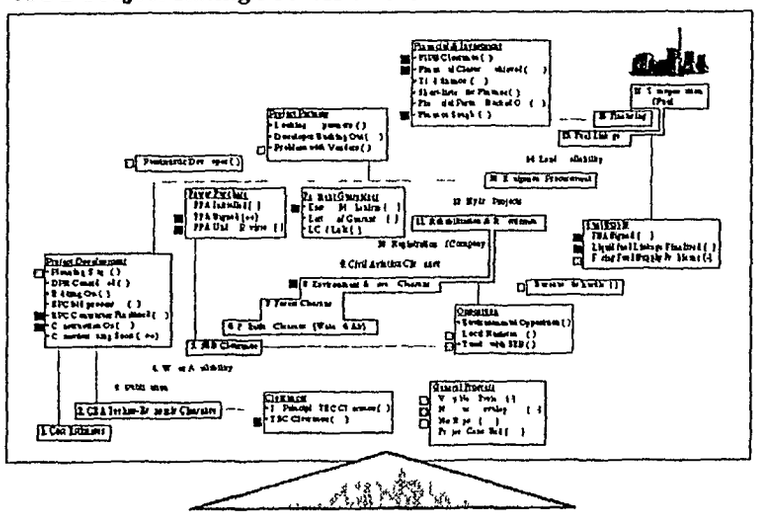
(1)

- **National Project Track** (NPT) is an integral part of the National Power Model and designed to support Power Supply Projections

Source ACG Models & Databases, ACG Analysis

ASIA CONSULTING GROUP POWER PROJECT & ELECTRICITY SUPPLY PROJECTION METHOD

ACG Project Rating Process & Criteria



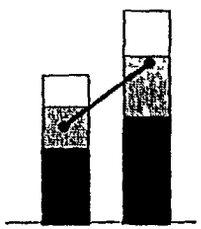
Ratings Assigned (For Project Success Potential)

- High
- Medium
- Low
- Nil

Capacity Addition Projection

- MW
- Generation fn~(PLF)

By Technology & Year



Discussion of Sample Key Issues in the Rating Process

Key Issues	*Details*
Status of the PPA	Issues regarding PPA negotiations initialled signed or under revision • Escrow mechanism security & guarantee of PPA payment (Typically critical for financial closure)
Escrow Mechanism	
Status of the FSA	Issues regarding FSA negotiations initialled signed or under revision Fuel Supply assurance and implementation
EPC Contractors	• Bids tenders and issue of finalization of EPC contractors for the project
Equipment Suppliers	• Equipment finalization (GT ST DG etc) and selection of equipment supplier
Financial Tieup	Financing of projects with issues on debt equity and amount of foreign loan sought/secured
Land Acquisition	Land selection acquisition and survey work
Clearance from CEA	• Techno economic clearance from the CEA is the final clearance a project requires Issues on In principle clearance from CEA are also examined for a project in preliminary stages
Other Key Clearances	• Clearances from various State & Central Agencies

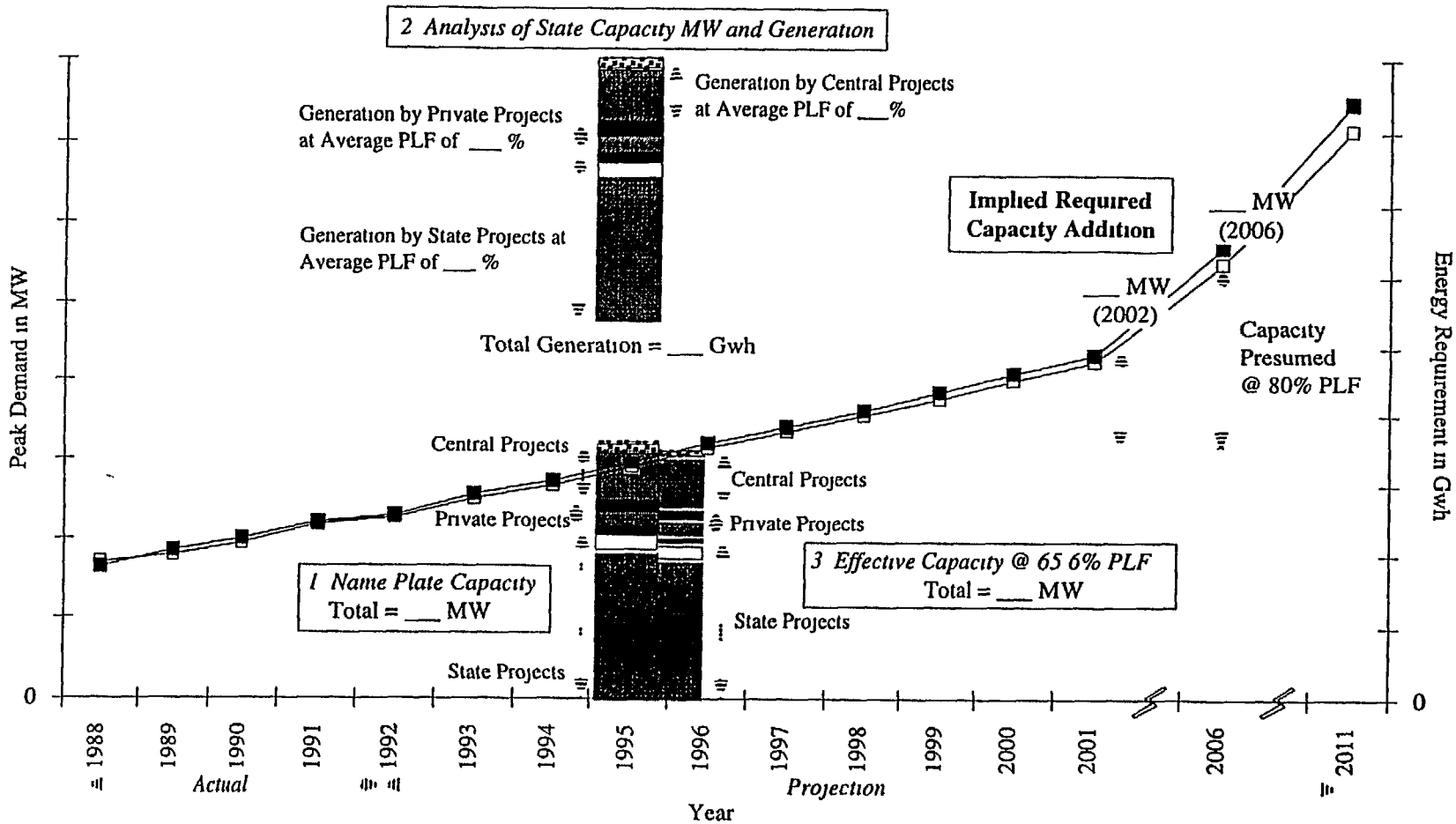
Important Note

- ACG tracks 2,400 + projects and rates project success potential on an ongoing basis
- Potentially over 50 factors may be taken into account in judging the success potential of projects
- The projects include installed projects, new projects under all stages of consideration and development
- ACG invariably conducts intensive primary research to ascertain the status of projects as often no official information is available
- *Ministry of Power tracks less than 150 projects & often SEBs do not track the status of all the projects*

Source Industry & Government Reports, ACG Models & Databases ACG Analysis

Projections are evaluated for two main year ends - 2002 and 2006

ELECTRICITY DEMAND PROJECTION - CEA XVTH SURVEY



Comments

- Demand projections are arrived by taking into account the demand projections of key state generating entities
- Central Sector includes National Thermal Power Corporation (NTPC), NHPC, NPC etc as applicable
- The total power imported by State is analyzed to arrive at the share of state in central projects
- The effective capacity takes into account the generation figures at 65 6% PLF, as applied in the 15th Survey
- The additional capacity required by 2002 & 2006 to meet the demand is projected in MW
- With most new projects being IPPs, the PLF's will be higher essentially resulting in lesser capacity being required

Legends

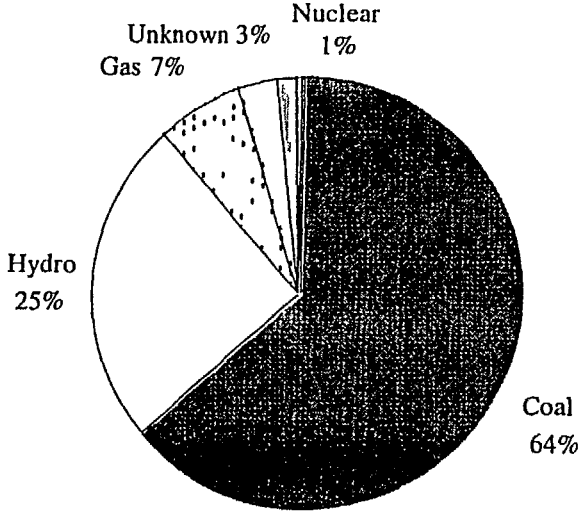
Peak Load in MW	Hydro
Energy Requirement in GWH	Gas
Coal	Nuclear
	Others

Source 15th Electric Power Survey of India, Profile of Power Utilities and Non Utilities in India - 1997, ACG Models & Databases, ACG Analysis

Coal projects form most of the installed as well as new projects under development

INSTALLED AND NEW POWER PROJECTS BY FUEL CATEGORY

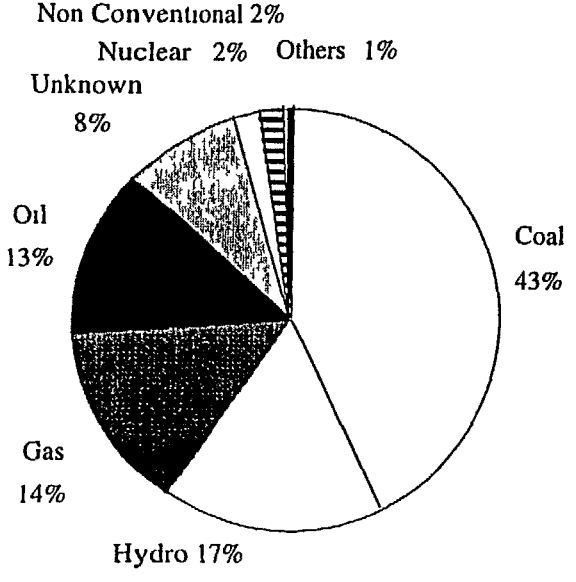
Installed Projects by Fuel Category



Total 84,000 MW (approx)

† Oil Non conventional and Others are negligible

New Projects by Fuel Category

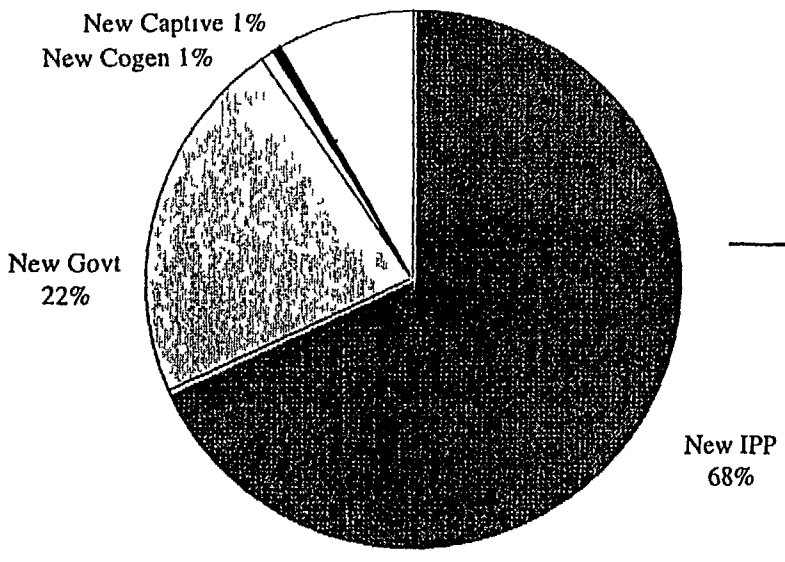


Total 334,000 MW

Source National Project Track (NPT)™, ACG Models & Databases, ACG Analysis

New IPP and Captive projects together constitute 70% of the new projects under development / consideration

NPT™ (NATIONAL PROJECT TRACK) STATUS. NEW PROJECTS BY TYPE



Total = 341 GW

† New Captive/Cogen Projects are negligible

New Captive Projects

- Analysis of the captive projects
  - By Industry
  - By Region
  - By Technology and Fuel
- Analysis of Top 10 Industries
  - By Installed Base
  - By New Captive projects
  - By Generation
  - By Technology and Fuel
- Ascertain number of Projects based on Clean Technology

New IPP Projects

- Leverage ACG resources to differentiate projects by Technology and Fuel
- Survey of the identified projects to ascertain the current status of these projects
- Rating of these projects based on the information from survey of these project and ACG analysis, as
  - High
  - Medium
  - Low
  - Nil
- Taking the High and Medium rated projects, to assess the number of projects likely to come up in next 4-5 years
- Of the High and Medium projects to ascertain number of projects based on Clean Technology

- Forecast of Projects based on Clean Technology
  - By Type (IPP Vs Captive)
  - By Technology
  - By Industry (Captive Projects)

22 January 1998

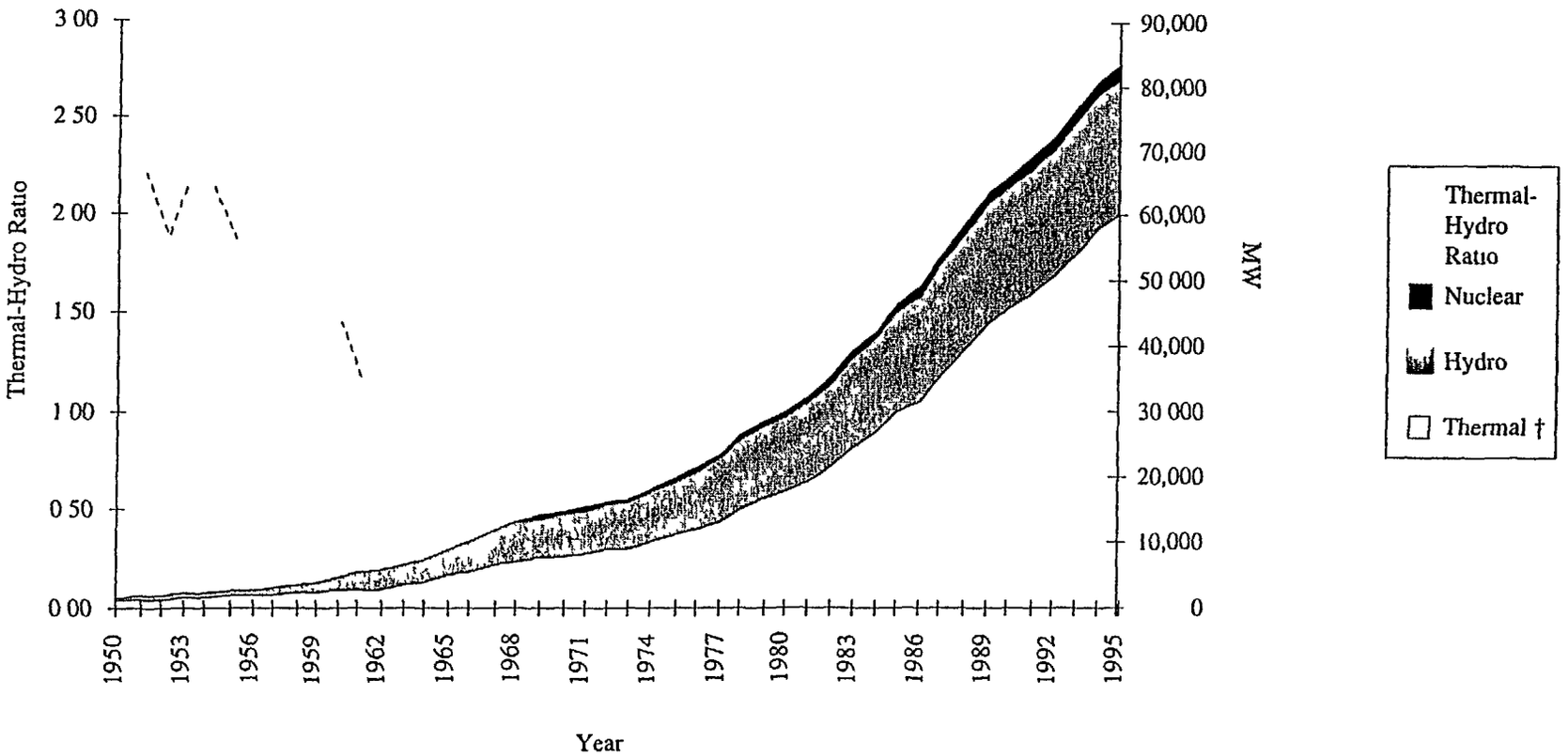
Source Industry & Government Reports ACG Models & Databases, ACG Analysis

There has been a steady increase in the thermal-hydro installed capacity ratio from the year 1974

GROWTH IN INSTALLED GENERATING CAPACITY BY PRIME MOVERS

- As of March 1996, the share of thermal power in the total installed capacity is 72 14%
- The increase in the thermal hydro installed capacity ratio is primarily due to the commissioning of large super thermal power stations
- Further hydro projects have been facing problems related to environment, land acquisition, water sharing between states and rehabilitation

Growth in Installed Capacity by Primer Movers

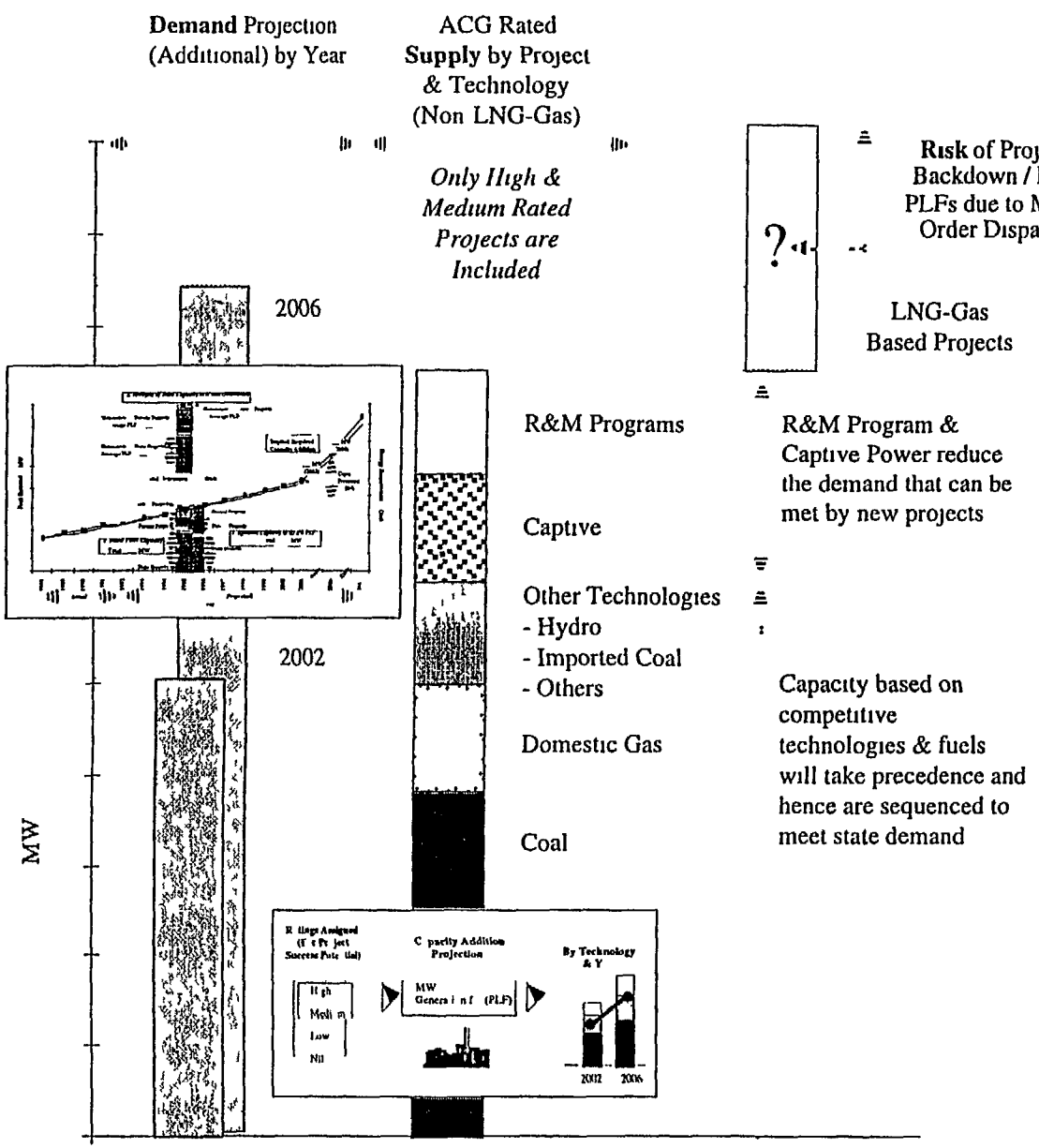


† Thermal Includes Gas, Steam, Diesel and Wind

Source General Review Central Electricity Authority 1993 94 India s Electricity Industry 1997, ACG Models & Databases ACG Analysis

ACG will utilize the following methodology to arrive at LNG-gas based project risk assessment The objective is to assess the reliability of high PLFs being agreed on

INTEGRATED ASSESSMENT BY ALL TECHNOLOGIES (METHODOLOGY ILLUSTRATION)



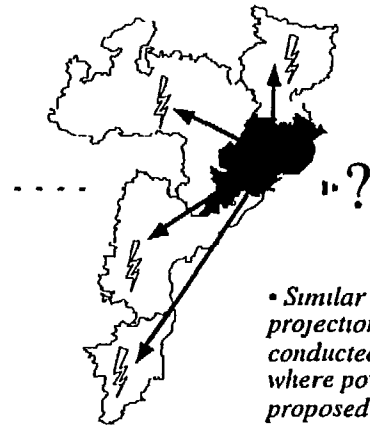
Risk of Project Backdown / Low PLFs due to Merit Order Dispatch

LNG-Gas Based Projects

R&M Program & Captive Power reduce the demand that can be met by new projects

Capacity based on competitive technologies & fuels will take precedence and hence are sequenced to meet state demand

Power Export Potential Assessment



- *Similar demand & supply projection analysis is conducted for each state where power is being proposed to be exported*

Explanation

- The projected capacity additions here are based on ACG's rating of all projects under consideration and development in the state
- Only projects with High & Medium success potential have been assumed to materialize by 2002
- Competitive technologies and fuels have 'first charge on capacity addition This view is also supported by ACG's primary survey and analysis of SEB's policy and planning perspectives
- R&M and Captive power developments are subtracted from the total projected capacity requirement to arrive at a sound estimate of capacity available to LNG-gas based power generation

Assumptions

- Captive projects although not rated may be accorded a 70 % success rate due to • Guaranteed Offtake • Balance sheet financing • Lower number of clearances required
- __ Project amounting to approximately ____ MW have been identified for R&M
- R&M projects have been assumed to add ____ to their original capacity

Source National Project Track™, ACG Models & Databases, ACG Methodology, ACG Analysis

This slide depicts the analysis categories for the identification of projects with clean technologies

CATEGORY OF ANALYSIS

Category	Definition	Comments
Clean Technology	• Clean technology can be termed as ' technology used in power generation which will have little or no impact on the environment With the growing awareness of environment degradation the upcoming power plants will have to be based on clean technology which focus on reducing the emission levels of classic pollutants like carbon sulfur and nitrogen oxides and trace metals like mercury drastically It aims at extremely clean and virtually free of acid rain pollutants emissions It also focuses on better efficiency and economy With 50% of the upcoming power plants in Asia being thermal plants clean coal technology is being developed and has been implemented successfully in plants in Europe using the Integrated Coal Gasification Combined Cycle (IGCC) and Pressurized Fluidized Bed Technologies (PFB) The program has also focussed on upgrading of low rank coal by developing process like ENCOAL's liquid fuel coal process and Rosebud Syncoal Partnership's Advanced coal conversion process	• Clean technology is presumed in the renewable energy source except for hydro projects where the impact on the surrounding environment has to be taken care of • Clean coal technology is now being put forward as a step to reduce the impact of the thermal power plants on the environment • Fuels like gas and naphtha are being seen as clean fuel technologies • This analysis will assess the present power projects and forecast potential capacity addition based on clean technologies
IPP/ Captive / Cogeneration	• IPP s are the Independent power producers who establish the power plants with the sole aim of selling power to others, be it the SEB or directly to the consumers • Captive power plants are set up by existing industries to fulfill their power demands and in case of extra generation they sell it to the SEB • Cogeneration plants are put up by the industries where combined generation /use of electricity and heat(steam) applications exist This is the area where most of the sugar and steel industry are focussing on as a source of power generation	• The analysis ' by type ' will focus on the type of power plants being established • This analysis will be useful to gauge if the industry is going in for captive plants, cogeneration or IPP s for power supply
Industry	• The electrical intensity analysis by industry is aimed at the actual consumption of electricity With the advent of new technologies and the capacity utilization of industries changing, it affects the overall electrical consumption by industry and hence affects the demand The analysis will also examine aspects of cogeneration which is being focussed on mainly by sugar and steel industries as an alternative source of energy	• Electricity analysis will highlight the energy efficiency in industries

Source Industry & Government Reports, ACG Models & Databases, ACG Analysis

Clean Technology based power projects have little or no impact on the environment and hence are being promoted by various agencies

CLEAN TECHNOLOGY FUEL IDENTIFICATION & CATEGORIZATION

Fuel Category	Specific Fuel	Clean Technology
Coal	Coal	☐
	Coal Gas †1	■
	Lignite	☐
Petroleum Oil	Aviation Turbine Fuel (ATF)	☐
	Diesel	☐
	Furnace Oil (FO)	☐
	Heavy Oil	☐
	Heavy Residual Oil	☐
	High Speed Diesel (HSD)	☐
	Light Diesel Oil (LDO)	☐
	Low Sulfur Furnace Oil (LSFO)	☐
	Low Sulfur Heavy Stock (LSHS)	☐
	Naphtha	☐
	Petroleum Coke	☐
	Residual Oil	☐
Gas	Gas	■
	Liquefied Natural Gas (LNG)	■
	Liquefied Petroleum Gas (LPG)	■
	Methane	■
Bagasse	Agro Waste	■
	Bagasse	■
	Biogas	■
	Biomass	■
	Blast Furnace Gas (BF Gas)	■
	Solid Municipal Waste	■
Non-Conventional	Geo-Thermal	■
	Solar	■
	Tidal	■
	Wind	■
Waste Heat	Waste Heat	■

Fuel Category	Clean Technology
Hydro †2	■
Nuclear	☐

Combinations Possible †3	Clean Technology
Bagasse/ Oil	■
Blast Furnace Gas/ Furnace Oil	☐
Blast Furnace Gas/ Heavy Furnace Oil	☐
Coal/ Heavy Furnace Oil	☐
FO/ LSHS	☐
FO/ LDO	☐
Gas/ Naphtha	☐
Heavy Furnace Oil (HFO)/ Diesel	☐
Naphtha/ Blast Furnace Gas	☐

Legend

■ Clean Technology Based Fuel (as classified by USAID)

†1 Clean Coal Technology - Integrated Gasification Combined Cycle (IGCC) & Atmospheric Fluidized Bed Combustion (AFBC) - have been categorized under Coal Gas

†2 Hydro Projects less than 25 MW are classified as Clean Technology

†3 Combinations possible are Projects which have Dual Fuel Capability or Projects with different Turbines planning to use different fuels

Source USAID Briefing, ACG Analysis

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Coal and hydro are the technologies with lower cost of generation, easy availability, less polluting and with the advent of new clean coal technologies, these are the technologies for the future

POWER GENERATION BY TECHNOLOGY

Sources of Energy	Sub Category	Definition	Pollution aspects	Project Cost (per MW)
Renewable Energy	Hydro	• Conventional hydro power projects are of 3 types run of the river type, single purpose hydro electric project with regulating storage and multi projects with regulating storage having hydro power as one of the components (viz irrigation)	• Impact on environment with respect to inundation of land and seismic zones pose a major hurdle in the hydro project implementation	Rs 3 6 Cr /MW
	Wind	• Wind power generation requires a wind electric generator The grid connected wind electric conversion systems are the most promising Wind farms appear to be the most feasible and cost effective for supplementing the conventional means of power generation on a large scale	• Wind being a clean source of fuel poses no environment problems	Rs 4 03 Cr /MW
	Solar	• There are 2 techniques available for commercially viable solar power plant - Solar Photovoltaic Cell energy system - Solar thermal energy system	• Solar energy is being used and there is no degradation of environment	Rs 11 Cr /MW
Non Renewable Energy	Coal	• Existing thermal power plants are Coal fired with steam turbines and clean coal technology using integrated coal gasification combined cycle, pressurized fluidized bed technology and ultra super critical pulverized coal technology is being put forward to reduce the environmental impact of the thermal power plants	• Existing technology results in problems in disposal of fly ash and also the pollution caused by emissions of sulfur and nitrogen oxides	Rs 3 65 Cr /MW
	Gas	• Oil or gas fired with gas turbines, open cycle gas turbines based on oil or gas and combined cycle with waste heat recovery boilers and steam turbines	• Gas is one of the clean fuel in the non-renewable energy source category	Rs 4 77 Cr /MW
	Nuclear	• Heavy water reactor technology with use of natural uranium was preferred to light water and magnet reactors in India due to its technological and economic advantages	• Nuclear energy poses problems with the disposal of contaminated waste which is dumped or buried in the sea or land	Rs 4 25 Cr /MW
	Residual Oils	• DG sets or large gas turbines based on open cycle or combined cycle with waste heat recovery boilers and steam turbines are used for power generation	• Residual fuels are one of the main sources of pollution resulting in emissions of Carbon di oxide SOx and NOx gases	Rs 3 17 Cr /MW
	Naphtha	• Naphtha fired with gas turbines open cycle gas turbines based on naphtha and combined cycle with waste heat recovery boilers and steam turbines	• Naphtha being a clean fuel is an class I explosive	Rs 3 03 Cr /MW

† Note Cost / MW derived from average figures in National Project Track

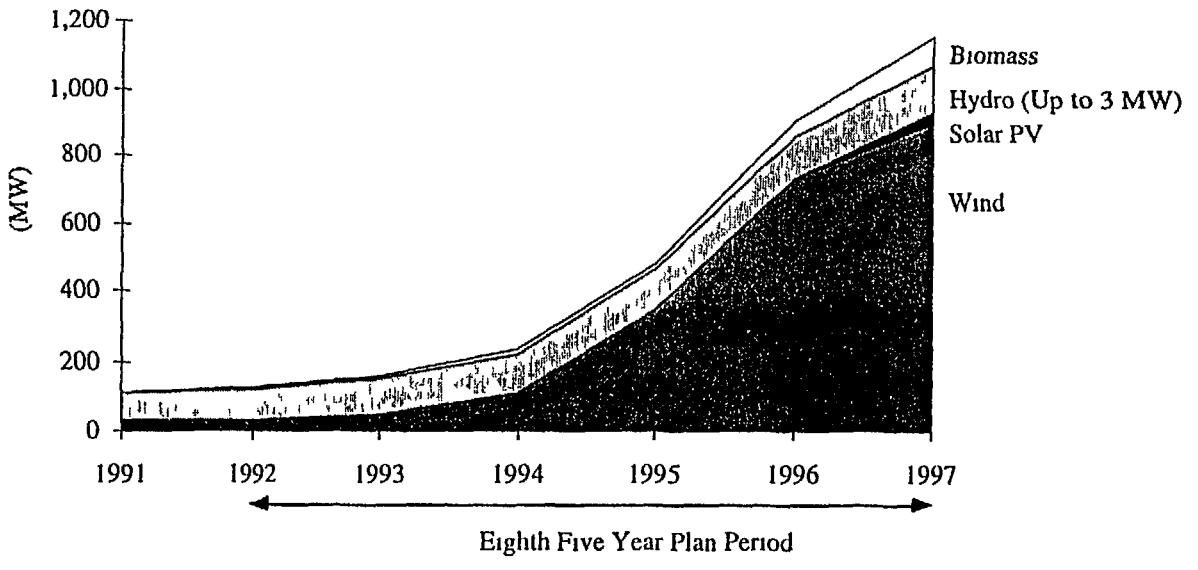
Source Industry & Government Reports ACG Models & Databases ACG Analysis

There was a considerable increase in the installed capacity of renewable energy sources in the eighth five year plan primarily due to the capacity addition in the wind based power projects

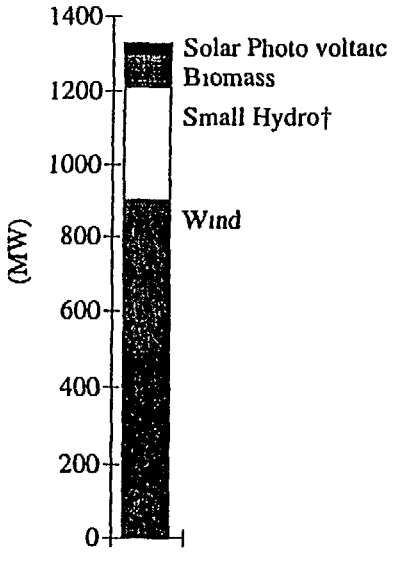
RENEWABLE ENERGY GROWTH IN INSTALLED CAPACITY

Non conventional energy sources which can generate grid-quality power are Biomass, Wind, Small Hydro Power, Solar Photo Voltaic Power, Solar Thermal and Energy from Urban, Municipal and Industrial Waste

Growth in Installed Capacity



Total Installed Capacity (Renewable Energy)



† As per official definition hydro projects under 15 MW are considered as small hydro projects

Comments

- The aggregate installed capacity based on renewable energy sources is approximately 1340 MW of which 67% is power generated from wind
- Total Installed capacity based on Waste Heat from Urban and Municipal Waste as of 31 March 1997 is 3 75 MW
- Projects aggregating to 90 MW are in the pipeline
- There are two demonstration solar thermal power projects in the country aggregating to 70 KW

Source Annual Report MNES, ACG Analysis

In wind energy development India is third in the world with 900 MW of installed capacity (As of March 1997)

RENEWABLE SOURCE OF ENERGY WIND

Overview

- The current programme to harness wind power in India gives high priority to development of wind farms on a large scale in the private sector
- The role of government is to act as a facilitator and to focus on policy legislation testing and standards training and education
- Promotional and fiscal incentives are being provided which includes
  - Tax concessions such as accelerated depreciation, tax holidays for power generation projects, soft loans customs and excise duty reliefs liberalized

Estimated Potential

- India has a wind power generation potential of over 20,000 MW

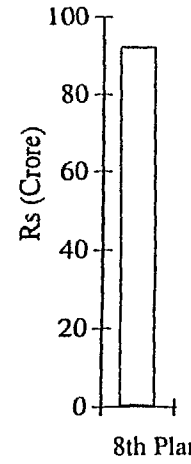
Installed Capacity

- Grid quality power generation from wind had considerable growth in the 8th Five year plan
- Wind power installed capacity as of September 1997 is 925 MW
- Approximately 50 MW of the total installed wind projects are demonstrative projects

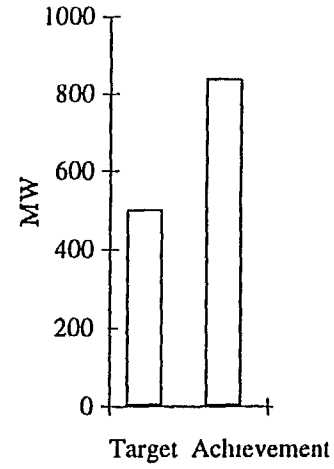
Incentives provided by Government for Wind Projects

- 100% depreciation benefit in the first year of installation
- Sales tax benefit in certain states
- Zero import duty on critical components
- In addition to these incentives different state government offer incentives to promote wind based power generation

Eighth Plan(1992-97) Outlay to Wind Power Projects



Target and Achievement (8th Plan)



The government is targeting an additional 2,000 mw through wind farms in the ninth plan, involving an investment of Rs 8,000 crore

Key Developments

1985-1990	1991-94	1994-97
• Wind survey programme was initiated in 1985 • A Wind Energy Centre set up at National Aeronautical Laboratory, Bangalore to provide technological inputs • The first Wind farm in the country was set up in January 1986 near Mandvi in the Gulf of Kachchh Gujarat • Comprehensive wind resource assessment program undertaken comprising of wind monitoring and wind mapping in several States/Union territories • World Bank fields an Economic Feasibility Mission to develop bankable projects aggregating to 75 MW in Tamil Nadu	• To attract private sector generation, states such as Tamil Nadu and Gujarat introduce promotional incentives • MNES revises its policy for wind power generation programme Policy to aim at commercialization, predominantly in the private sector	The government is targeting an additional 2 000 mw through wind farms in the ninth plan, involving an investment of Rs 8,000 crore

Source Annual Report MNES ACG Analysis

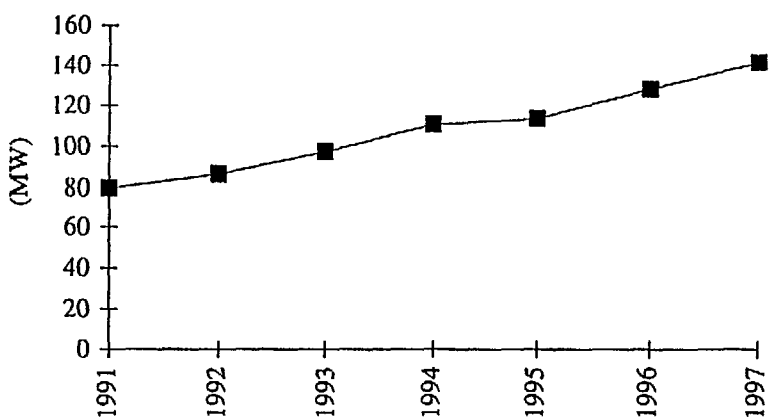
Total Installed clean technology' (based on USAID definition of clean technology) small hydro projects amounts to 650 MW

SMALL HYDRO PROJECTS DEFINITIONS

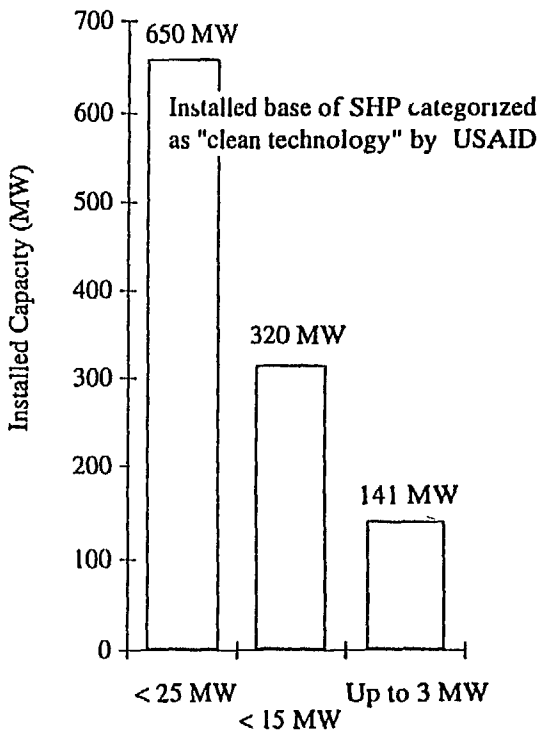
Small Hydro Project systems are generally of two basic types "run of the river" and "canal fall schemes"
The official definition of Small Hydro Projects in India is " Hydel projects under 15 MW"

- Hydel projects up to 3MW capacity come under the purview of Ministry of Non-Conventional Sources of Energy (MNES)
- Small hydro projects above 3 MW are dealt by Ministry of Power
- USAID categorizes hydro projects under 25 MW as "clean technology"

Growth in Installed Capacity (SHP Up to 3 MW)



Installed Capacity of Hydro Projects by MW Category



MNES Ministry of Non Conventional Energy Sources
SHP Small Hydro Project

Source Annual Report MNES ACG Analysis

Against the Eighth plan target for SHP projects of 600 MW the actual achievement in terms of installed capacity was only 60 MW

RENEWABLE SOURCE OF ENERGY SMALL HYDRO

Overview

- Small Hydro Power (SHP) technology was introduced in India in 1882, and the first SHP plant was commissioned in Darjeeling in the year 1887
- According to official definition small hydro implies hydel projects under 15 MW
- Soft loans are available from IREDA for these projects
- Other funding agencies like IFCI, ICICI and REC also provides financing for these projects
- In addition to central government incentives several state governments have announced polices to support Small Hydro Projects, which includes allowing wheeling & Banking third party sale and buy back of power by SEB's
- Three states which have been active in developing small hydro projects are Andhra Pradesh, Kerala and Uttar Pradesh

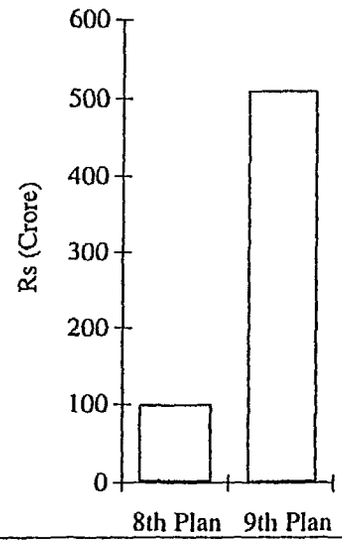
Estimated Potential

Approximate potential of small hydro projects is estimated as 10, 000 MW

Installed Capacity

- Total installed capacity of projects under 15 MW amounts to approximately to 320 MW
- As of March 1997 the installed base of small hydro power projects under 3 MW is 141 MW

Five Year Plan Allocation for Small Hydro (Rs Crore)



A capacity of 60 mw was commissioned during the Eighth Plan against a target of 600 mw
Bulk of the projects sanctioned during the Eighth Plan are likely to be commissioned during the first two years of the Ninth Plan

Key Developments

1985-1991	1992-1993	1994-1995	1996-1997
• The responsibility for developing micro/mini hydel projects (< 3 MW) transferred from Department of Power to Department of Nonconventional Energy Sources in early 1989 • World Bank Pre-Investment Survey of small hydel schemes initiated • Department of Nonconventional Energy Sources plans to add 200 MW capacity through small hydro projects during the Eight five year plan	• MNES revises its target for the 8th plan to 600 MW for Small Hydro Power Projects • World Bank line of credit of US $70 million made available to IREDA to provide soft loans for a total capacity of about 100 MW, to private developers for setting upto 15 MW capacity	• MNES introduces an interest subsidy scheme in the year 1995, in place of capital subsidy scheme The scheme involves an interest subsidy of up to 5% for SHP projects financed by financial institutions	A five-fold increase in the outlay for small hydro power is envisaged in the Ninth Plan It is likely to be about Rs 511 crore compared to Rs 100 crore in the Eighth plan

Source Annual Report MNES, ACG Analysis

Over 35,000 solar photo voltaic system aggregating to about 28 MW have been installed in the country

RENEWABLE SOURCE OF ENERGY· SOLAR

Overview

- Grid quality power can be generated from Solar Photo Voltaic and Solar Thermal Energy
- Grid interactive solar photo voltaic power projects aggregating to 810 kw have so far been installed
- Another 560 kw capacity was under implementation

Estimated Potential

Approximate potential of solar energy is estimated at 5 x 1015 KWh / y

Installed Capacity

- Over 350, 000 solar Photo Voltaic system aggregating to about 28 MW have been installed in the country
- A solar thermal power plant of 50 KW capacity was commissioned at the Solar Energy Centre, Gwal Pahari, Gurgaon as an R&D facility in April 1989
- This facility is the only one of its kind available in the country and Asia

Solar Thermal Power Plants

- The government of Rajasthan has chalked out plans to set up solar thermal power plants in the state
- The Government has signed a letter of intent in 1995 with Energen International, a Srilankan led consortium, to build a 140 MW solar thermal combined cycle power plant in Mathania This project is getting a financial aid of $49 million from Global Environment Facility
- The current configuration of the plant is a solar field of 40 MW, a conventional combined cycle of 60 MW and waste heat recovery of 40 MW
- There has not been any progress in this project even though a PPA was signed in 1996

Financial Support Pattern

- MNES provides subsidy for Small Solar PV Power Plant, which is 50% of the ex-works cost, subject to a maximum of Rs 2 0 lakh / KW

Key Developments

1985-1991	1992-1994	1995-1997
• A solar thermal power plant of 50 KW capacity commissioned • Feasibility study for a 30 MW Solar thermal power plant near Jodhpur in Rajasthan prepared	• Proposal for setting up of the 30 MW Solar thermal power plant is under appraisal for its techno economic viability	The centre is planning intensive use of solar energy to ensure continuous power supply in the Ninth Plan The ministry of non-conventional energy plans to commercialize and develop entrepreneurship in the renewable energy sector (1997)

Source Annual Report MNES, ACG Analysis

Inspite of incentives the total biomass energy potential tapped (for electricity generation) is less than 1%

RENEWABLE ENERGY SOURCES BIOMASS AND WASTE HEAT

Overview

• The biomass power generation activity of the MNES comprises of
(i) Bagasse based cogeneration (ii) Biomass combustion based power generation and
(iii) Grid interactive biomass gasifier based power generation

Estimated Potential

• Approximate potential of Biomass power is 17,000 MW and that of Power from Urban and Municipal wastes is 1700 MW

Installed Capacity

• Up to March 1997 the installed capacity of power projects based on biomass and Urban and Municipal Waste are 83MW and 3 75 MW respectively
• Projects (Waste Heat) aggregating to 90MW is under implementation

Financial Support from MNES for Biomass based power generation

1 Biomass Combustion Based Power MNES provides
(i) Capital Subsidy for Taluka level Biomass based power plant (1MW and above)
(ii) Interest Subsidy for captive projects (2MW and above)
(iii) Interest Subsidy for field based projects (2MW and above)

2 Bagasse based Co generation
(i) Capital Subsidy in Cooperative and Public Sector sugar mills
(ii) Capital Subsidy in other sugar mills
(iii) Interest Subsidy for projects of surplus power generation capacity

3 Biomass Gasification
(i) Subsidy for biomass gasifier for village electrification (75% of the project cost)

Key Developments

• DNES intensifies R&D in development and utilization of gasification technologies (1990)
• A programme initiated to recover energy from agricultural residues and industrial and municipal wastes
• Efforts to encourage cogeneration of power in sugar mill by using bagasse from sugarcane (1991)
• Pilot plant for development of cogeneration technology taken up in Tamil Nadu (1992)

• National Programme on Bagasse-based Cogeneration was launched in January 1994
• Andhra Pradesh announces policy for promoting generation of power from biomass projects (1994)
• Maharashtra Government issues formal notification
• MNES launches a National Programme with view to promote appropriate technologies for improving waste management practices in the country The duration of the programme is two years (1994)
• National Bioenergy Board (NBB) has been set up in the MNES for development of bioenergy in the country (1995)

• A comprehensive policy on non-conventional energy, spelling out the role of the govt, industry, the non-government organizations, research institutes and the users, is being finalized by the government and is expected to be announced shortly (1997)
• The Haryana government on Friday cleared a new policy to attract private investment in the non conventional energy sector The policy promises financial incentives to private entrepreneurs (IPPs) for setting up projects based on non conventional sources of energy like solar, wind, biomass cogeneration mini or small hydro and waste recycling

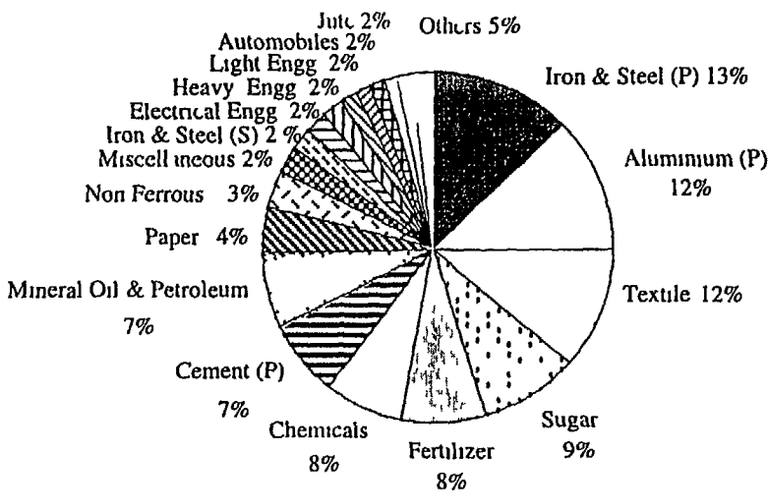
1985 1993 | 1994 1995 | 1996 1997

Source Annual Report MNES ACG Analysis

Iron and Steel, aluminium and textiles industries constitute 35% of the installed base of captive / cogen plants in India

CAPTIVE/COGENERATION INSTALLED BASE BY INDUSTRY AND TECHNOLOGY

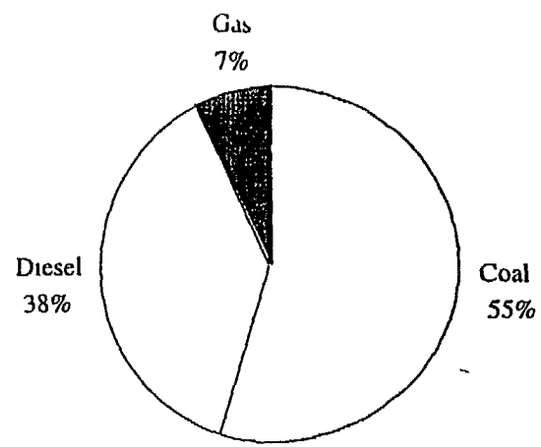
Captive/ Cogeneration Installed Base by Industry



Total 10,500 MW

† Others constitute Rubber, Collieries, Food Products, Aluminium (S) and Cement (S)
† Plastic & Mining & Quarrying are negligible

Captive/ Cogeneration Installed Base by Technology



Total 10,500 MW

† Wind and Hydro projects are negligible

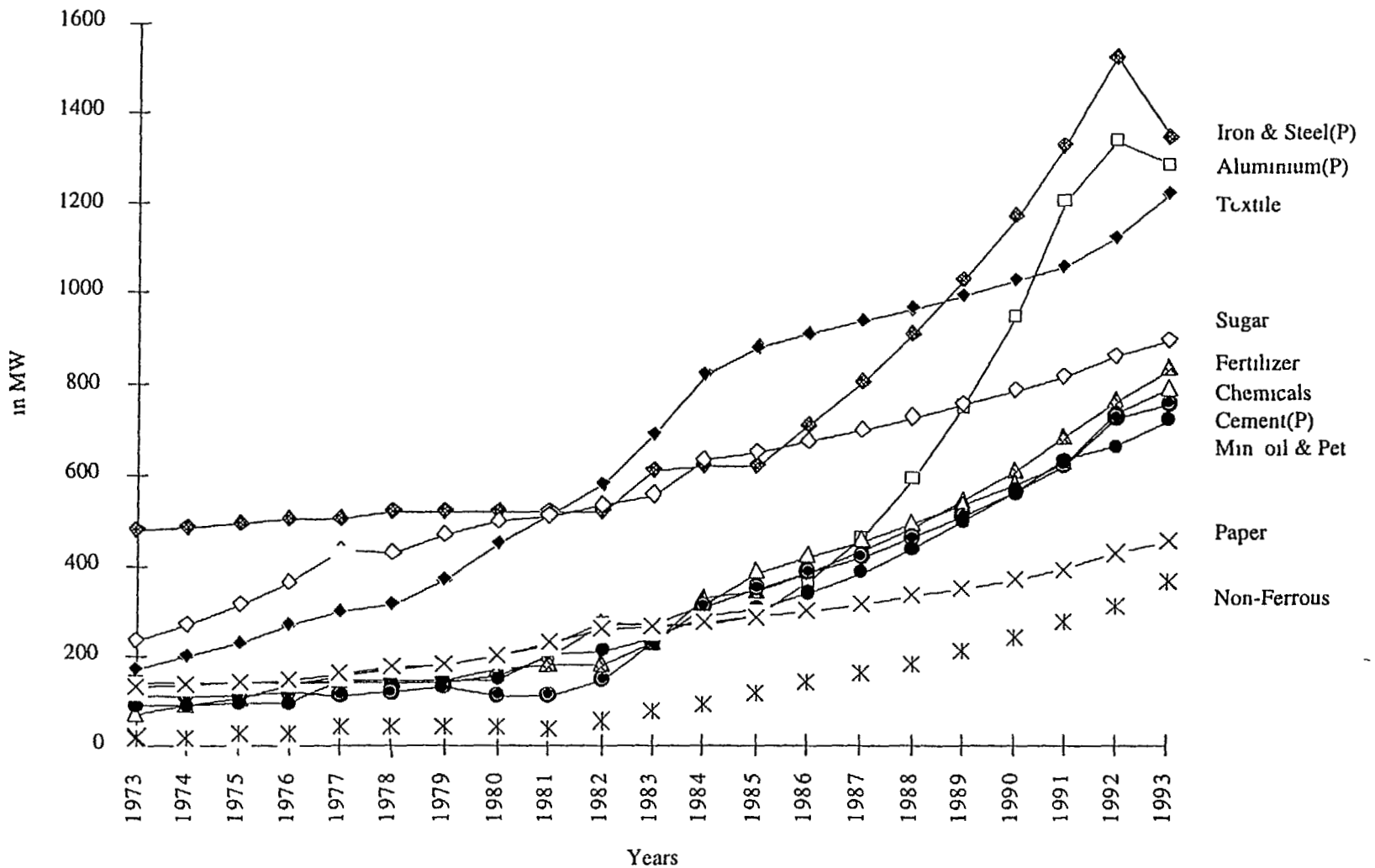
Comments

- Coal based plants are the preferred mode for power generation by captive/ cogeneration plants
- Installed base in Iron & Steel , Aluminium and textile sectors account for 35% of the total captive/ cogeneration base of India

Source Industry & Government Reports, ACG Models & Databases, ACG Analysis

The capacity additions started to rise in the early eighties with Iron & Steel (P) Aluminium (P) and Textile industries forming the major segment

HISTORICAL CAPTIVE / COGENERATION CAPACITY BY INDUSTRY (1973 - 93)



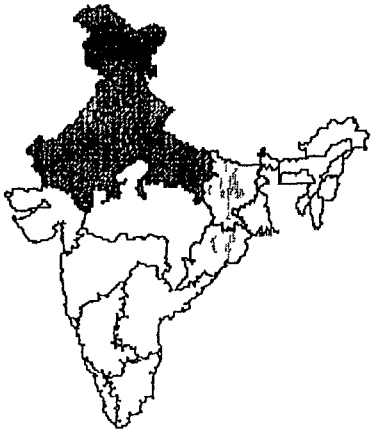
- Iron & Steel (P), Aluminium (P) and Textiles constitute 36% of the total installed generation in 1993
- Non ferrous and Chemical s sector have increased their capacities by over 90% since 1973
- In the past 5 years Non ferrous and Aluminium (P) have shown an increase in capacities by over 40%

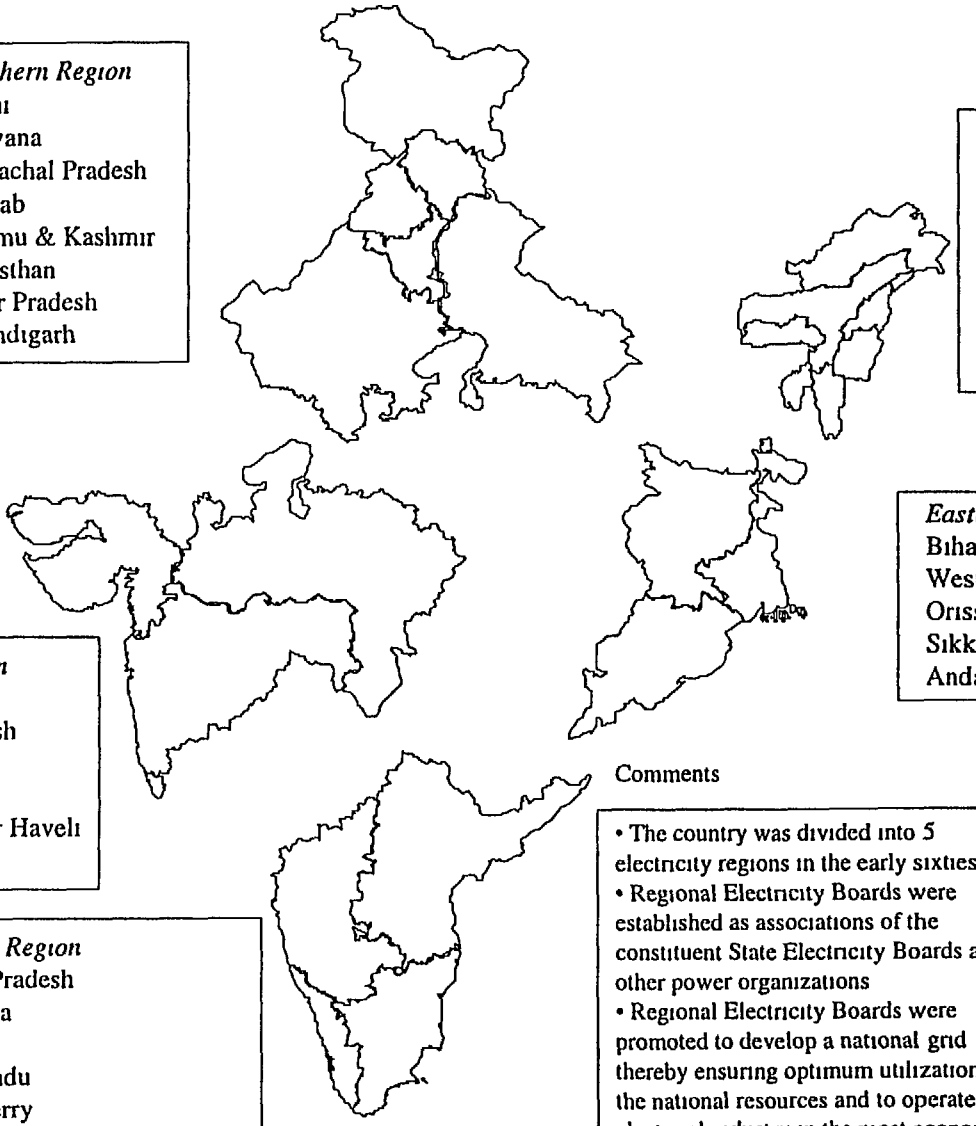
† (P) denotes primary industry

Source Industry & Government Reports, ACG Models & Databases, ACG Analysis

India is divided into 5 electricity regions with Regional Electricity Board's charged with the responsibility of coordinating the operation of power supply in their respective regions

INDIA REGIONAL ELECTRICITY BOARDS





Northern Region
Delhi
Haryana
Himachal Pradesh
Punjab
Jammu & Kashmir
Rajasthan
Uttar Pradesh
Chandigarh

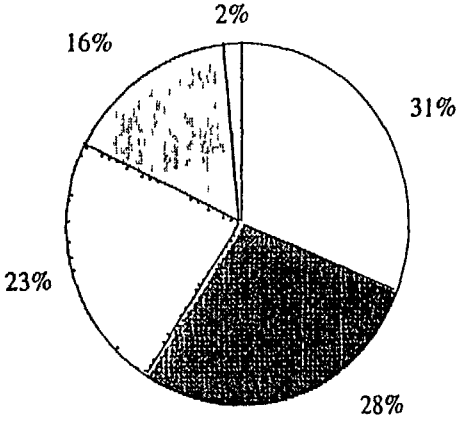
North Eastern Region
Assam
Meghalaya
Arunachal Pradesh
Manipur
Tripura
Mizoram
Nagaland

Eastern Region
Bihar
West Bengal
Orissa
Sikkim
Andaman & Nicobar Islands

Western Region
Gujarat
Madhya Pradesh
Maharashtra
Goa
Dadra & Nagar Haveli
Daman & Diu

Southern Region
Andhra Pradesh
Karnataka
Kerala
Tamil Nadu
Pondicherry
Lakshdweep & Minicoy Islands

Installed Capacity By Region



Total = ~ 85 GW

Comments

- The country was divided into 5 electricity regions in the early sixties
- Regional Electricity Boards were established as associations of the constituent State Electricity Boards and other power organizations
- Regional Electricity Boards were promoted to develop a national grid thereby ensuring optimum utilization of the national resources and to operate the electrical industry in the most economic and efficient way after recognizing the limitations of the state as a spatial unit of power planning and operation

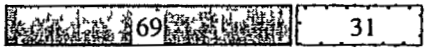
22 January 1998

† Lakshdweep & Minicoy Islands & Andaman & Nicobar Islands are not members of their respective regional grids

Source Profile of Power Utilities and Non Utilities in India - 1997, Industry & Government Reports, ACG Models & Databases, ACG Analysis

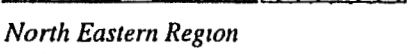
Western and Eastern regions are predominantly thermal based regions

INDIA REGIONAL ELECTRICITY BOARDS



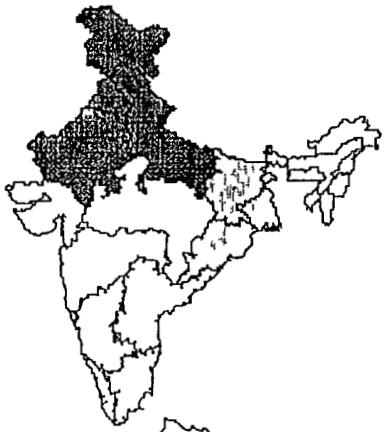
Northern Region

- Hydro electric resources are mainly located in the states of Jammu & Kashmir Himachal Pradesh and parts of Uttar Pradesh
- The region has a hydro electric potential of 30 GW and only 25% has been developed so far
- Coal deposits are located mainly in south eastern part of Uttar Pradesh



North Eastern Region

- The region has 37% of the total hydro electric potential of the country
- The region has a hydro electric potential of 31 GW
- Coal deposits have been found in Assam and Meghalaya



Eastern Region

- The region has 6% of the total hydro electric potential of the country
- The region has a hydro electric potential of 5 5 GW
- The region has about 70% of the total coal deposits of the country in the states of Bihar, Orissa and West Bengal

Western Region

- The region has inadequate hydro electric resources
- Coal deposits are mainly located in Madhya Pradesh and parts of Maharashtra and lignite deposits are located mainly in Gujarat

Southern Region

- Hydro electric resources are located in Karnataka, Kerala, Tamil Nadu and Andhra Pradesh
- The region has a hydro electric potential of 6 GW
- Coal deposits are located mainly in Godavari Valley and lignite deposits at Neyveli

Bars represent the Thermal Hydro ratio in the region
Numbers within the Bars represent the % Capacity in the region

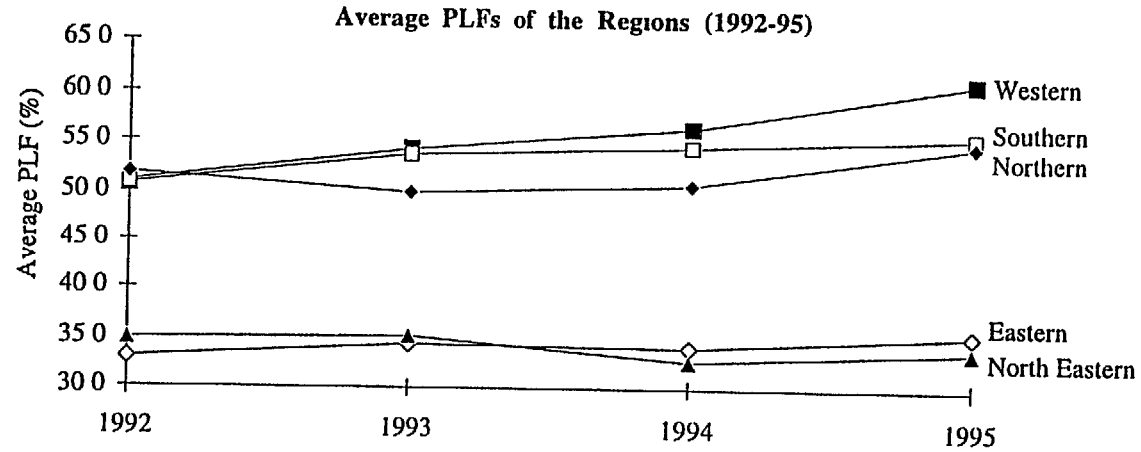
Legends for the Bars

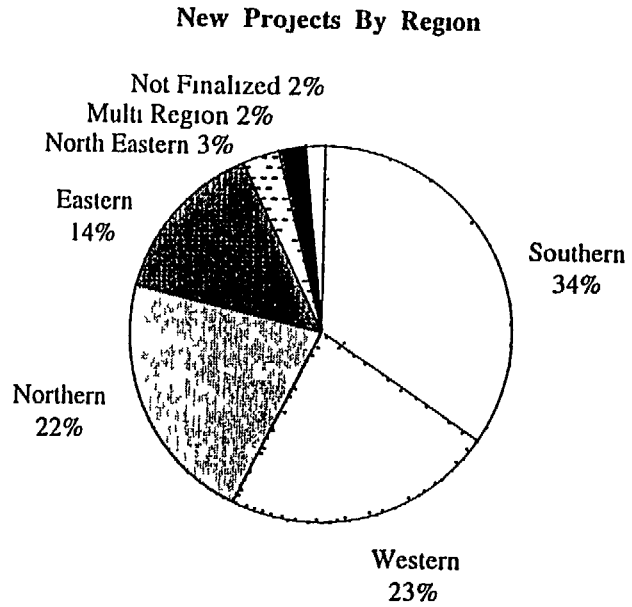
- Thermal
- Hydro

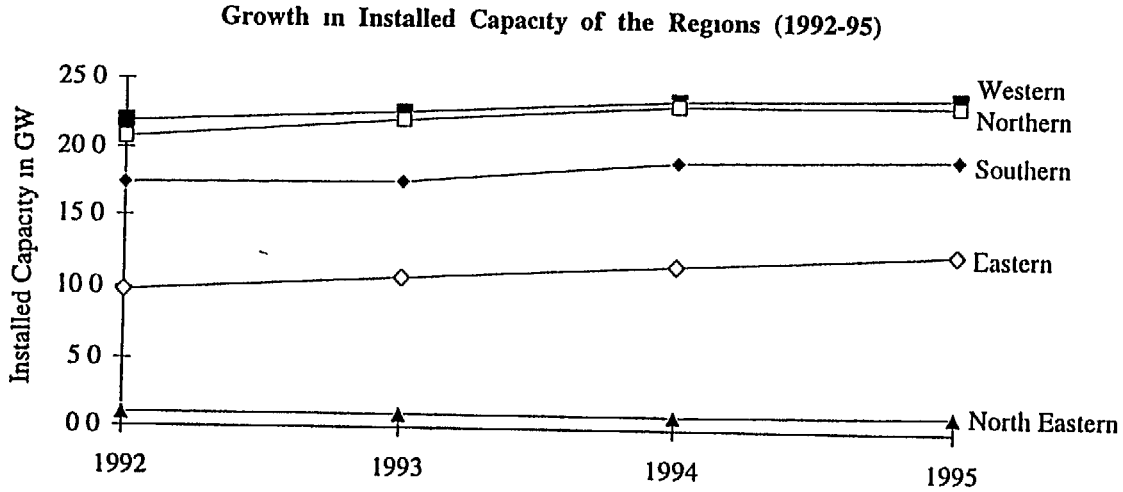
Source Profile of Power Utilities and Non Utilities in India 1997, Industry & Government Reports ACG Models & Databases ACC Analysis

Eastern and North Eastern Region power plants operate at PLFs in the 30% range

REGIONAL PERFORMANCE & PLANS







Total = 336 GW

† Note Captive/ Cogen projects have been omitted above

Note
- Multi Region represents those projects which are proposed to be setup in different states but their locations have not been finalized as yet

Comments

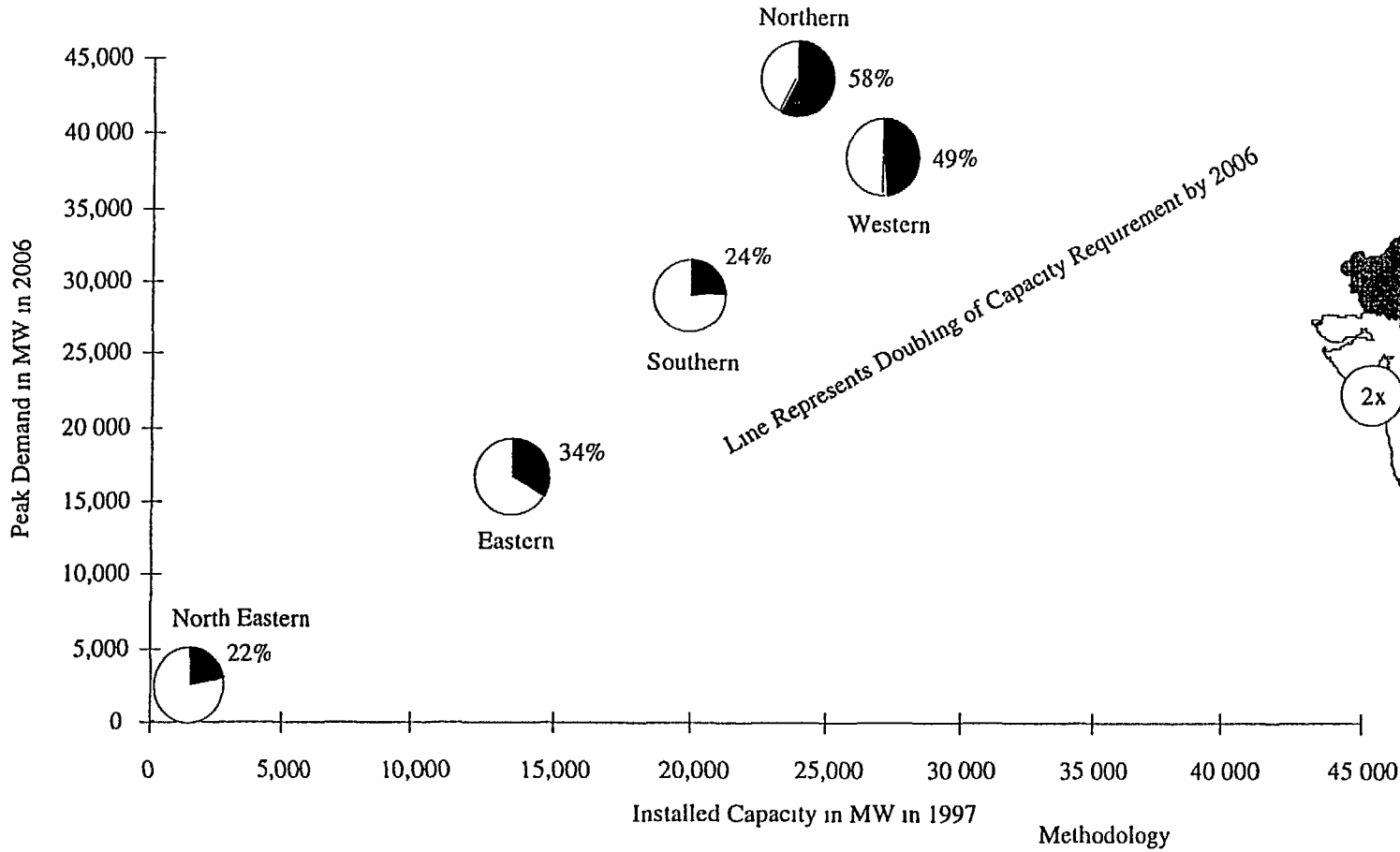
- Western Region has the largest share in the installed base and the plants in the region operate at about 60% PLF
- Southern Region accounts for one third of the new projects being developed in the country

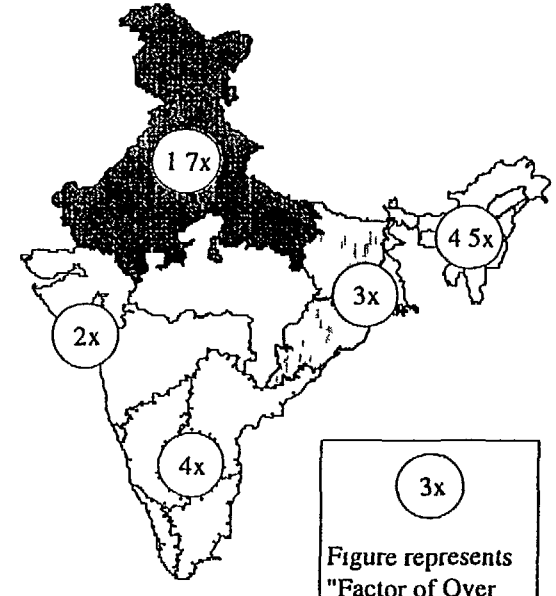
22 January 1998

Source Profile of Power Utilities and Non Utilities in India - 1997, Industry & Government Reports, ACG Models & Databases, ACG Analysis

The demand as % of the projects under development gives the % risk associated with the region's new projects

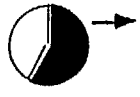
REGIONAL ANALYSIS OF DEMAND VS SUPPLY POTENTIAL





3x

Figure represents "Factor of Over Development" relative to Demand Projection



- Demand Projection of the region as % of Total MW Under Consideration / Development in the region
- The Black portion represents success rate required of projects under development / consideration required to meet the demand projection

Methodology

- The Installed Capacity by Region is derived from NPT ™
- The Peak Requirement in the region for year 2006 is sourced from the 15th Annual Power Survey
- The Total MW under consideration / development is derived from NPT ™

22 January 1998

Source National Project Track™ 15th Electric Power Survey of India ACG Models & Databases ACG Analy is

RLDC s do not follow merit order dispatch Presently, scheduling is being done for Central sector utilities

REGIONAL LOAD DISPATCH CENTER OVERVIEW

Regional Electricity Board

Regional Electricity Board

- Chairman of the Representing SEBs († one of the Chairman then is elected as the chairman of the REB)
- Representatives of Generating Agencies († not eligible for appointment as chairman)

Regional Load Dispatch Centers

- Set up in 1962 by Government of India for coordination in the area of power system planning and operation
- Main function is overall grid management
- Operating arm of the Regional Electricity Board
- RLDCs till recently were staffed and funded by the Central Government and functioned under the overall guidance and control of the Regional Electricity Board
- The RLDCs have now been transferred to the Power Grid

Power Grid Corporation of India Limited

Southern RLDC (1994)	North Eastern RLDC (1995)	Eastern RLDC (1995)	Western RLDC (1996)	Northern RLDC (1996)

† Numbers in bracket represent the year of transfer of Region's RLDC to Power Grid Corporation of India

Operating Practices

- Regional Electricity Boards are presently responsible for scheduling and dispatching the regional power system which includes maintenance schedules, setting of tariffs for inter agency power transfer and billing
- Load Despatch Center s are the basic prerequisites for economic despatch of power between Regions/ States and effective on-line grid management of Regional and National Power Grids
- At present RLDCs are not scheduling all the power stations in the region
- Scheduling is being done for central sector generating stations only and many of the state's generating stations are being left out
- SLDCs are working independently and their power stations are not directly controlled by the RLDCs
- Each state in a region operates as a independent control area although state grids are connected by central transmission networks and inter state links
- At present, there is no standard methodology and procedure for overall merit order operation being followed
- Appropriate system for determining the priorities for generation amongst different generating stations is non-existent

† Regional Load Despatch Center (RLDC)
† State Load Despatch Center (SLDC)
† Regional Electricity Board (REB)
† State Electricity Board (SEB)

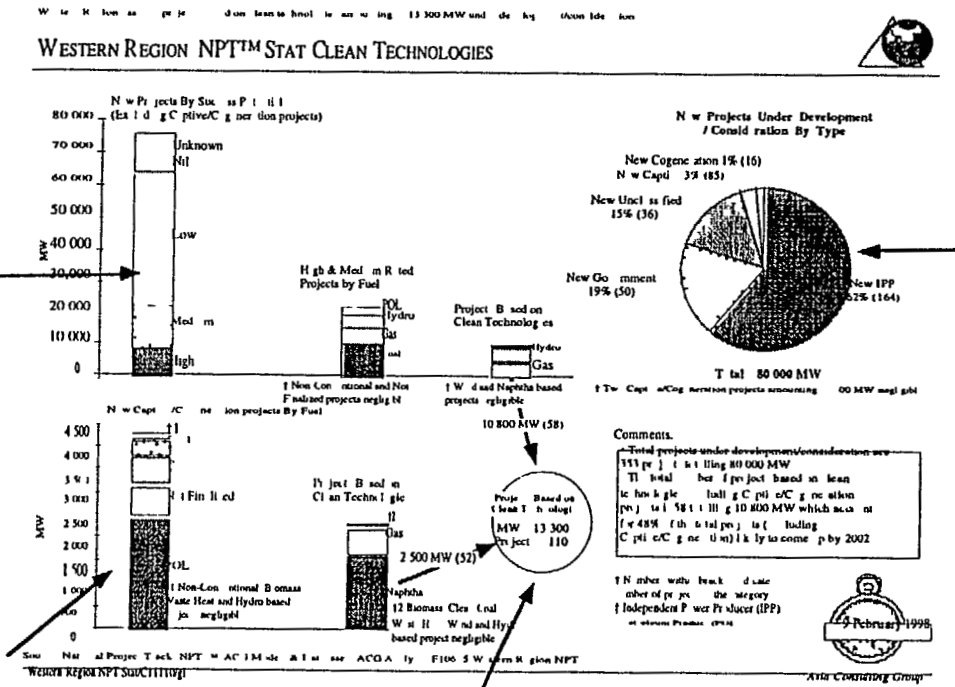
Source Industry & Government Reports, ACG Models & Databases, ACG Analysis

The methodology takes into account all projects including captive/cogeneration projects likely to materialize by 2002 in the final analysis

METHODOLOGY REGIONAL NPT™ STATUS CLEAN TECHNOLOGIES

- Clean technology based projects are hydro, gas naphtha based projects
- Projects which use Clean coal technologies like Integrated Coal Gasification Combined Cycle (IGCC) and Pressurized Fluidized Bed Technologies (PFB) are classified as projects based on clean technology
- Projects based on renewable sources of energy - wind & solar are also clean technology based projects
- National Project Track™ tracks 2,400+ projects including Captive/Cogeneration projects in the country

- Projected Capacity additions are based on ACG s ratings
- Only projects with High and Medium success potential have been assumed to materialize by 2002
- Classification of the High and Medium rated projects by Fuel type
- Identification of projects based on clean technology

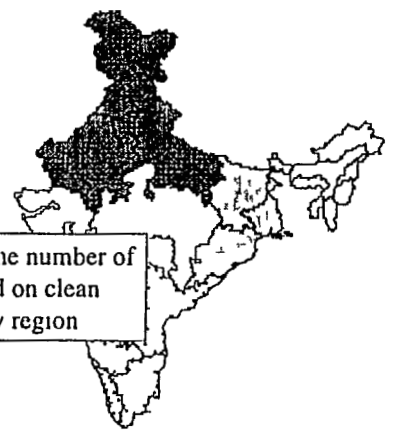


- New Project classification by Type-includes Captive, Cogeneration, IPP, Government etc in the region

- Captive/Cogeneration projects although not rated may be accorded a high medium success potential due to
  - Guaranteed Offtake
  - Balance sheet financing
  - Lower number of clearances required
- Classification of the Captive/Cogeneration projects by Fuel Type
- Identification of projects based on clean technology

Total projects including captive/cogeneration based on clean technology likely to materialize by 2002

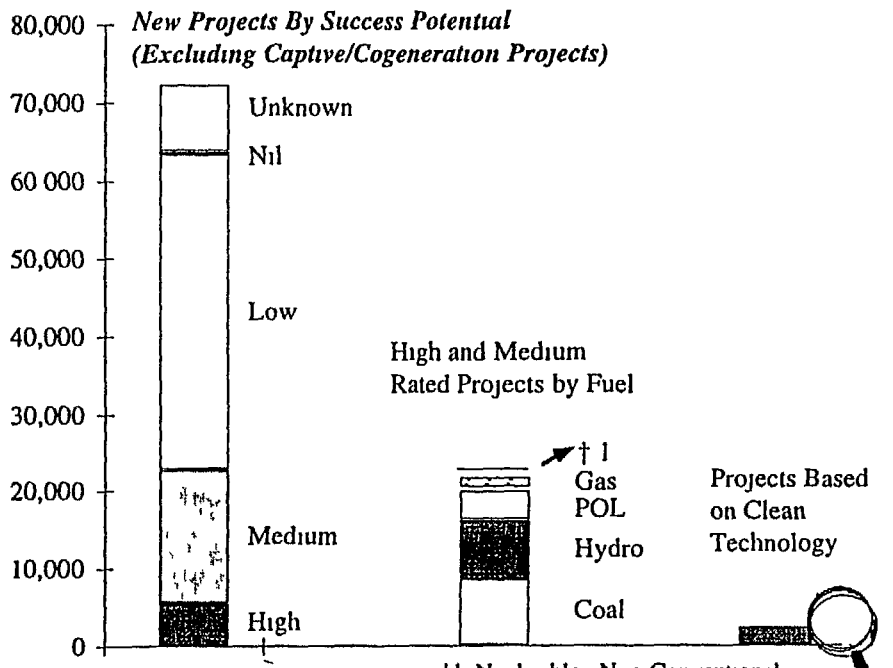
- This gives the number of projects based on clean technology by region



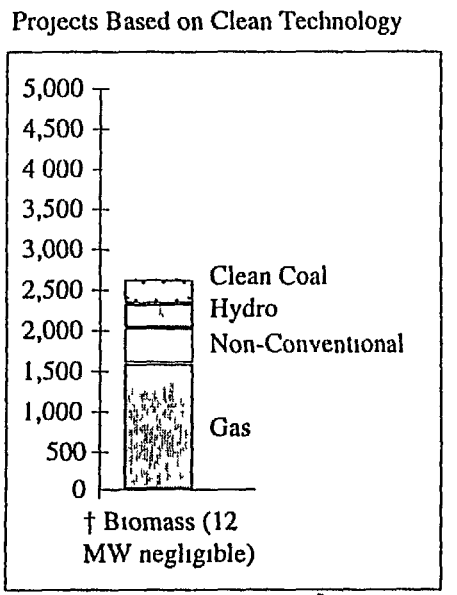
Source National Project Track™, ACG Models & Databases, ACG Analysis

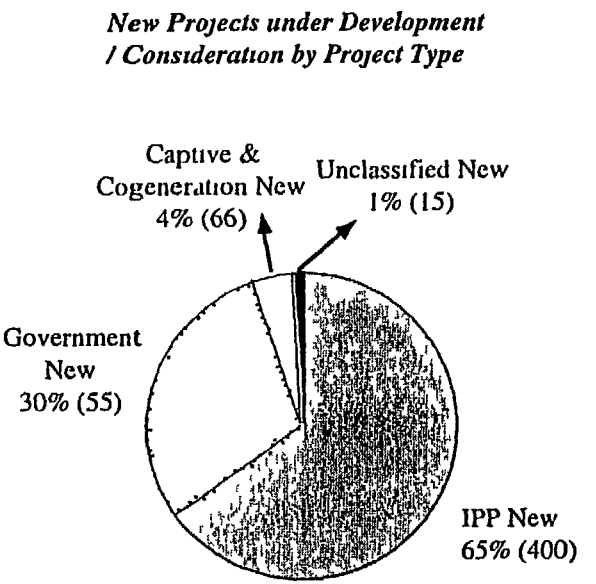
Northern region may add 3,091 MW based on clean technologies by the year 2002

NORTHERN REGION NPT™ STATUS CLEAN TECHNOLOGIES

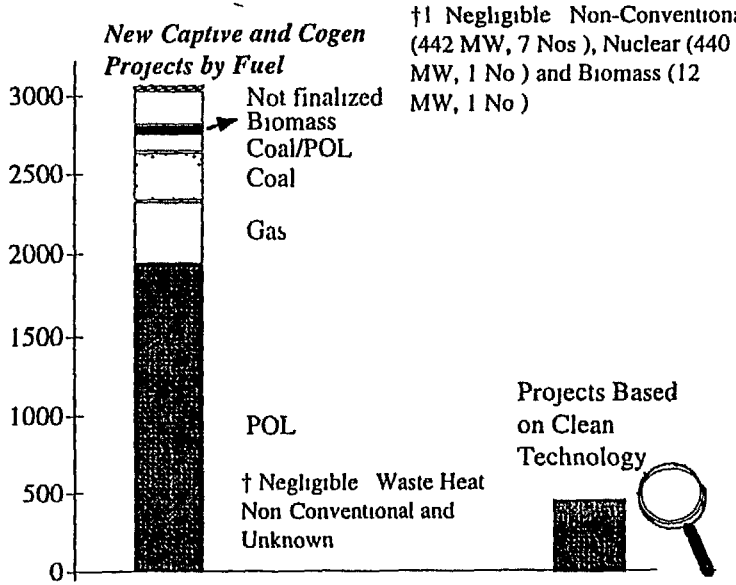


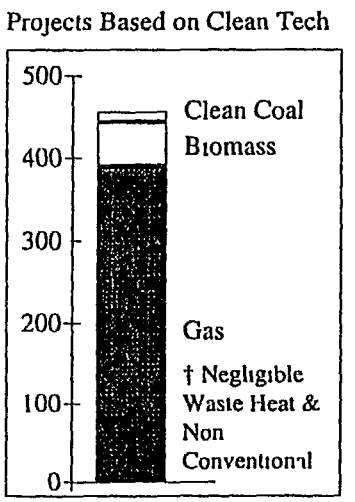
†1 Negligible Non-Conventional (442 MW, 7 Nos), Nuclear (440 MW, 1 No) and Biomass (12 MW, 1 No)





Total = 75,440 MW (536)





Projects based on Clean Tech
MW = 3,091 MW, Projects 184

Comments

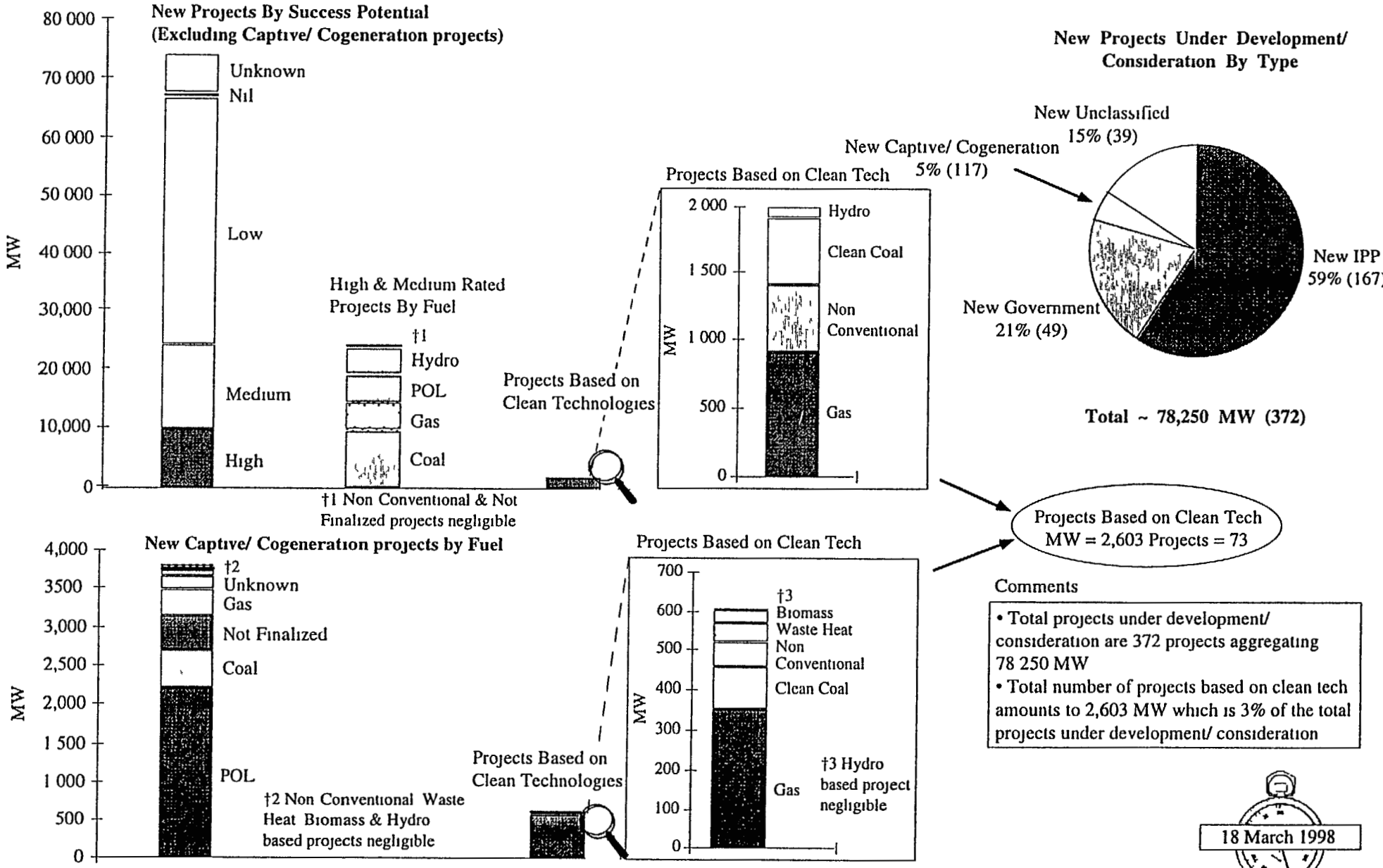
- Total projects under development / consideration in the Northern region amount to 75,440 MW
- Total number of projects based on clean technologies amount to 3,091 MW which equals 4% of the total MW of the projects under development in this region

Source National Project Track (NPT)™, ACG Analysis

† Numbers in parenthesis indicate the number of projects

Western Region has 73 projects based on clean technologies aggregating 2 600 MW under development/ consideration

WESTERN REGION NPT™ STATUS CLEAN TECHNOLOGIES



Comments

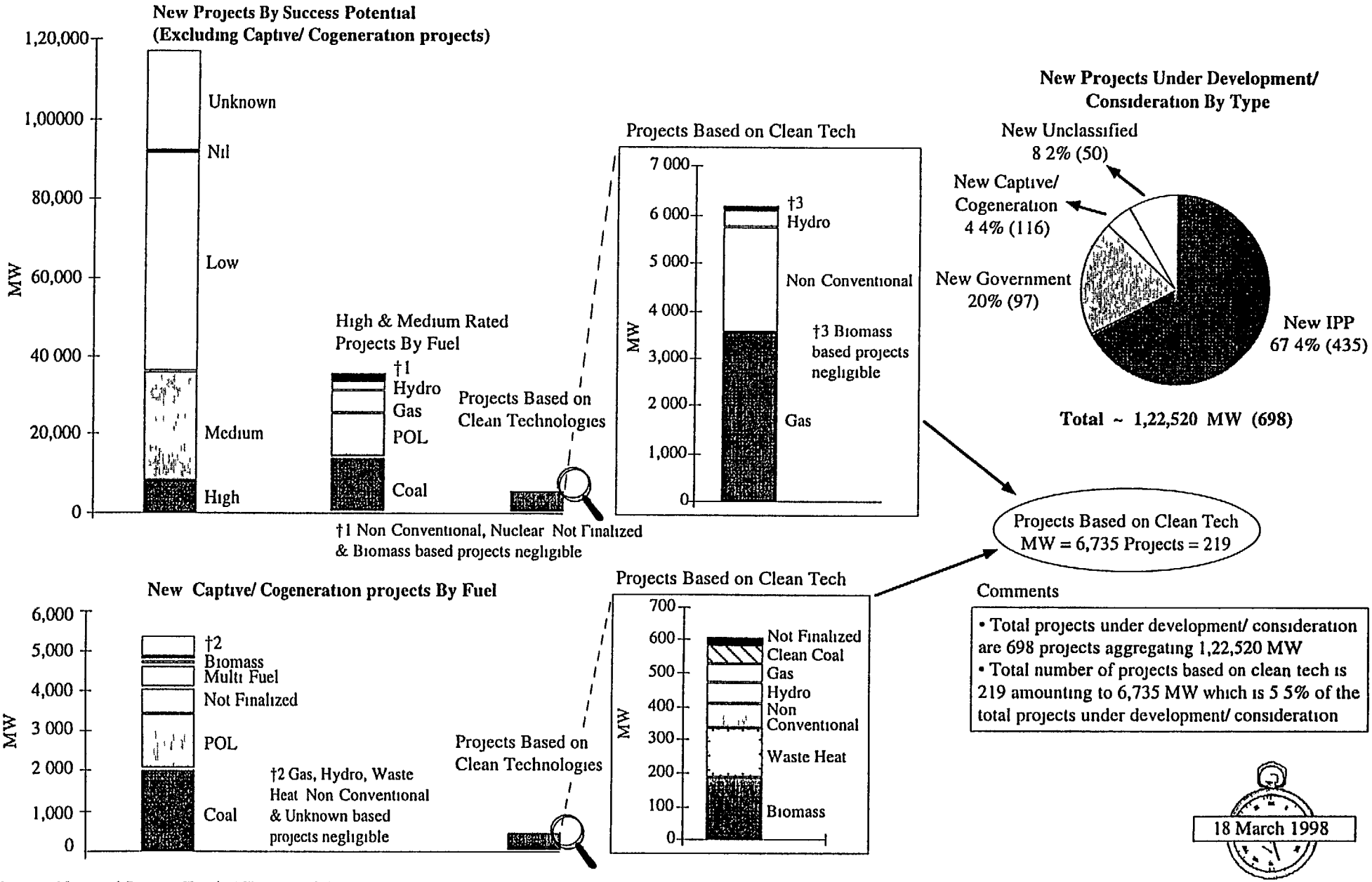
- Total projects under development/ consideration are 372 projects aggregating 78 250 MW
- Total number of projects based on clean tech amounts to 2,603 MW which is 3% of the total projects under development/ consideration

Source National Project Track (NPT)™, ACG Analysis

† Number in parenthesis indicates the number of projects

Southern region has 219 projects based on clean technologies aggregating to 6,735 MW under development/ consideration

SOUTHERN REGION NPT™ STATUS CLEAN TECHNOLOGIES

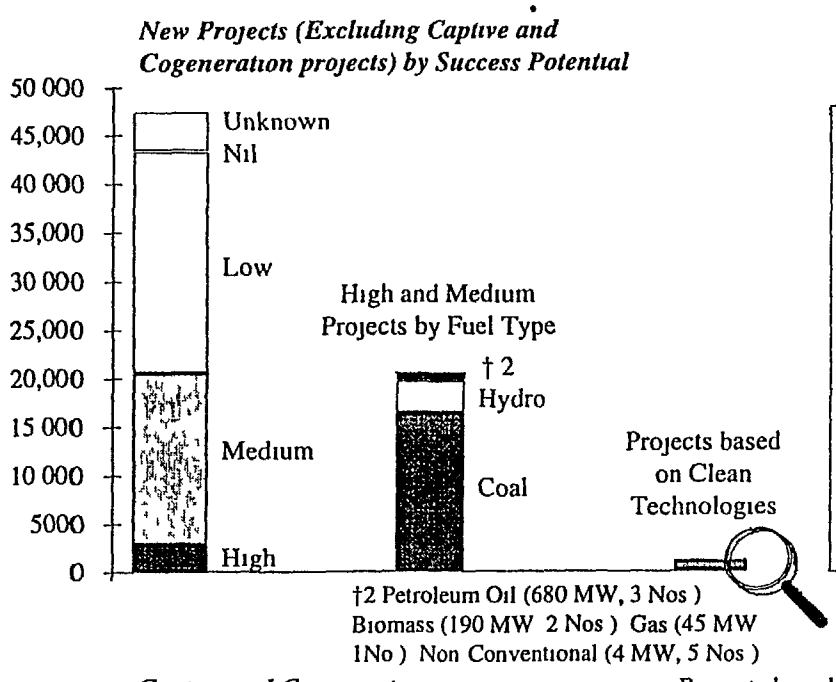


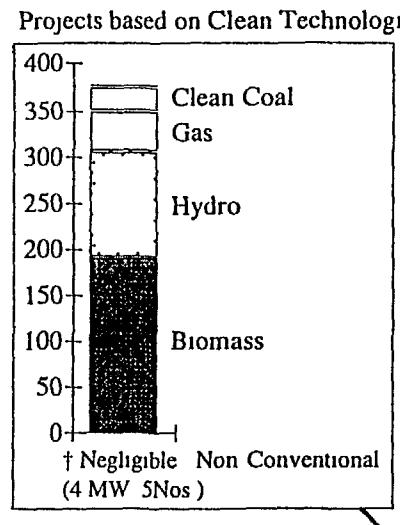
Source National Project Track (NPT)™, ACG Analysis

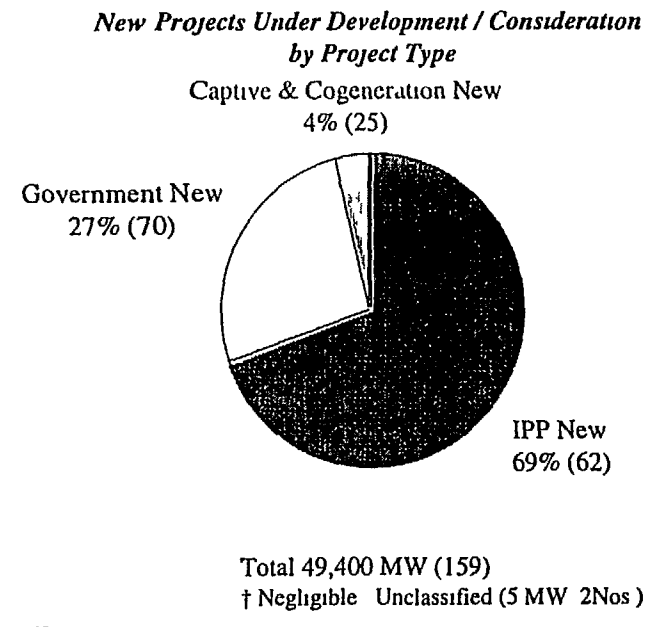
† Numbers in parenthesis indicate the number of projects

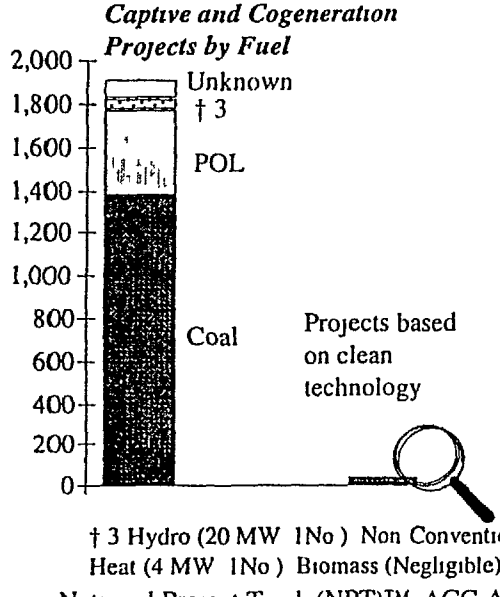
Eastern Region has 33 projects based on clean technologies amounting to 407 MW, which are expected to be commissioned by 2002

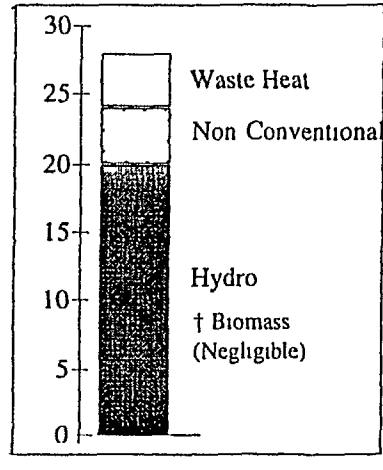
EASTERN REGION NPT™ STATUS CLEAN TECHNOLOGIES











Total projects based on clean technology 407 MW, 33 Nos

Comments

- Total projects under development/ consideration are 159 projects amounting to 49,400 MW
- Total number of projects based on clean tech amounts to 407 MW which is 0 8 % of the total projects under development/ consideration in this region

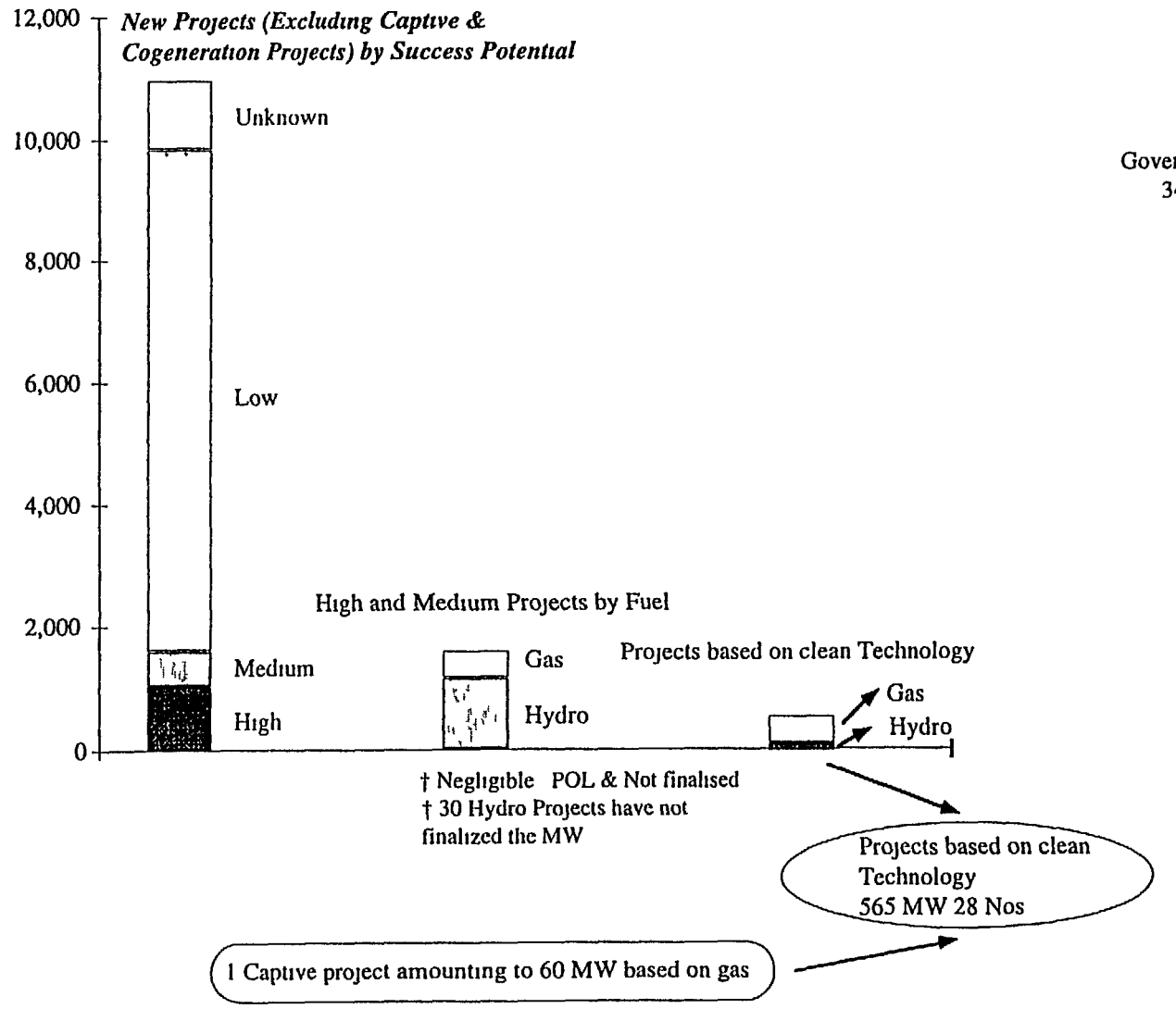
18 March 1998

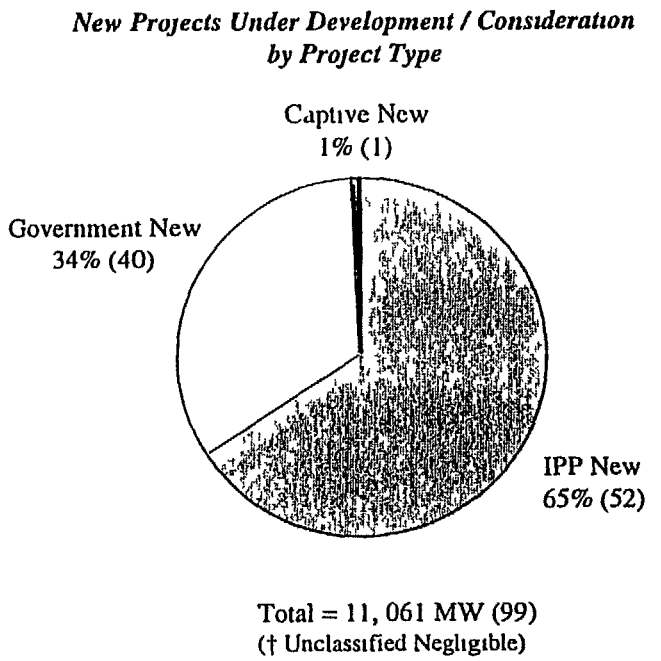
Source National Project Track (NPT)™, ACG Analysis

† Number in parenthesis indicate the number of projects

North Eastern Region is expected to add approximately 565 MW based on clean technologies

NORTH EASTERN REGION . NPT™ STATUS CLEAN TECHNOLOGIES





Comments

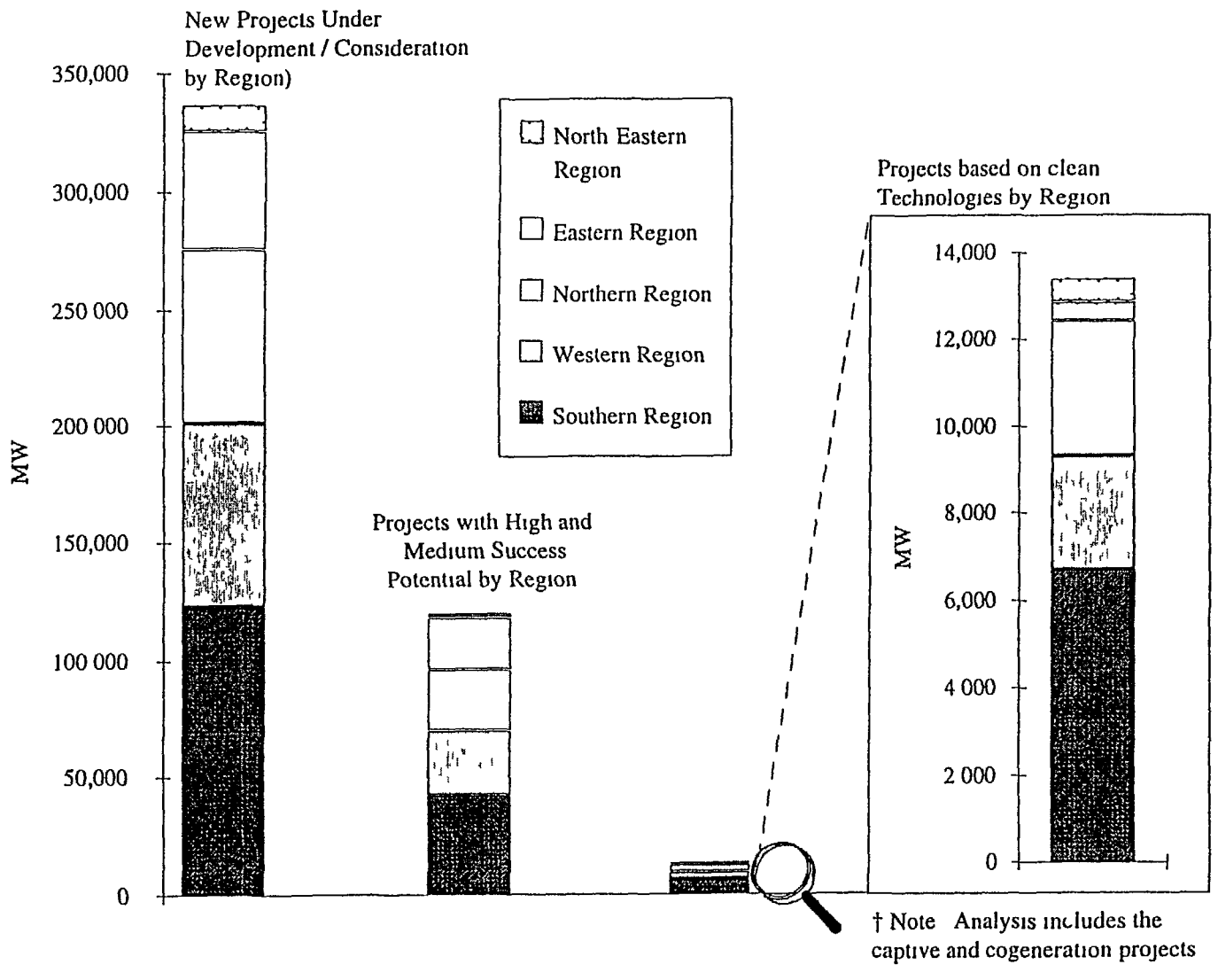
- 99 Projects amounting to 11,061 MW under development / consideration
- 28 projects amounting to 565 MW to be based on clean technologies which is approximately 5% of the total projects under development

Source National Project Track (NPT)™, ACG Analysis

† Numbers in parenthesis indicate the number of projects

Approximately 535 projects amounting to 13,400 MW (based on clean technologies†1) may be commissioned by 2002

NPT™ STATUS CLEAN TECHNOLOGIES SUMMARY



† Note Analysis includes the captive and cogeneration projects

Comments

- Approximately 535 projects amounting to 13 400 MW (based on clean technologies†1) are expected to be commissioned by 2002
- Southern Region alone accounts for nearly 50% of the capacity expected to be added by 2002
- Projects based on clean technologies †1 (expected to be commissioned by 2002) in all the regions (except the eastern region) form nearly 3-5% of their total capacity under development as on date

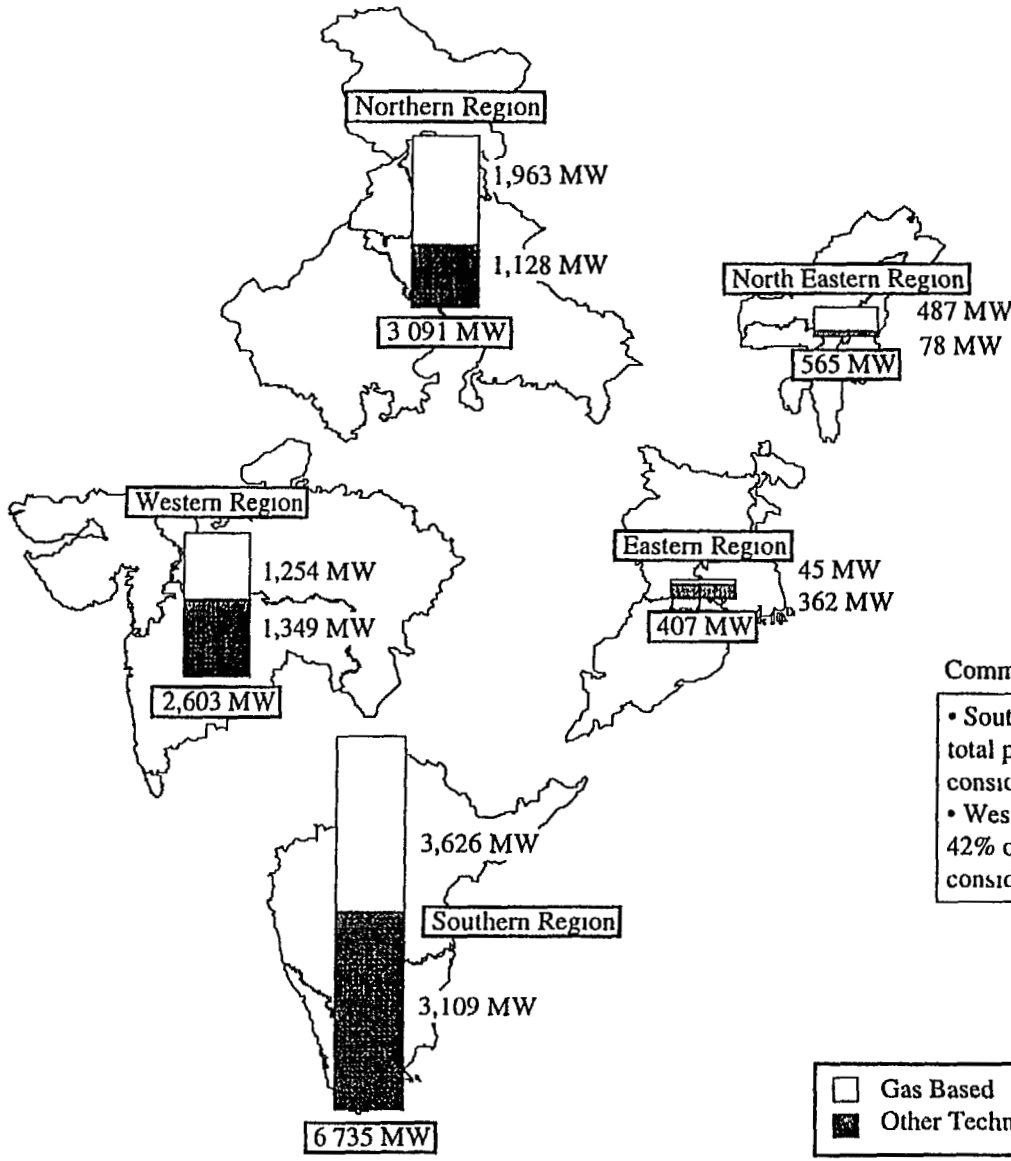
†1 Clean Technology As Defined by US Agency for International Development (USAID)

18 March 1998

Source National Project Track™ ACG Models & Database ACG Analysis

537 projects aggregating 13,401 MW under development/ consideration are based on clean technology

NPT™ STATUS CLEAN TECHNOLOGIES SUMMARY



Comments

- Southern Region accounts for 50% of the total projects under development/ consideration based on Clean Technology
- Western & Northern Regions account for 42% of the total projects underdevelopment/ consideration based on Clean Technology

Gas Based
Other Technologies

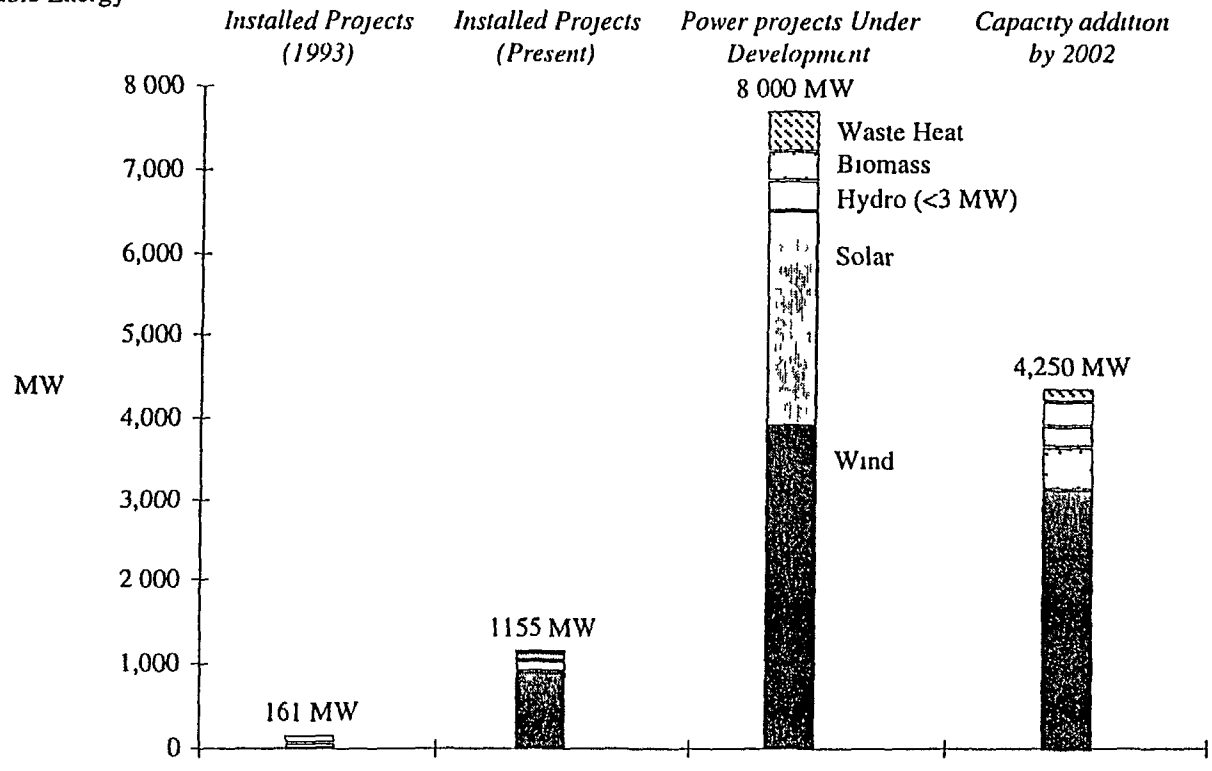
Source ACG Analysis

Power projects based on Clean Technology ' are expected to constitute approximately 19% of the total installed capacity by the year 2002

CLEAN TECHNOLOGY STATUS SUMMARY

Historical and Projected Installed Capacity (Clean Technology)

Power Projects Based on
Renewable Energy



- Power projects based on "Clean Technology" constitute approximately 9% of the total installed capacity of the country
- " Clean Technology" power projects would constitute approximately 19% of the total installed capacity by the year 2002
- Gas based power projects are expected to constitute 55% of the capacity addition in clean technology

Gas	6,177 MW	37,650 MW	7865 MW
Hydro (>3 < 25 MW)	612 MW	1,530 MW	865 MW
Others †	-	-	420 MW
Total (Clean Technology)	7,944 MW	47,180 MW	13,400 MW
Total (All Technologies)	89, 150 MW	360,660 MW	112,550MW
	8 9%	13%	18 9%

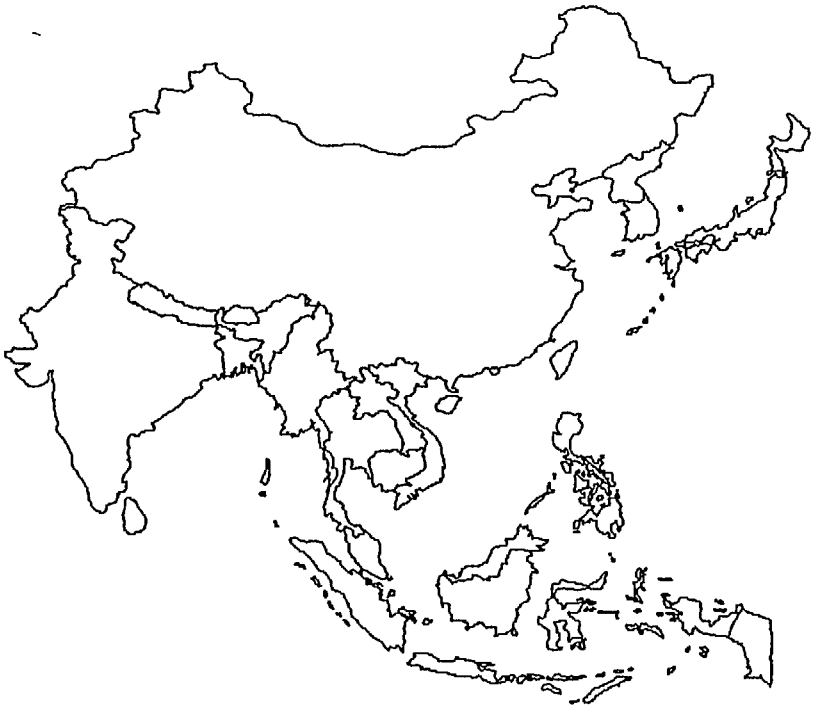
Note
- Non Clean Technology Capacity addition has been assumed as 2500 MW per year
- Figures in circle indicate Clean Tech based projects as a % of total projects MW by all technologies

(%)

† Others include projects based on clean coal technologies

Source ACG Models & Databases, ACG Analysis

SECTION TITLE CONCLUSION



CONTENTS

CLEAN TECHNOLOGY CONCLUSIONS
CLEAN TECHNOLOGY CONCLUSION (CONDT)

1 2 3 4 5

Source

CLEAN TECHNOLOGY CONCLUSION

"Clean Technology" according to USAID definition includes Gas/LNG, Clean Coal Technology, Hydro (> 3 < 25 MW) based power projects, in addition to Renewable Energy Power projects

Overview

- "Clean Technology" based power projects accounts for 9% of the total installed capacity of the country, this is expected to grow to approximately 19% by the year 2002
- A total of 537 projects aggregating to 13,400 MW, based on clean technology are expected to be commissioned by 2002
- Primary reason for this growth is the projected capacity addition of Gas/LNG based power projects in the country

Government Initiatives

- Renewable Energy power projects are promoted by the government with policy as well as financial incentives
- The central government as well as various state government has formulated a number of incentives for developers of renewable energy power projects
- In addition soft loans at nominal interest rates are provided by IREDA for developing these projects
- The initiatives of the government has resulted in a seven fold increase in the installed capacity of renewable energy power projects from 1993 to 1997
- The Ministry projects a capacity addition of 3000 MW in the renewable energy sector

Regional Analysis

- Southern region accounts for approximately 50% of the total "clean technology" based projects expected to be commissioned by the year 2002
- Southern states, have given major thrust to the development of non-conventional energy sources
- Western & Northern accounts for 42% of the total new projects on clean technology expected to be commissioned by the year 2002

Source Annual Report MNES ACG Analysis

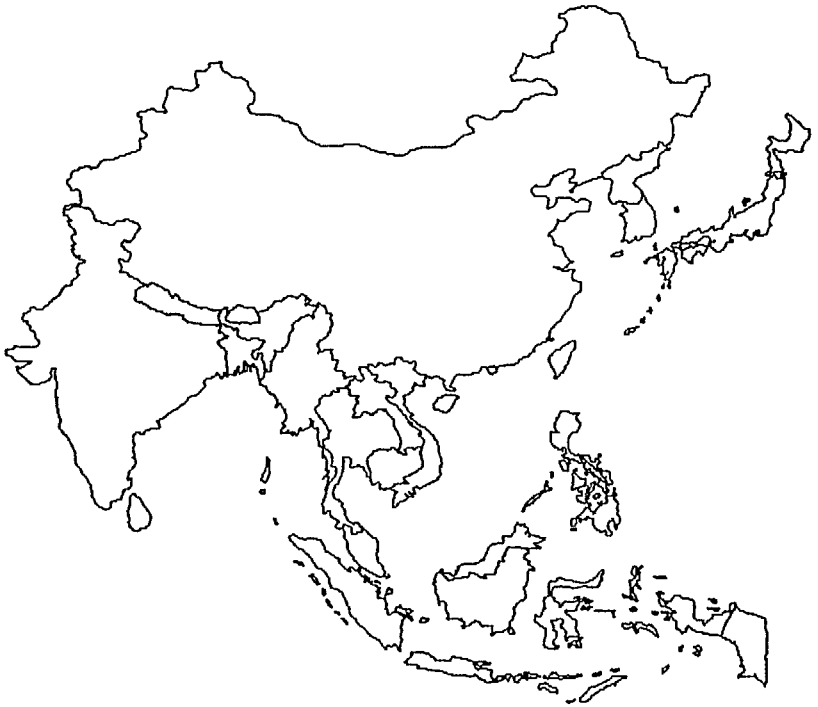
USAID can play significant role to develop the ' clean technology" based power projects in the country

CLEAN TECHNOLOGY CONCLUSION (CONDT)

Technology	Activities	Possible USAID Role
Gas	• A number of private players and government companies have plans to develop large Gas / LNG based power projects owing to the environment friendly nature of these projects • New gas based projects are expected to be commissioned by the year 2002	• Program to develop awareness for developing Gas based projects could be conducted at the Ministry / SEB level
Wind	• Driven by incentives from state as well as central government there has been considerable rise in the installed base • Against a projected capacity addition of 500 MW in the Eighth five year plan the actual capacity addition was around 800 MW • The government has plans to install an additional capacity of 2000 MW in the Ninth five year plan	• Can play key role in formulating new innovative policies for the growth of this sector
Solar	• In spite of key initiatives by Rajasthan government to develop solar thermal power projects there has not been any significant progress in capacity addition • The primary hinderance in the PPA signed between the government and the private party • Installed Solar Photovoltaic modules amount to 28 MW	• Awareness program for rural population for using solar energy could be undertaken • Could be involved in developing special contractual documents for solar thermal projects
Biogass / Cogeneration	• The present installed capacity based on this technology is approximately 85 MW • With a total potential of approximately 17,000 MW this technology can contribute substantially to the capacity addition of clean technology in the coming years	• USAID has played significant role in promoting projects based on biomass
Small Hydro Power	• Capacity addition in Small Hydro Power projects have been slow in the recent years • Against a target of 600MW in the, 8th Plan the actual installed was approximately 60 MW • Long gestation period of these projects are	• Could play a significant role in formulating policies for increasing private participation in this sector
Industrial and Municipal Waste	• A number of states have come up with incentives to promote this technology • The present installed capacity is mere 3 75 MW, with almost 90MW of projects in the pipeline	
Other Technologies	• 490 MW of clean coal technology based power project are under implementation • Other sources such as Ocean Thermal Power, Geothemal and Tidal power in spite of having high potential have not yet been exploited	• USAID has played significant role in promoting projects based clean coal technology

Source Annual Report MNES, ACG Analysis

SECTION TITLE APPENDIX



CONTENTS

CLEAN COAL TECHNOLOGY OVERVIEW
INTEGRATED GASIFICATION COMBINED CYCLE TECHNOLOGY
INTEGRATED GASIFICATION COMBINED CYCLE OUTLINE
ABBREVIATIONS

1 2 3 4 5

CLEAN COAL TECHNOLOGY OVERVIEW

- Coal will continue to be an important primary energy source worldwide and will have to meet the increasing stringent requirements in terms of cost effectiveness and environmental compatibility Increasing environmental concerns have resulted in a growing interest in clean coal technologies
- The Burning of Coal liberates 2 types of gases which are linked to the formation of acid rain
  - Nitrogen Oxides (NO_x)
  - Sulfur Dioxide (SO_2)
- New technologies are required to utilize coal efficiently and cleanly than the pulverized coal fired technology presently adopted
- Clean coal technologies focuses on total system improvements that yield higher efficiencies and very low emissions
- Clean coal technology addresses a wide range of energy and environmental issues
  - Acid Rain
  - Global Climate Change
  - Improved Energy Efficiency
  - Energy Security
  - Environmental Quality

Clean Coal Technology (CCT) Program of USA (1985)

- The CCT program is a partnership between the United States Department of Energy and Industry
- Total projects - 40, of which 20 have completed operations, 7 are in operation, 5 in construction, 7 in design and 1 in negotiation

Application Categories

- Advanced Electric Power Generation
  - Fluidized bed Combustion
  - Integrated Gasification Combined Cycle
  - Advanced Combustion Technologies
- Environmental Control Devices
  - NO_x Control Technologies
  - SO_2 Control Technologies
  - Combined SO_2/ NO_x Control Technologies
- Coal Processing for Clean Fuels
  - Coal Preparation Technology
  - Mild Gasification
  - Indirect Liquefaction
- Industrial Applications

Clean Coal Technologies

- Coal Cleaning Washing the coal for power generation
- Fluidized bed Combustion
  - Atmospheric Fluidized Bed Combustion (AFBC)
  - Pulverized Fluidized Bed Combustion (PFBC)
- Integrated Gasification Combined Cycle (IGCC)

(The IGCC plants can be built as new facilities or as refurbishment to existing units)

  - Fixed Bed Gasification process
  - Fluidized Bed Gasification process
  - Entrained Bed Gasification process
- Advanced Combustion Technologies
  - Externally fired Combined Cycle
- Integrated Gasification Fuel Cell (IGFC)
- Magneto Hydrodynamics (MHD)
- Coal fired Diesel engine

Technology	Efficiency	Emission Control (%)	
		SO_2	NO_x
Advanced Pulverized Coal	43	95	80
PFBC	52	>95	80
IGCC	52	>99	>90
IGFC	62	>99	>99
Magneto hydrodynamics	63	100	

Source Industry & Government Reports, ACG Models & Databases, ACG Analysis

IGCC technology is capable of using the ' dirty fuels without degrading the environment

INTEGRATED GASIFICATION COMBINED CYCLE (IGCC) TECHNOLOGY

Concept & Key Features

Concept

- IGCC incorporates an oxygen or air blown gasifier operating at high pressure and producing raw gas which is cleaned of most pollutants and burned in combustion chambers of the gas turbine generator for power generation

Features

- Nearly complete gasification of the feedstock
- Efficient removal of dust and other pollutants from the gas meeting the requirements of both gas turbine blading and environmental protection
- Effective integration and coupling of sub systems in terms of process engineering, plant operations and thermodynamic considerations

Main Equipment

- Gasification Plant including preparation of feedstock
- Raw gas heat recovery system
- Gas Purification System with Sulfur recovery
- Air separation plant (only for Oxygen blown gasification)
- Gas turbine generator with heat recovery steam generator
- Steam Turbine - Generator

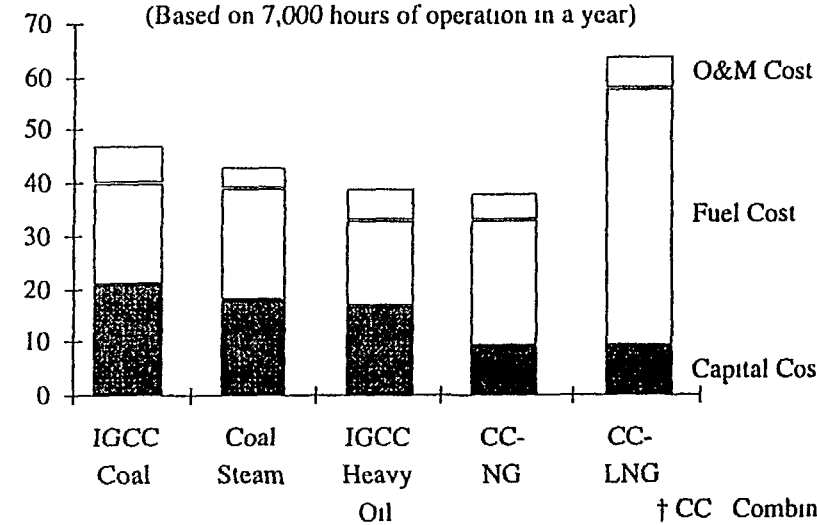
Fuel

- Operating IGCC plants are fueled by Coal, Lignite, Heavy Oil and Petroleum Coke Industrial solid waste and by product gases found in the steel chemical and petroleum refining industries
- Plants produce power and steam and coproduce chemicals such as hydrogen and methanol
- Use of heavy oils as feedstock instead of coal will result in elimination of coal handling and preparation systems and oil having lower ash content than coal will reduce fouling of the Synthesis Gas (Syngas) coolers
- IGCC Technology is more capable of using poorer environmental grade coal as well as heavy oils

Key Factors Driving IGCC Economics

	• Plant Cost	• O&M Costs	• Efficiency	• Cost of Electricity
• *MW Plant Size*	x	x		x
• Number of Power Trains	x			
• Gasification Configuration	x		x	
• *Fuel Type*	x		x	x
• GT Technology Level	x		x	
• Region Labor Cost/ Productivity	x			
• *Co production/ Co generation*	x		x	x
• Repowering	x			
• Plant Type		x		
• Fuel Cost				x
• Load Factor				x

Total Cost of Electricity in $/MWh (1997 Prices)
(Based on 7,000 hours of operation in a year)

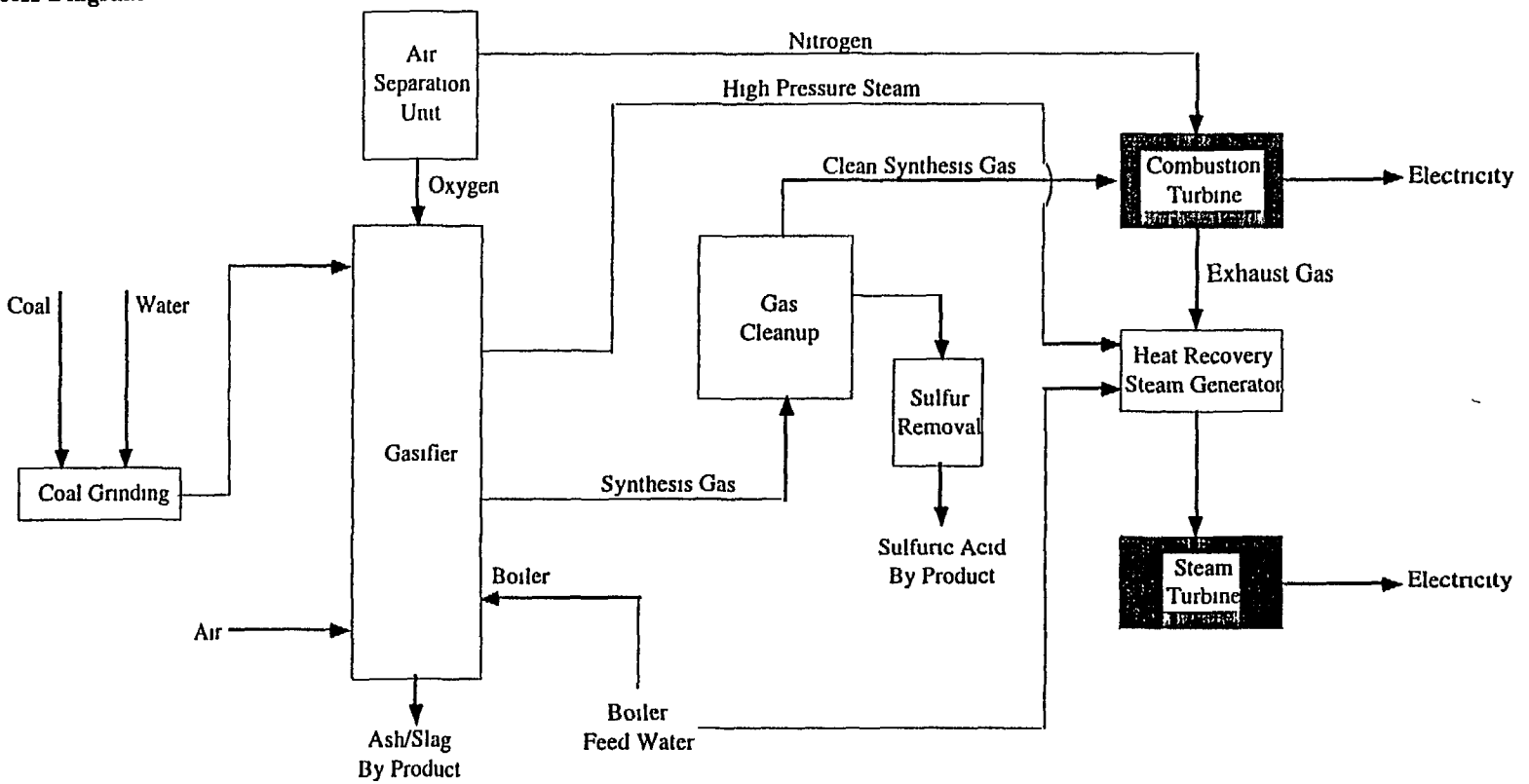


† CC Combined Cycle
† NG Natu

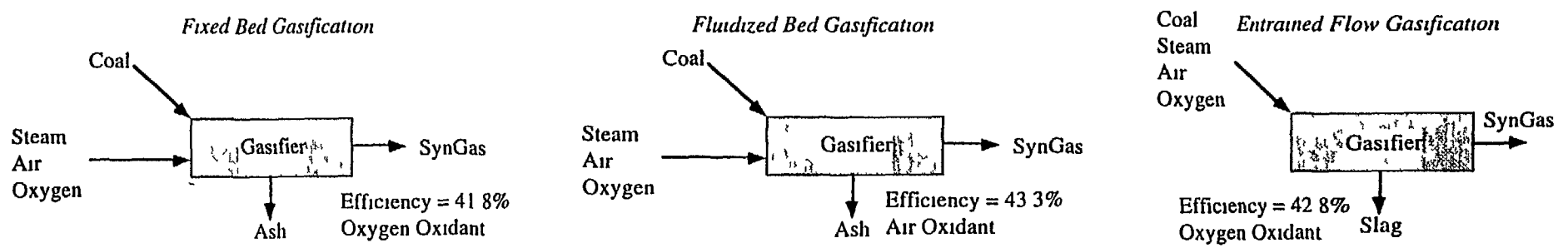
Source Power Gen ia - 95 96 %97 (P ver C meri 94 C nce s A fode Data'

INTEGRATED GASIFICATION COMBINED CYCLE (IGCC) OUTLINE

IGCC Process Diagram



Primary Gasification Technologies



† SynGas Synthesis Gas

Source Industry & Government Reports, ACG Models & Databases, ACG Analysis

ABBREVIATIONS

A	
A&P	Administration and Planning
ABB	Asea Brown Boveri
ACG	Asia Consulting Group
ADB	Asian Development Bank
AFBC	Atmospheric Fluidised Bed Combustion
APSEB	Andhra Pradesh State Electricity Board
Aug	August
B	
BHP	British Horse Power
BJP	Bhartiya Janata Party
C	
CAGR	Cummulative Accrued Growth Rate
CBM	Coal Bed Methane
CC	Combined Cycle
CCFI	Cabinet Committee for Foreign Investment
CCGT	Combined Cycle Gas Turbine
CCPP	Combined Cycle Power Project
CDC	Commonwealth Development Corporation
CEA	Central Electricity Authority
CESC	Calcutta Electric Supply Corporation
CM	Chief Minister
CNG	Compressed Natural Gas
CPM	Communist Party of India (Marxist)
CWC	Central Water Commission
D	
Dec	December
DG	Diesel Generator
DGFT	Director General Foreign Trade
DPR	Detailed Project Report
DVB	Delhi Vidyut Board
DVC	Damodar Valley Corporation
DPC	Dabhol Power Company
Dy	Deputy
E	
EPC	Engineering, Procurement and Construction
ERLDC	Eastern Regional Load Despatch Center
E/S	Electricity Supply
Exe	Executive
Expn	Expansion
F	
FDI	Foreign Direct Investment
FI	Financial Institution
FIPB	Foreign Investment Promotion Board
FO	Fuel Oil / Furnace Oil
FSA	Fuel Supply Agreement
G	
GAIL	Gas Authority of India Limited
GBPP	Gas Based Power Project
GDR	Global Depositary Receipt
Govt	Government
GT	Gas Turbine
GW	Giga Watt
Gwh	Giga Watt Hour
H	
HBJ	Hazira-Bijapur-Jagdishpur
HC	High Court
HPCL	Hindustan Petroleum Corporation Ltd
HSD	High Speed Diesel
HT	High Tension
I	
IAS	Indian Adminstrative Services
ICICI	Industrial Credit and Investment Corporation of India
IDBI	Industrial Development Bank of India
IEM	Industrial Entrepreneurs Memorandum
IFC	International Finance Corporation
IFFCO	Indian Farmers Fertilisers Cooperative ltd
IGCC	Integrated Coal Gasification Combined Cycle
IGFC	Integrated Gasification Fuel Cell
IOC	Indian Oil Corporation
IPP	Independent Power Producer
IREDA	Indian Renewable Energy Development Agency
J	
Jan	January
Jul	July
JV	Joint Venture
K	
KEB	Karnataka Electricity Board
Km	Kilometers
Kribhco	Krishak Bharati Co operative Limited
KV	Kilo Volts
Kwh	Kilo Watt Hour

Source Industry & Government Reports, ACG Models & Databases, ACG Analysis

ABBREVIATIONS (CONTD)

L	
L/C	Letter of Credit
LDC	Load Despatch Center
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
LROT	Lease, Rehabilitate, Operate & Transfer
LSHS	Low Sulfur Heavy Stock
LT	Low Tension
LoI	Letter of Intent
LoP	Letter of Permission
Ltd	Limited
M	
Mar	March
MHD	Magneto Hydro Dynamics
MMBtu	Million Metric British Thermal Units
MMSCMD	Million Metric Standard Cubic Meters per Day
MMT	Million Metric Tonnes
MMTPA	Million Metric Tonnes Per Annum
MNC	Multi National Corporation
MoP	Ministry of Power
MoP&NG	Ministry of Petroleum and Natural Gas
MoE& F	Ministry of Enviornment and Forestry
MoU	Memorandum of Understanding
MP	Madhya Pradesh
MSEB	Maharashtra State Electricity Board
MU	Million Unit
MVA	Million Volt Amperes
MW	Mega Watt
N	
NERLDC	North Eastern Regional Load Despatch Center
NFL	National Fertiliser Ltd
NHPC	National Hydro Power Corporation
NPC	Nuclear Power Corporation
NPT	National Project Track
NRLDC	Northern Regional Load Despatch Center
NSDP	Net State Domestic Product
NTPC	National Thermal Power Corporation
No	Number
Nov	November
O	
O&M	Operation & Maintenance
OC	Open Cycle
OECF	Overseas Economic Corporation Fund
OSEB	Orissa State Electricity Board
Oct	October
P	
PFB	Pressurise, Fluidised Bed Technologies
PFBC	Pulverised Fluidised Bed Combustion
PHDCCI	PHD Chamer of Commerce & Industry
PIB	Public Investment Board
P O	Post Office
PLF	Plant Load Factor
PM	Prime Minister
POL	Petroleum Oil
PPA	Power Purchase Agreement
PSU	Public Sector Undertaking
R	
R&M	Renovation and Modernization
RCF	Rashtriya Chemicals and Fertilisers
REB	Regional Electricity Board
RLDC	Regional Load Despatch Center
RoR	Rate of Return
Rs	Rupee
S	
SBI Caps	State Bank of India Capital
SBM	Single Buoy Mooring
SC	Supreme Court
SEB	State Electricity Board
SERC	State Electricity Regulatory Commission
Sep	September
SIL	Special Import License
SLDC	State Load Despatch Center
Sq	Square
Sr	Senior
SRLDC	Southern Regional Load Despatch Center
ST	Steam Turbine
T	
T&D	Transmission and Distribution
TEC	Techno-Economic Clearance
Tel	Telephone
Twh	Tera Watt Hour
U	
UK	United Kingdom
UPSEB	Uttar Pradesh State Electricity Board
USA	United States of America
UTI	Unit Trust of India
V	
V	Fifth
VI	Sixth
W	
WRLDC	Western Regional Load Despatch Center

Source Industry & Government Reports ACG Models & Databases, ACG Analysis