



**Department of Industrial and Management Engineering
Indian Institute of Technology Kanpur**



Forum of Regulators

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Officers of Electricity Regulatory Commissions
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Frontiers of Power Sector Regulation & International Experience


Anoop Singh
Associate Prof.
Dept of Industrial and Management Engg.
IIT Kanpur



Agenda

- International Experience in Reform & Regulation
- Existing Regulatory Practices in some of the European Countries
- Performance Based Regulation
- Benchmarking
- Retail Competition
- Multi-sector Regulation

International Experience in Power/Energy Regulation



Country	Great Britain	Norway	Russia (Federal)	Spain
Name of Body	Gas and Electricity Markets Authority (GEMA), responsible for the Office of Gas and Electricity Markets (OFGEM)	Norwegian Water Resources and Energy Directorate (NVE)	Federal Tariffs Service (previously called and still often referred to as the FEK—the Federal Energy Commission)	National Energy Commission (CNE)
Estd.	1989 (as OFFER)	1921, competences were last modified in 1990	1995 as the Federal Energy Commission (FEK)	In 1998 as “Commission for the National Electricity System”;
Number of Members	Min. 3, currently 15 (2005)	One	Maximum 7 (one board for each regulated natural monopoly)	9 Members (in addition to a non-voting Secretary)
Term of Office	Maximum 5 years	6 years, renewable once	Not defined	6 years, renewable once
Required Qualifications	No specific requirements	No specific requirements	Not defined	Recognized technical and professional competence

Country	USA (Federal)	Australia (Federal)	Brazil	Argentina	India (Federal)
Name of Body	Federal Energy Regulatory Commission (FERC)	Australian Energy Regulator (AER).	Agência Nacional de Energia Elétrica (ANEEL)	Ente Nacional Regulador de la Electricidad (ENRE)	Central Electricity Regulatory Commission (CERC)
Established	October 1 1977 (substituting the Federal Power Commission, FPC, estd. In 1920)	AER commenced operations in July 2005	1996; substituted the National Department of Waters and Electric Power	1991 (Law 24065, creating ENRE , was approved in December 1991)	July, 1998
Number of Members	Up to five commissioners	Three	ANEEL is managed by a collegiate Board of Directors	5 members: a president, a vice-president and three co-commissioners	Five (1+4) including the Chairman, CEA as ex-officio Member
Term of Office	5 years	upto five years	4 years	5 years, but can be reelected for an indefinite term	Maximum 5 years
Required Qualifications	Subjective requirements to fulfill objectives	No specific qualifications. One member must be a Commissioner of the ACCC	No specific requirements	No specific requirements. To be defined by the Energy Secretary of the Govt. for each appoint.	Engg., law, comm., economics, finance, mgnt., or retired judge of Supreme Court or CJ of High Court

Country	Great Britain	Norway	Russia (Federal)	Spain
Members Appointed by	Department for Trade and Industry	Proposed by the Ministry of Pet. and Energy and appointed by the King	Govt. of the Russian Fed. appoints and removes the Head and Deputies of the FTS	Proposed by the Minister of Industry. Appointed through a Govt. decree, after appearance in Congress
Degree of Independence	Subject to Parliamentary oversight, but no significant control by Govt. Dept.	NVE is subordinated to the Ministry of Petroleum and Energy. NVE's decisions are reviewed by the Ministry	Very little	Formally independent. The Ministry is responsible for monitoring the efficacy of the Commission
Sectors	Electricity and natural gas	Water and energy	Electricity; District heat; Nat. Gas; Oil Pipelines; Rail ; Ports & Airports; Post; Telecom.	Electricity, natural and liquefied petroleum gases and oil

Country	USA (Federal)	Australia (Federal)	Brazil	Argentina	India (Federal)
Appt. by	President of the United States with the advice and consent of the Senate	Two members to be recom. by Ministers of the States and Territories, third to be recom. by Chair, ACCC	Presidente da República (but previously approved by Brazilian Senate)	Selection Committee incl. sector Reps., Consejo Federal de la Energia, after approval of a Parliamentary Commission	Central Govt on Recomm. of selection committee headed by Member of PC (Energy); as per Act
Degree of Indp.	Independent. There is no review of FERC's decisions by the President or Congress	Independent. Not subject to ministerial or policy direction	Semi-autonomous depends on the Ministry of Mines and Energy (MME).	independent inside the Energy Dept. of the Eco. Min. Subject to auditing.	No significant control by Govt. Dept., except policy guidelines budgetary Allocations
Sectors	Natural gas, oil and electricity	Natural gas and electricity	Electricity	Electricity	Electricity

Country	Great Britain	Norway	Russia (Federal)	Spain
Types of Entities Regulated	Mainly Private Sector companies, +nuclear generator	Entities mostly owned by local and /or regional authorities	Natural monopolies (mostly state-owned)	Private entities
Range of Electricity Sector Responsibilities	Generation, transmission (including system operation), distribution, and supply sector	Mainly network regulation and licensing. NVE monitors the country's energy systems	Generation,transmission (including system operation), distribution,and supply sector	Advisory body for the Govt., competition supervision, regulated costs of the electricity system
Price Regulation Powers	Yes, full authority on prices	Yes, NVE sets income limits for distribution companies and approves their tariffs	Gen. tariffs, tariffs for system operation, market services, ancillary services, trans., and limits for retail tariffs	No, although it is compulsory for the CNE to draft a non-binding decision of each tariff proposal.
Authority over Market Design	Yes, full powers over NETA	Only setting guidelines for overall system operation	No — this is the responsibility of the Government.	No,although non-binding decisions by CNE are required in most issues
Invest. Regulation Powers	Indirectly through price regulation	Indirectly through price regulation	In so far as tariffs based on budgeted costs — incl. any investment requirement	No, although non-binding decision by CNE is required in the energy planning process
Quality Regulation Powers	Yes	Yes(new regulations on quality of service to enter into force in January 2005)	In practice— No	No, but it monitors quality of service

Country	USA (Federal)	Australia (Federal)	Brazil	Argentina	India (Federal)
Types of Entities Regulated	Private entities (limited jurisdiction entities owned by the public sector)	Both Private Sector and State-owned companies	Concession companies, both private and state owned	Concession companies, all of which are privately owned	Generation owned by Central Govt., generation serving more than one state, and Inter-state Trans.
Range Of Elec. Sector Responsi-bilities	FERC regulates interstate electricity transmission, the sale of electricity for resale and mergers	Electricity and gas access pricing and transmission revenue regulatory decisions;	to regulate and supervise the gen- eration, transmi- ssion, distribution and commercializati on of electric power, +.....	Security, technical aspects, measurement and billing, metering, quality of service;	Tariff of Generating Companies and Inter-state transmission & trading margin
Price Reguhn. Powers	On transmission prices	Yes. electricity and gas access pricing and tran .revenue regulatory decisions	Yes	Yes, ENRE sets maximum tran- smission and distribution prices	Yes, full authority on prices

Country	USA (Federal)	Australia (Federal)	Brazil	Argentina	India (Federal)
Authority over Market Design	Yes, FERC has complete jurisdiction over the wholesale electricity marketplace	No.This is the responsibility of the Ministerial Council on Energy (MCE) and/or the Australian Energy Market Commission	Only in the frame work of MME's general guidelines	No	Market design determined by Electricity Act 2003. Time and phases of introduction to be decided by Commission
Invest. Regn. Powers	Indirectly through price regulation	Yes, through promulgating the regulatory test for transmission Investment	Indirectly through price regulation, concession bids and concession contract terms	Indirectly through price regulation	Indirectly through price regulation
Quality Regn. Powers	Together with North American Electric Reliability (Council NERC)	Yes, under the service incentive regime in revenue cap determinations.	Yes,	Yes	Yes

Current Regulatory Practices for Distribution in Europe

Current Regulatory Practices for Distribution in Europe



- Opex allowances - benchmarking: Data Envelopment Analysis (DEA), also Stochastic Frontier Analysis (SFA) and Corrected Ordinary Least Squares (COLS)
- Regulated Asset Base (RAB) - The investments for a given year, in most cases, need the approval of the regulator.



Investment approvals

- Spain: Reference grid model to ensure that the grid is constructed in an efficient manner.
- Denmark: Investments in ABC can be financed by higher tariffs.
- Great Britain: Specific incentive mechanisms – Innovation Funding Incentive (funding is capped at 0.5% of regulated revenue).



Investment approvals (Contd.)

- Italy: base rate of return (7%) is increased by 2% for
 - Investments in new High Voltage /Medium Voltage substation in regions with low electrification for 8 years;
 - Investments in substitution of existing transformers with low loss transformers in Medium Voltage / Low Voltage substations for 8 years;
 - Investments in new High Voltage /Medium Voltage substations in regions with low electrification which provides at least 2 new interconnections to the High Voltage meshed network for 12 years;
 - Investments in automation, protection and control systems on the MV network: 2% for 12 years



Investment approvals (Contd.)

Portugal: Specific incentives for:

- Environment protection (PPDA - environment promotion plan with actions to be implemented by the DSO);
- Quality of service (the DSO has an incentive to invest in order to obtain better quality of service);
- Losses reduction (the DSO has an incentive to invest in order to obtain lower losses);
- Energy efficiency (PPEC - energy efficiency plan with actions to be promoted by the DSO and the retailers)



Rate of Return

- Regulators use Capital Asset Pricing Model (CAPM) methodology to determine the weighted average cost of capital (WACC).
- RoE Vs RoCE
- Pre-tax Vs post-tax



Estimated RoE and WACC for power companies

	Cost of Debt	After-tax Cost of Debt	Return on Equity	WACC
BHEL	10.72%	7.51%	17.07%	14.42%
CESC	10.41%	7.29%	15.87%	12.34%
EMCO	11.32%	7.93%	16.82%	15.28%
JPHYDRO	9.00%	6.30%	19.37%	13.92%
NEPCMI.	0.67%	0.10%	17.18%	8.46%
NEYVELI	4.00%	3.10%	18.40%	16.79%
NTPC	10.70%	7.50%	15.21%	13.85%
NOIDATOLL	6.97%	4.00%	14.95%	11.64%
REL	4.80%	2.90%	18.78%	14.42%
SIEMENS	1.10%	0.80%	15.43%	15.43%
SUZLON	12.93%	9.00%	22.23%	19.91%
TATAPOW	5.30%	3.70%	17.41%	14.67%

So: Study at Dept of IME, IIT Kanpur



Tariff setting

- CoS based Tariff
- Price Cap
- Revenue Cap



Distribution Losses

- Some challenges in measurement
 - Time of data collection
 - Own consumption
 - Theft
- Regulator sets an allowed reference of losses for the price control period.
- In many cases losses are differentiated by voltage level.
- Incentives for investment in loss reduction



Quality of Service

- 11 out of 43 Discoms in EU are subject to a penalty/reward scheme under their price control in relation to overall network performance.
- Targets are set based on overall indicators (SAIDI, SAIFI or equivalent) for each of the years of the regulatory period. Targets agreed between DSOs and regulator, or only by regulators. In some cases, targets without any influence on allowed revenue.
- Compensate individual customers in case of non-compliance with certain standards of performance, e.g. number of customer interruptions and customer minutes lost per year.

Performance Based Regulation: Incentive Regulation & Yardstick Competition

Performance based regulations (PBR)

- Price Cap (PC)
- Revenue Cap (RC)
- Yardstick Competition (YC)
- Quality Regulation (QR)





RPI – X Regulation

- Revision in price of electricity (for a basket of consumer category) based on

$$P_t = P_{t-1} * (1 + RPI - X + Z)$$

- RPI – Increase in tariff based on an identified price index
- X – Improvement in performance
- Z – Correction factor for force majeure events



Yardstick Competition

- Decoupling the regulated entities prices from its own costs.
- Instead link it to ‘mean’ cost of a peer group
- Tendency to collude among the utilities
- Need for benchmarking

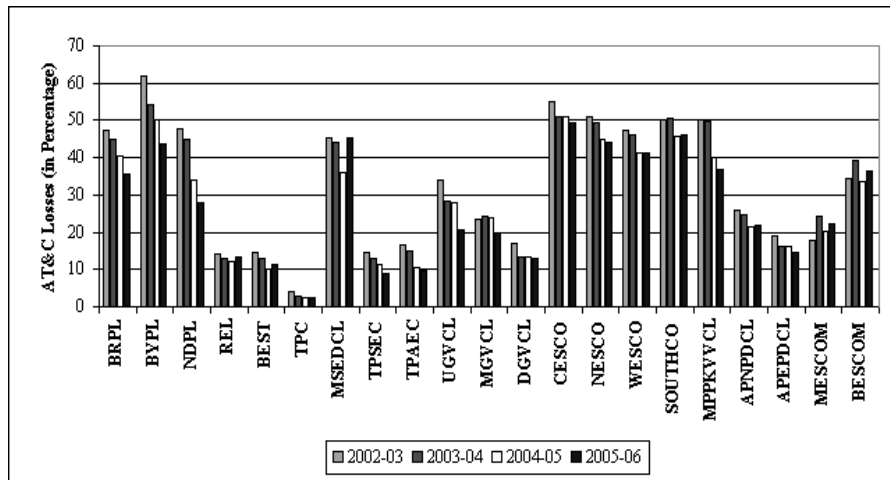
Efficiency Measurement & Benchmarking

Methodology of Benchmarking

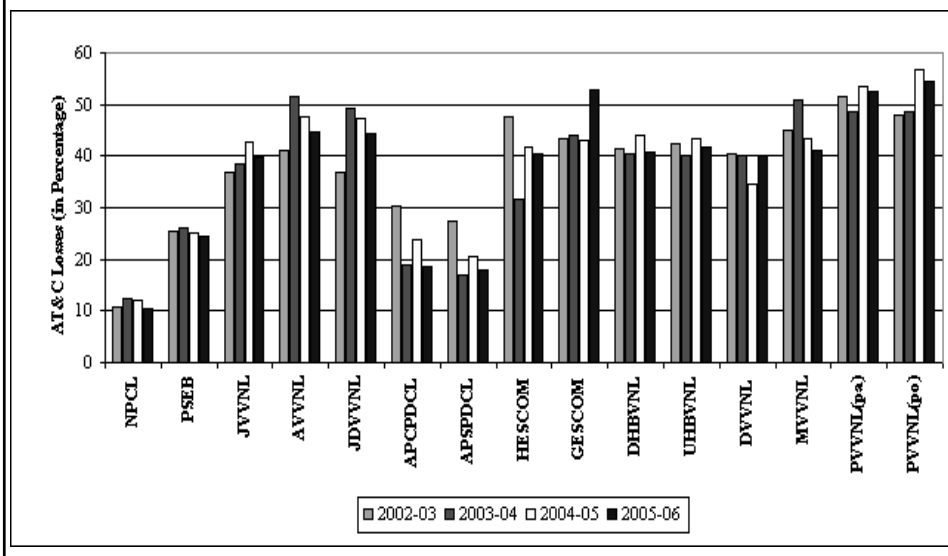


- Benchmarking Techniques
- Parametric
- Non-Parametric
 - Parametric Techniques are:
 - Corrected Ordinary List Squares (COLS)
 - Stochastic Frontier Analysis (SFA)
 - Total Factor Productivity (TFP)
- Non- Parametric Techniques are:
 - Data Envelopment Analysis (DEA)

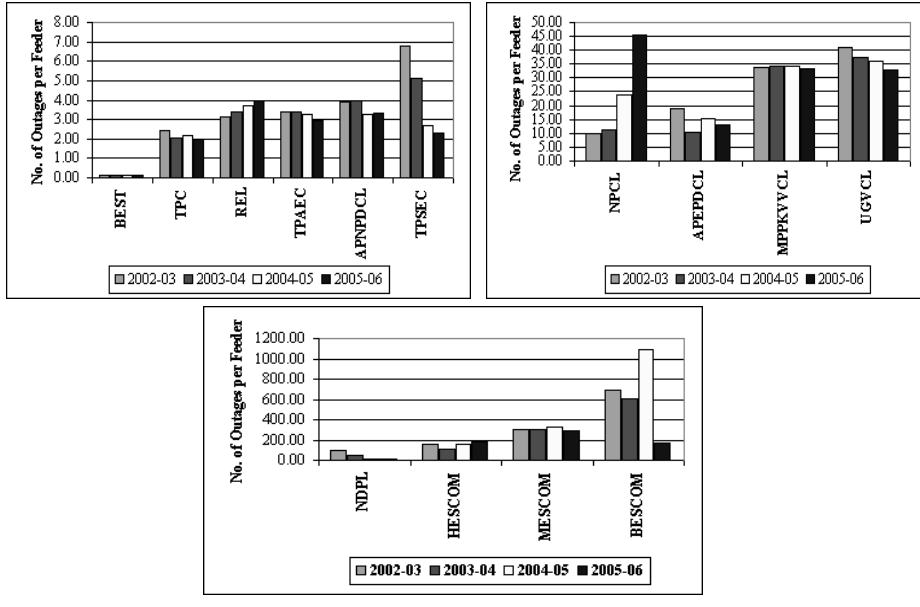
Comparison of AT & C losses in Discoms



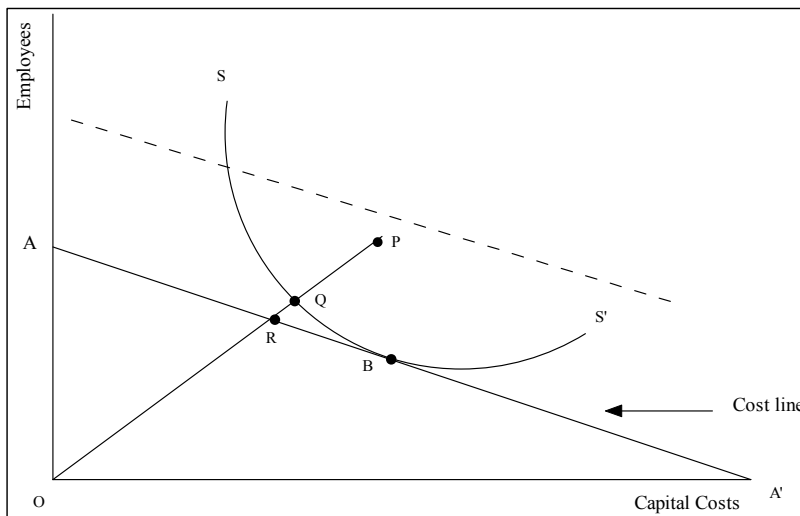
Comparison of AT & C losses in Discoms (Contd.)



Outages per Feeder Across Discoms



Concepts of efficiency & DEA





Data Envelopment Analysis (DEA)

Technical Efficiency (TE):

- Ratio of Physical Inputs and Outputs
- $TE = OQ/OP$,

Allocative Efficiency:

- Cost minimizing choice (choice of Inputs, given a level of Outputs and a set of prices)
- $AE = OR/OQ$,

Cost Efficiency:

- Product of TE & AE
- $CE = OR/OP$,



Output-Oriented version of DEA

• Maximize
$$E_m = \frac{\sum_{j=1}^J V_{jm} Y_{jm}}{\sum_{i=1}^I U_{im} X_{im}}$$

• Subject to:
$$\frac{\sum_{j=1}^J V_{jm} Y_{jn}}{\sum_{i=1}^I U_{im} X_{in}} \leq 1$$

$$V_{jm}, U_{im} \geq 0; i = 1, 2, \dots, I; j = 1, 2, \dots, J; n = 1, 2, \dots, N$$



Approach and data

- We apply Data Envelopment Analysis (DEA) incorporating operational and financial parameters to compare efficiency of distribution companies across states.
- Previous work (Thakur et al., 2005) at SEB level.
- 27 electric distribution companies (Discoms) from 2002-03 and 2005-06.



Input and Output Parameters

Data for 3I/1O model

Input Parameter	Output Parameter
Unit Input (MUs) OPEX (in Rs. Crore = 10 million) Total No. of DTs	Unit Realized (MUs)

Data for 4I/1O model

Input Parameter	Output Parameter
Unit Input (MUs) OPEX (in Rs. Crore) Total No. of DTs Duration of Outages	Unit Realized (MUs)



Results: efficiency of Discoms across states (3I_10)

S. No.	Discoms	Efficiency Score 3I_O_CRS	Efficiency Score 3I_O_VRS	Efficiency Score 3I_I_VRS
DELHI				
1	BRPL	54.80 – 66.03	54.85 – 66.05	54.93 – 66.13
2	BYPL	39.03 – 57.48	39.17 – 57.58	43.36 – 57.73
3	NDPL	53.48 – 73.63	53.64 – 73.75	53.87 – 68.04
MAHARSHTRA				
4	REL	87.74 ~ 90.05	87.83 ~ 90.13	87.87 ~ 90.15
5	BEST	87.61 ~ 92.23	87.9 ~ 92.15	87.96 ~ 92.55
6	TPC	99.65 – 100	100	100
GUJARAT				
7	TPSEC	91.13 ~ 100	95.18 ~ 100	96.39 ~ 100
8	UGVCL	74.15 – 90.03	74.67 – 91.54	74.17 – 90.03
9	MGVCL	81.22 – 82.77	81.3 – 82.85	81.34 – 82.88
10	DGVCL	95.49 – 100	95.64 – 100	95.59 – 100
ORISSA				
11	CESCO	50.09 – 51.87	50.25 – 52.02	50.49 – 52.24
12	NESCO	53.68 – 59.19	53.84 – 59.31	54.01 – 59.43
13	WESCO	57.13 ~ 63.16	57.23 ~ 63.36	57.34 ~ 63.35
14	SOUTHCO	50.74 ~ 55.54	51.26 ~ 56.11	51.84 ~ 56.63



Contd...

S. No.	Discoms	Efficiency Score 3I_O_CRS	Efficiency Score 3I_O_VRS	Efficiency Score 3I_I_VRS
MADHYA PRADESH				
15	MPPKVVCL	51.19 – 67.89	51.20 – 68.47	51.25 – 67.91
ANDHRA PRADESH				
16	APNPDCL	77.73 – 84.88	77.76 – 84.90	77.79 – 84.92
17	APEPDCL	85.86 ~ 92.45	85.93 ~ 92.49	85.95 ~ 92.50
18	APCPDCL	74.83 ~ 90.27	84.49 ~ 100	77.74 ~ 100
19	APSPDCL	75.84 ~ 88.65	75.84 ~ 88.66	75.87 ~ 88.67
KARNATAKA				
20	MESCOM	77.48 ~ 84.21	77.90 ~ 84.72	78.02 ~ 84.84
21	BESCOM	64.94 ~ 70.09	68.42 ~ 75.78	64.94 ~ 70.09
22	HESCOM	53.51 ~ 70.01	53.63 ~ 70.11	53.83 ~ 70.21
23	GESCOM	49.28 ~ 60.37	49.33 ~ 60.44	49.44 ~ 60.53
WEST BENGAL				
24	CESC	55.99 ~ 66.07	56.09 ~ 66.34	56.22 ~ 66.54
UTTAR PRADESH				
25	NPCL	91.45 ~ 96.97	97.63 ~ 100	97.79 ~ 100
HARYANA				
26	DHBVNL	57.4 ~ 63.7	57.41 ~ 63.71	57.49 ~ 63.75
27	UHBVNL	58.01 ~ 62.81	58.02 ~ 62.82	58.10 ~ 62.85

Results: efficiency of Discoms across states (4I 10)



S. No.	Discoms	Efficiency Score 4I_I_VRS	Efficiency Score 4I_I_VRS
DELHI			
1	BRPL	54.8 - 66.03	54.93 - 66.13
2	BYPL	39.03 - 57.48	43.36 - 57.73
3	NDPL	53.48 - 73.63	53.87 - 73.84
MAHARSHTRA			
4	REL	87.74 ~ 90.05	87.87 ~ 90.15
5	BEST	87.61 ~ 92.23	89.57 ~ 100
6	TPC	99.65 ~ 100	100
GUJARAT			
7	TPSEC	91.13 ~ 100	94.15 ~ 100
8	UGVCL	74.15 - 90.03	74.17 - 90.03
9	MGVCL	82.77 <- 95.13	82.88 <- 96.45
10	DGVCL	95.49 - 100	95.59 - 100
ORISSA			
11	CESCO	50.09 - 51.87	50.49 - 52.24
12	NESCO	53.68 - 59.85	54.01 - 60.33
13	WESCO	58.42 ~ 78.98	58.71 ~ 81.45
14	SOUTHCO	50.74 ~ 55.54	51.84 ~ 56.63

Contd...



S. No.	Discoms	Efficiency Score 4I_I_VRS	Efficiency Score 4I_I_VRS
MADHYA PRADESH			
15	MPPKVCL	51.19 - 69.23	51.25 - 72.49
ANDHRA PRADESH			
16	APNPDCL	77.73 - 84.88	77.79 - 84.92
17	APEPDCL	85.86 ~ 92.45	85.95 ~ 92.5
KARNATAKA			
18	MESCOM	77.48 <~ 84.21	78.05 <~ 84.84
19	BESCOM	64.94 <~ 70.09	64.94 <~ 70.09
20	HESCOM	53.51 <~ 70.01	53.83 <~ 70.21
WEST BENGAL			
21	CESC	55.99 <- 66.07	56.3 <- 66.54
UTTAR PRADESH			
22	NPCL	91.45 - 96.97	97.79 ~ 100

Retail Competition

Retail Competition in EU



- EU's Electricity Directive
- All customers should have the freedom to choose their supplier from 1 July 2007 and all customers and suppliers should have access to the transmission and distribution networks “based on published tariffs applicable to all eligible customers and applied objectively without discrimination between system users”.
- From 1 July 2004: large and industrial users, should procure electricity on the competitive market.



Retail Competition in UK

Ofgem lifted Price Controls since April 1, 2002

- Choice of suppliers
- High level of customer switching
- Significant savings could be made against former incumbents
- Barriers to entry low
- Benefits of competition extended to all customer groups
- General Statutory Legislation sufficient to ensure consumer protection



Retail Competition in UK (Contd.)

- Separation of Supply and Distribution
- Consolidation has led to 'The Big Six' suppliers & Vertical Integration
- A few 'very small' suppliers – some offering 'niche' services
- Wide range of products in the market
- Various Multi-Party Industry Codes (all with separate governance arrangements)
- BETTA – British Electricity Trading and Transmission Arrangements
- Renewable Obligation/Energy Efficiency Commitment



Issues in Implementing Retail Competition

- Removal of Price Regulation (Partial or full)
- Unbundling of Retail Tariff : Separation of energy and network charges
- Basket of Services (like tariff plans in telecom)
- Price Signals – Demand Response
- Universal Service Obligation
- Supplier of last resort
- Energy Accounting
- Balancing and Settlement

Multi-Sector Energy Regulator?



Multi-Sector Energy Regulator

- The inter-linkages of energy sectors make it an appropriate time for a multi-sector Energy Regulator encompassing “Electricity, Gas and Coal Sector”.
- International experience suggest that a single energy regulator brings in regulatory harmonization and is able to address bottlenecks. This especially true in case the regulated entities provide multiple services like electricity, gas heating etc.
- In the present context, sectoral regulators have a lot on the table to address. However, institutional exchange/learning across different sector regulators should be emphasised at the regulatory staff level.

Country	Established	Initial Stage	Power	Coal	Gas
Germany	2006	1998 –Telecom and Posts; 2005 – Electricity and Gas 2006 - Railways	Y		Y
Italy	2000	1996 – Electricity 2000 - Gas	Y		Y
Mexico	1995	(As a consultative body for Electricity since 1993)	Y		Y
USA	1977	(As Federal Power Commission since 1920)	Y		Y
Japan	1995		Y		Y
Philippines	2001		Y		-
UK	2000	Ofgas since 1986; Offer since 1989	Y		Y
Argentina	1992		Y		---
Argentina	1992		---		Y
Chile	1978	1978	Y	Y	Y
Sri Lanka	2007	2002 – Electricity and Water 2007 – Petroleum	Y		

