

Improving Efficiency in Electricity Distribution

A Holistic Approach

**Global Energy Efficiency Workshop
Washington, DC
March 9, 2010**

Why are efficient electric distribution networks important?



Because electricity is the preferred form of end-use energy

- **Electricity is the fastest growing form of end-use energy**

- Non-OECD countries will account for 58% of world energy use by 2030
- In the USA – a mature economy – power generation will increase by 77% between 2006 and 2030, i.e. from 18.0 to 31.8 trillion kilowatt hours
- The fraction of US energy needs met by electricity increased from 20% in 1960 to 40% in 2000

Source: US Energy Information Administration, *International Energy Outlook, 2009*

- **The power sector is also one of the largest sources of carbon emissions**

- In India, the 100 GW of thermal power generation capacity accounts for 60% of net power generation capacity and 57% of total greenhouse gas emissions
- Based on current plans, this scenario is expected to persist until 2020

Although much energy value is lost before it is used

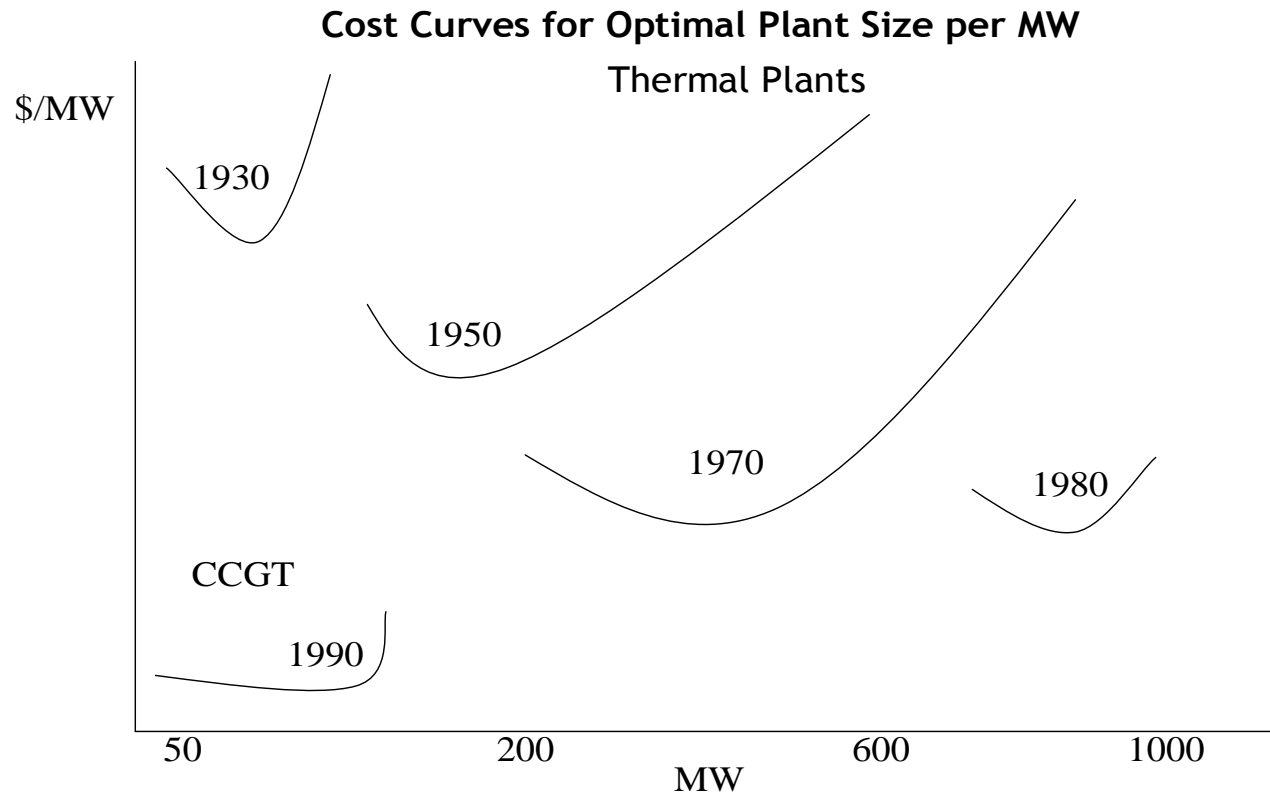
- **Average energy lost in converting fuel to electricity is about 30-35%**
 - For each 100 units of energy in coal, 30-35 units are lost at the power plant
 - Internal consumption can add another 5-10%
 - Of the 60 units that enter the T&D grid, technical losses range from 7% to 25%
 - Adding commercial losses can increase combined losses to 50% or more

Sources: Robert Galvin and Kurt Yeager in *Perfect Power*, McGraw Hill, 2009; Karen Forsten in "Tomorrow's T&D", *Public Utilities Fortnightly*, February 2010; and PA experience
- **Experience shows that technical and commercial losses can be managed. Experience also shows that the approach taken can have a huge impact on results achieved.**
- **The principle of "control the controllables" suggests that increasing distribution efficiency should be a top priority for management**

An historic convergence is reshaping the electric business

- **Unrelenting increases in demand for electricity**
 - **Population growth**
 - **Increasing affluence creates higher demand for more reliable power**
 - **Electricity is the premium source of energy**
 - **An increasingly digital world requires it**
- **Technological advances**
 - **Information and communications technology (ICT)**
 - **Metering**
 - **Generation**
- **The need to reduce carbon emissions**
 - **A growing consensus about climate change**
 - **Electricity production is one of the largest sources**

These forces are changing the industry's business model



Source : Sally Hunt and Graham Shuttleworth -Competition and Choice in Electricity
John Wiley & Sons, Chichester, 1996

Meanwhile, the customer value exchange is deteriorating

- **Unit costs have turned up**
- **And service quality measures are declining**
 - **In the USA, SAIDI increased (worsened) by 21% from 2000 to 2005**
 - **SAIFI increased 13%**
 - **CAIFI increased 8%**

Sources:

US Department of Energy, *Smart Grid System Report*, July 2009

Judith Warrick, Morgan Stanley, *Energy Insights*, "Navigating Technological Change", January 2010

PA experience

Developing economies have added challenges

- Supply shortfalls
- Peak load management issues
- Higher technical and commercial losses
- Increasing global competition for resources

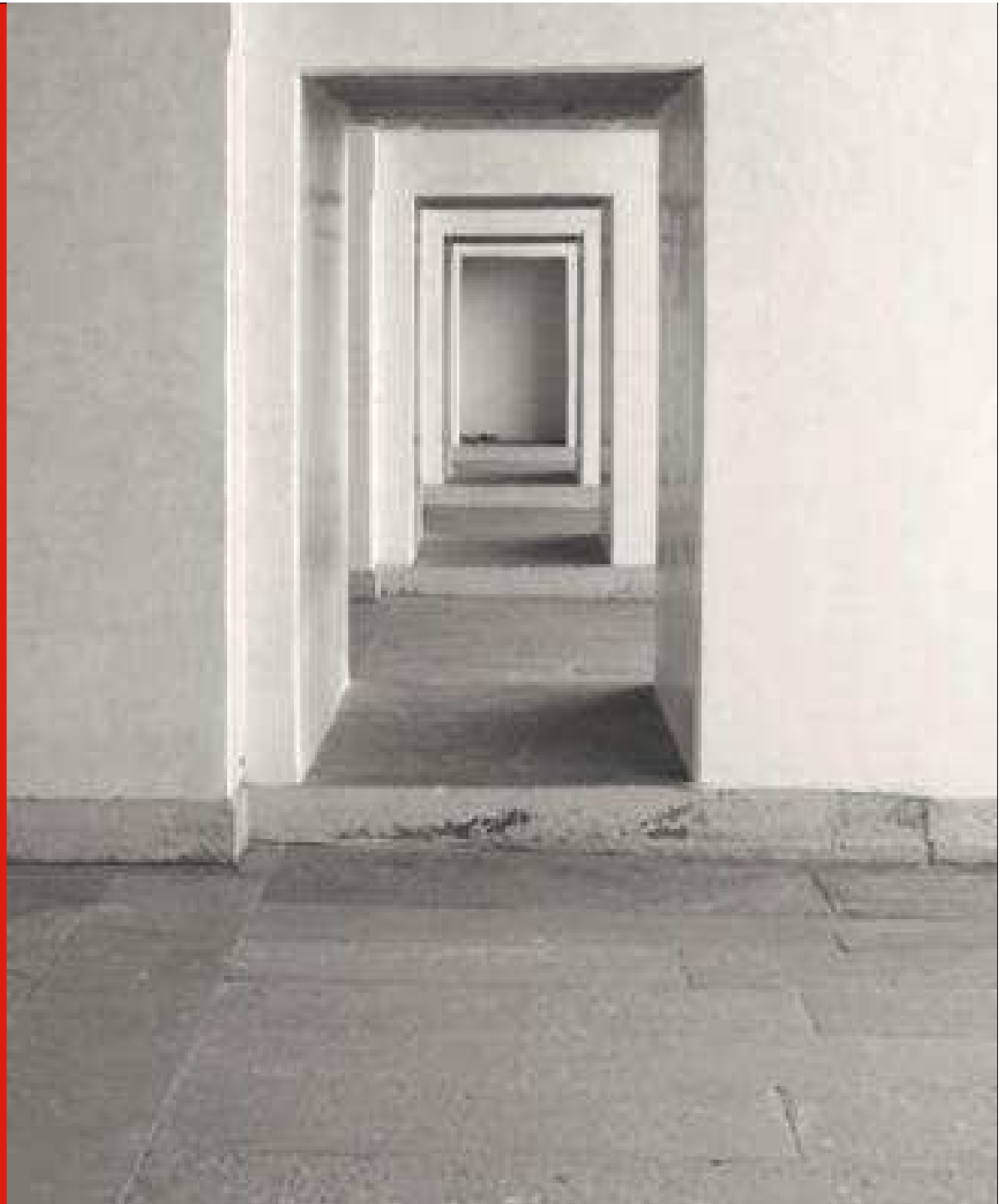
An infrastructure spending boom will trigger global competition for resources

Between 2005 and the end of 2010, China will have spent \$494 billion on infrastructure. India estimates \$250 billion in spending for the power sector alone over the next eight years and total spending on infrastructure of \$447 billion for 2006 through 2012.

One US company, Southern California Edison, recently launched a \$30 billion, ten-year construction program to replace almost half its transmission and distribution assets.

In Perfect Power, co-authored by the retired CEOs of Motorola and the Electric Power Research Institute, the International Energy Agency's *World Energy Outlook* estimated that over the next 25 years, China's power sector will need \$3 trillion in investment, India's will need \$1 trillion, Latin America's \$750 billion and Africa's about \$500 billion.

Is there a 'best practice' way to improve electric distribution efficiency in a developing economy?

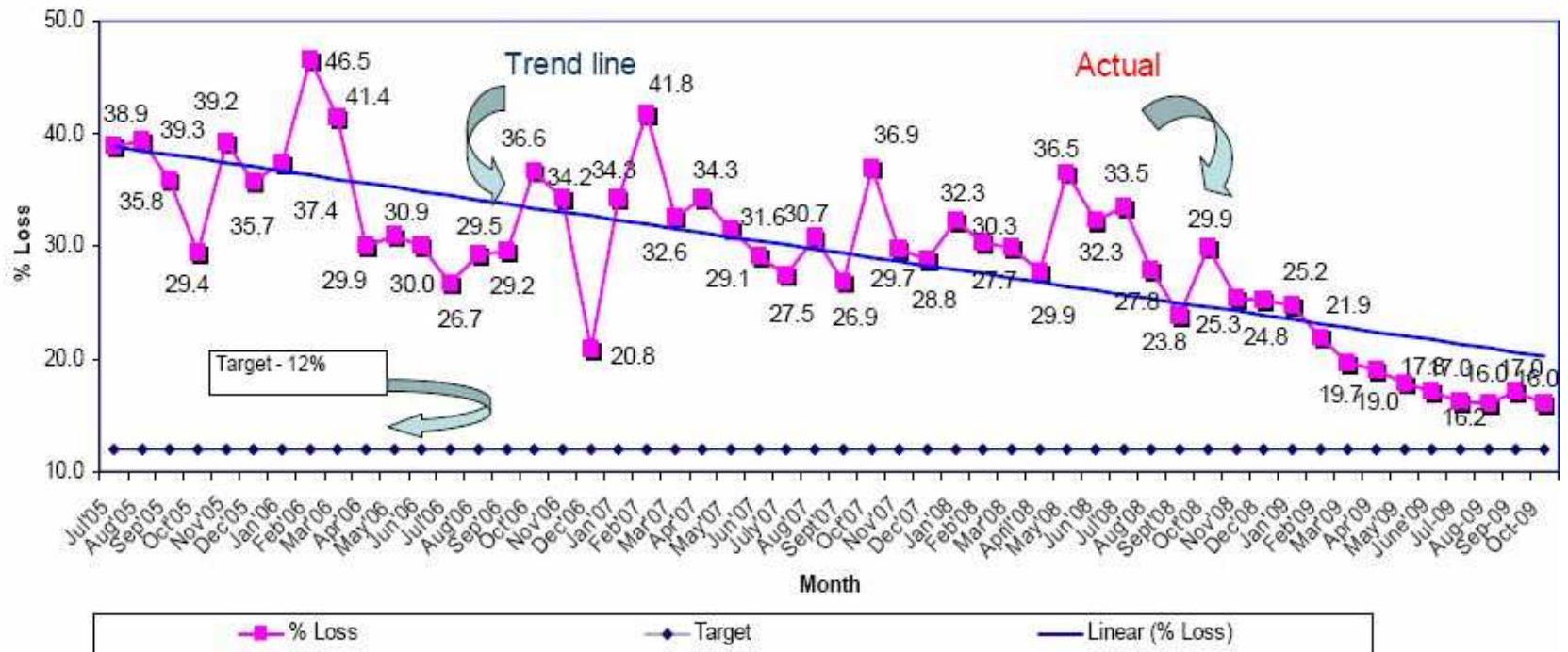


Yes, but first some results

- **Four discoms used this methodology on a pilot basis**
 - **Two urban divisions**
 - **Two rural sub-divisions**
- **The companies included three state-owned discoms and one private**
- **Total no. customers in the pilot areas was 214,000 ranging from 24,000 to 74,000**
- **More than 100 projects were proposed with capital investment of \$60 M**
- **Most of the capital requirement was obtained from banks on commercial terms**
- **The initiatives have been underway for over five years**
- **Savings of \$70 million per year were identified**
- **Actual savings achieved to-date were \$17 million p.a. as of mid-2009**
- **One company reduced its total technical and commercial losses from 53% to 23% of total electricity input to the distribution network**
- **Another developed an agricultural demand side management (Ag DSM) program to cut in half the 30% of electricity provided “free” to farmers**

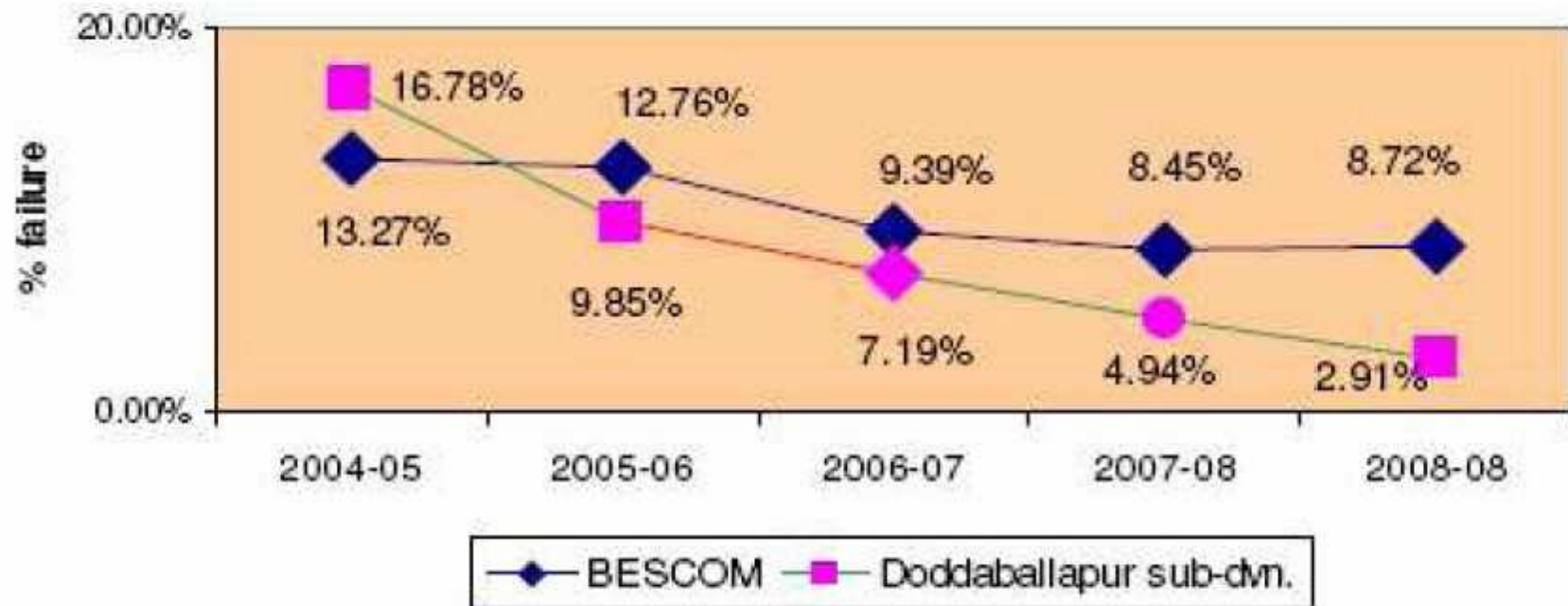
One discom cut it's AT&C losses by more than 50%

ATC Loss at BESCOM's Pilot Site



It also slashed its distribution transformer failure rate

Comparative analysis of DTRs failure rate in BESCOM vis-a-vis DRUM
Project site



The Success Formula

Begin at the end

ARC + GCR = Customer Satisfaction

Σ (Availability + Reliability + Cost) + Good Customer Relations = Customer Satisfaction

The methodology is straight-forward, but not simple

- Define key results *from the customer's perspective (see prior slide)*
- Identify the major business processes that drive results
- Define a model discom according to People, Process, Technology
- Identify best practices
- Specify key performance indicators (KPIs) to measure results
- Conduct an “As Is” assessment to enable gap analysis
- Develop candidate projects to create a center of excellence
- Implement and measure results

The Model Discom & Best Practices

The Model Discom: The Analytic Framework

People	Process	Technology
<p>Organization Structure</p> <p>Work Management</p> <ul style="list-style-type: none"> - Work Analysis & Staffing - Work Management Systems <p>Compensation and Benefits</p> <p>Training</p>	<p>Asset Management – Planning and managing the company’s investment in the physical assets used to provide high quality electric service to customers.</p> <p>System Operation & Dispatch – The activities involved in optimising the flow of electricity, incl. purchasing & trading plus economic dispatch, etc.</p> <p>Field Operations –Includes the classic operations and maintenance activities, including new hook ups, trouble calls and turn offs as well as meter testing and repair and other activities involved in the day-to-day operation of the business.</p> <p>Customer Processes – Includes the meter-billing-collection (MBC) process plus all customer interfaces, incl. customer relations and marketing as well as consumer education and outreach.</p> <p>Corporate Processes – This includes activities that enable the management of the primary business processes (above) or that are executive functions.</p>	<p>Distribution Network</p> <ul style="list-style-type: none"> - Wires - Transformers - Capacitors - Substations - Poles - Etc. <p>Metering Equipment</p> <p>O&M Equipment (trucks, tools, etc.)</p> <p>Computing and Telecommunications</p>

Business Process: Asset Management

Asset Management activities related to the planning and management of physical assets employed to provide high quality service to customers. This is a corporate-level business process.

Process Component	Best Practice	Technology	People
System Planning	<ul style="list-style-type: none"> • Proven load forecasting methodology • Empirical inputs, e.g. load flow studies 	<ul style="list-style-type: none"> • Modern IT systems • Advanced software 	<ul style="list-style-type: none"> • Adequate staff no. & mix • Continuous training
Capital Expenditure Analysis	<ul style="list-style-type: none"> • Use of sound engineering-economic principles 	<ul style="list-style-type: none"> • Modern IT systems • Advanced software 	<ul style="list-style-type: none"> • Adequate staff no. & mix • Continuous training
Long-term Investment Plan (15 year horizon)	<ul style="list-style-type: none"> • Rigorous challenge & review process • Use of ROA / SVA principles • Link to capital structure management • Post-completion evaluations done 	<ul style="list-style-type: none"> • Modern IT systems • Advanced software 	<ul style="list-style-type: none"> • Adequate staff no. & mix • Continuous training
Short-term Capital Budget (3 yrs)	<ul style="list-style-type: none"> • Bottom-up link to operating budget • Pre-launch authorization required 	<ul style="list-style-type: none"> • Modern IT systems • Advanced software 	<ul style="list-style-type: none"> • Adequate staff no. & mix • Continuous training
Major Project Management	<ul style="list-style-type: none"> • Specialized project management group 	<ul style="list-style-type: none"> • Modern IT systems • Advanced software 	<ul style="list-style-type: none"> • Adequate staff no. & mix • Continuous training
System Mapping	<ul style="list-style-type: none"> • Global mapping system • Comprehensive data base 	<ul style="list-style-type: none"> • Modern IT systems • Advanced software 	<ul style="list-style-type: none"> • Adequate staff no. & mix • Continuous training
Maintenance, Analysis & Planning	<ul style="list-style-type: none"> • Reliability-based maintenance plans • Comprehensive data base 	<ul style="list-style-type: none"> • Modern IT systems • Advanced software 	<ul style="list-style-type: none"> • Adequate staff no. & mix • Continuous training

Business Process: System Operations & Dispatch

System Operations: optimising electricity flows plus purchasing, trading & economic dispatch			
Process Component	Best Practice	Technology	People
Real time power supply monitoring and control incl. load dispatch center	<ul style="list-style-type: none"> • State estimator to estimate load flow on hourly, weekly, mo. basis to ensure 24 hour stable parallel operation with neighbouring grids 	<ul style="list-style-type: none"> • Modern IT systems • SCADA to optimise dispatch of electricity • Remote grid stations 	<ul style="list-style-type: none"> • Adequate staff no. & mix • Continuous training
Energy Audit and Accounting	<ul style="list-style-type: none"> • Energy audit & accounting of network, feeder-wise and dist'n transformer-wise monthly. • 100% reads of boundary meters • Load parameters. 	<ul style="list-style-type: none"> • Modern IT & s/w systems • High Voltage Distribution System • Continuous update of GIS maps • Feeder wise, distribution transformer wise energy balance 	<ul style="list-style-type: none"> • Adequate staff no. & mix • Continuous training
Operational load forecasting.	<ul style="list-style-type: none"> • Load forecasting (Short term) • Load flow / monitoring studies • Contingency / security analysis. • Effective outage management 	<ul style="list-style-type: none"> • Advanced computer systems • State-of-the-art software for automated dispatch management • SCADA system 	<ul style="list-style-type: none"> • Adequate staff no. & mix • Continuous training
Power procurement from market	<ul style="list-style-type: none"> • Evaluate power production & cost + cost of available power • Measurement of purchasing & trading of economical power 	<ul style="list-style-type: none"> • Advanced computer systems • State-of-the-art software 	<ul style="list-style-type: none"> • Adequate staff no. & mix • Continuous training
Load Management	<ul style="list-style-type: none"> • GIS/GPS digital mapping • Load mgmt by feeder control, DTC control, customer load control, capacitor introduction 	<ul style="list-style-type: none"> • State-of-the-art SCADA System • Distribution automation. • GIS/GPS mapping system 	<ul style="list-style-type: none"> • Adequate staff no. & mix • Continuous training

Business Process: Field Operations

Field Operations includes those activities related to the classic operations and maintenance (O&M) activities of the distribution business including construction, new hook ups, repair and other activities involved in the day-to-day operations of the business

Process Component	Best Practice	Technology	People
Asset Maintenance Management	<ul style="list-style-type: none"> • Maintenance manuals • Prioritize sked for life cycle maint • Reliability based maintenance plan • Veg. mgmt, periodic overhauls 	<ul style="list-style-type: none"> • Modern IT systems • Advanced software • GIS/GPS utility map • Feedback from outage mgmt 	<ul style="list-style-type: none"> • Adequate staff no. and mix • Continuous training
Revenue Expenditure Analysis	<ul style="list-style-type: none"> • Use engineering-economic principles 	<ul style="list-style-type: none"> • Modern IT systems • State-of-the-art software 	<ul style="list-style-type: none"> • Adequate staff no. and mix • Continuous training
Asset Outage Management and Disaster Management	<ul style="list-style-type: none"> • Fault detection system for 11KV feeders • Emergency load shedding schedule • Utility map integrated with SCADA 	<ul style="list-style-type: none"> • Modern IT systems & s/w • GIS/GPS Maps • Mobile maintenance crews • Mobile transformers 	<ul style="list-style-type: none"> • Adequate staff no. and mix • Continuous training
Building Vendor analysis	<ul style="list-style-type: none"> • Analyze equipment failures 	<ul style="list-style-type: none"> • Modern IT systems • State-of-the-art software 	<ul style="list-style-type: none"> • Adequate staff no. and mix • Continuous training
Releasing service connection	<ul style="list-style-type: none"> • Specialized commercial group w KPIs for time period to release a particular category of service 	<ul style="list-style-type: none"> • Modern IT systems • State-of-the-art software • GIS/GPS maps integrated w asset& customer D/Bs 	<ul style="list-style-type: none"> • Adequate staff no. and mix • Continuous training
Trouble Call Management	<ul style="list-style-type: none"> • Specialised ops group w link to assets, billing data base, complaint center and maintenance crews 	<ul style="list-style-type: none"> • Mobile phones to field staff • Toll free no. for customers • Call processing & analysis • Mobile maintenance crews 	<ul style="list-style-type: none"> • Adequate staff no. and mix • Continuous training

Business Process: Customer Processes

Customer Processes: includes the meter-billing collection (MBC) process plus all the customer interfaces, including customer relations and marketing (including advertising as well as customer education).

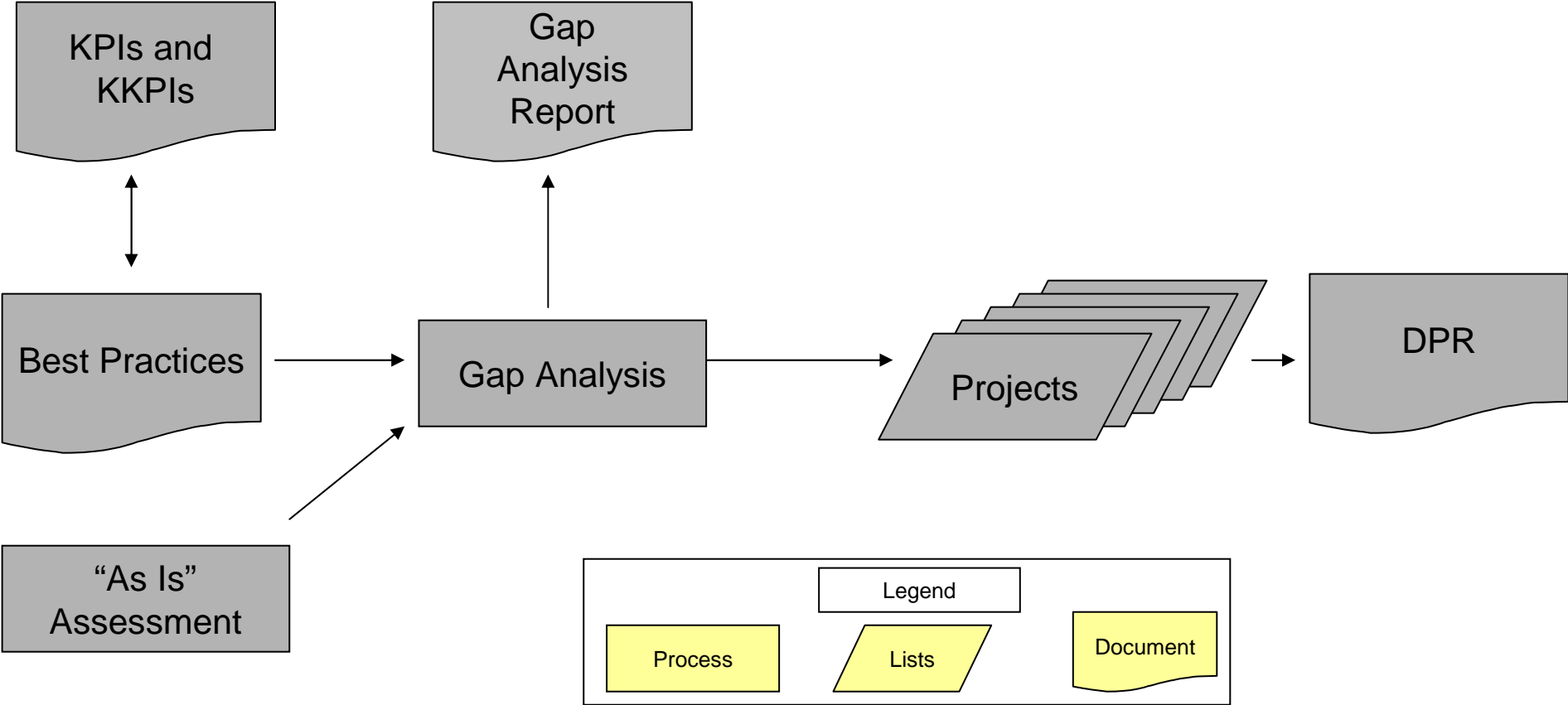
Business Process Component	Best Practice	Technology	People
Metering ,Billing and Collection (MBC)	<ul style="list-style-type: none"> • Installation of Electronic meters w appropriate networking interface. • Central billing & administration unit • Advanced techniques e.g. automatic / remote meter reading, spot reading & billing, online bill payment / query • Meter testing, meter inspection and replacement order for faulty, slow and fast meters. 	<ul style="list-style-type: none"> • Advanced computer systems • State-of-the-art software • RS 232,485 / radio telephone modems, data collection devices e.g. hand held MRIs, data concentration devices • Spot / pre-paid billing • Online bill payment system • Billing system integrated with trouble call system, 	<ul style="list-style-type: none"> • Adequate staff no. & mix • Continuous training
Customer Relationship Management (CRM)	<ul style="list-style-type: none"> • Trouble call management • Metering and billing management • On-line billing and collection • New Customer management • Customer communication / updates on power status / planned outages • Customer awareness re energy efficiency & DSM 	<ul style="list-style-type: none"> • Modern IT systems • State-of-the-art software • Integrated trouble call center w asset database, customer database with customer indexing; MBC center, inventory and stores wing, public relations wing, etc 	<ul style="list-style-type: none"> • Adequate staff no. & mix • Continuous training

Business Process: Corporate Processes

Corporate Processes include purely executive-level functions, or that support the management of primary (“line”) business processes. These include: organization structure, policy setting, planning and control, performance measurement, treasury and cash management, finance and accounting human resources information management, procurement and inventory management.

Process Component	Best Practice	Technology	People
Executive management	<ul style="list-style-type: none"> • GTG (Good to Great) principles • Effective mgmt selection, devel’t & training • Emphasize quantification and measurement 	<ul style="list-style-type: none"> • Modern IT systems • Advanced software 	<ul style="list-style-type: none"> • Adequate no. & mix of specialized staff • Continuous training
Planning and Control, including Performance Measurement and KPIs	<ul style="list-style-type: none"> • Use of global performance standards • Extensive use of quantification • Extensive benchmarking • Balanced scorecard & KPIs 	<ul style="list-style-type: none"> • Modern IT systems • Advanced software 	<ul style="list-style-type: none"> • Adequate no. & mix of specialized staff • Continuous training
Marketing and Sales	<ul style="list-style-type: none"> • Marketing analysis & consumer analysis • Empirical measurement of service quality • Consumer satisfaction surveys • Stratification of markets • Key account personnel 	<ul style="list-style-type: none"> • Modern IT systems • Statistical analysis tools • Customer Relationship Management s/w 	<ul style="list-style-type: none"> • Adequate no. & mix of specialized staff • Continuous training
Treasury and Cash Management	<ul style="list-style-type: none"> • Prepayments, where feasible • Automatic deduct for commercial accounts • Cash management system • Automated cash collection centers • Lock box system 	<ul style="list-style-type: none"> • Modern IT systems • Advanced software 	<ul style="list-style-type: none"> • Adequate no. & mix of specialized staff • Continuous training

The Analytic Ingredients



High impact detailed project report (DPR) projects

- **Distribution transformer replacement**
 - **Plus DTR management system**
- **Substation upgrades, replacements and new additions**
 - **In conjunction with line reconfiguration**
- **11kv line & LT line refurbishment**
- **Meter replacements**
- **Remote monitoring of SAIDI, SAIFI and voltage levels**

Key Performance Indicators

Key Key Performance Indicators (KKPI)

- 1. Transformer Failure Rate**
- 2. Cable/Overhead Line Failure Rate (11 kV)**
- 3. SAIDI – System Average Interruption Duration Index**
- 4. SAIFI – System Average Interruption Frequency Index**
- 5. CAIDI – Customer Average Interruption Duration Index.**
- 6. Response time to voltage complaints.**
- 7. End-to-end money-flow efficiency: Ratio of bank deposits to energy received (monetized) from Transco**
- 8. Customer Satisfaction Index**
- 9. AT& C Losses - Aggregate Technical and Commercial Losses**
- 10. ROCE - Return on Capital Employed**
- 11. O&M (Revenue Expenses) per unit energy input.**
- 12. Training Statistics**

KKPI Algorithms

Perspective	UOM	Measures
Availability		
SAIDI – System Average Interruption Duration Index	<i>Hours</i>	$\frac{\Sigma (\text{Duration of outage}) \times (\text{No. Customers affected})}{(\text{Total No. of Customers})}$
Distribution Transformer Failures	%	$\frac{(\text{No of DTR failure during a year})}{\text{Average No of DTRs during the year}}$
CAIDI – Customer Average Interruption Duration Index	Minutes per occasion	$\frac{\Sigma (\text{Customer Interruption Durations})}{(\text{Total No. of Customer Interruptions})}$ = SAIDI/SAIFI
OH/Cable Failure Rate	Faults per 100 ckt-km of 11 kV line	$\frac{\text{No of Faults during a year} \times 100}{(\text{Total 11 kV circuit kilometer})}$

KKPI Algorithms (cont.)

Perspective	UOM	Measures
Reliability		
SAIFI – System Average Interruption Frequency Index	Instances	$\frac{\Sigma(\text{No of interruptions}) \times (\text{No Customers affected})}{(\text{Total No. of Customers})}$
Customer Service		
Customer satisfaction index	% customers, somewhat or very satisfied	$\frac{\text{No of customers expressed satisfaction}}{\text{Sample size of customers interviewed}}$
Response Index to voltage complaint	% complaints resolved in time	$\frac{\text{No of complaints resolved within time-limits}}{(\text{Total No of complaints})}$

KKPI Algorithms (cont.)

Perspective	UOM	Measures
Aggregate Technical & Commercial Losses	%	<u>Energy Realized</u> Energy Import
End-to-end Money Flow Efficiency	%	<u>Collection Deposited In Bank</u> Energy Delivered to the Division (Monetised)
ROCE – Return on capital employed	%	<u>(Profit before Interest & Tax)</u> (Long term loan + Equity)
O&M expenses per unit of energy input	Paise	<u>Total O & M expenses</u> Total energy imported

KKPI Algorithms (*cont.*)

Perspective	Measures
Training	
% of People having undergone training	Actual Versus Training

Lessons Learned

There are some important lessons learned

- **The ‘how’ of the process (not just the ‘what’) makes a big difference**
- **Begin with a definition of desired – and measurable – results**
- **An integrated and holistic approach get the best results**
- **Start in a small area, then set up “shadow” units to promulgate results**
- **Rigorous planning and analysis pays off**
- **Dedication of an experience team with the right skills mix a must**
- **Senior executive support is essential**
- **Collaboration is the most critical ingredient**

**Who are these
discoms?**



The Companies

- **North Delhi Power, Ltd.**
- **Bangalore Electricity Supply Company**
- **Maharashtra State Electricity Distribution Company, Ltd.**
- **Madhya Gujarat Vij Company, Ltd.**

Post Script

Inefficient irrigation pumps waste electricity ... and water

- **Water is an increasingly scarce resource**
- **Many countries are pursuing increased agricultural production**
- **Pumping irrigation water from underground aquifers has increased**
- **Some countries have granted preferential tariffs to farmers**
- **This can lead to wasteful consumption of both electricity and water**
- **If efficient tariffs aren't politically viable, an Ag DSM methodology is an option**
- **The approach is complex and has notable risks**
- **An article explaining a concept that is currently in a pilot process is available for those interested**

Thank you

Additional information on these projects can be found at:

www.drumindia.com

www.waterenergynexus.com

If you send me a question by email, I will do my best to respond quickly:



PA Consulting Group

James M. Hogan

4601 N. Fairfax Drive, Suite 600
Arlington, VA 22203 USA
+1 (571) 227 9000 (office)
+1 (802) 488 0646 (mobile)

jim.hogan@paconsulting.com