Improving Efficiency in Electricity Distribution

A Holistic Approach

Global Energy Efficiency Workshop
Washington, DC
March 9, 2010

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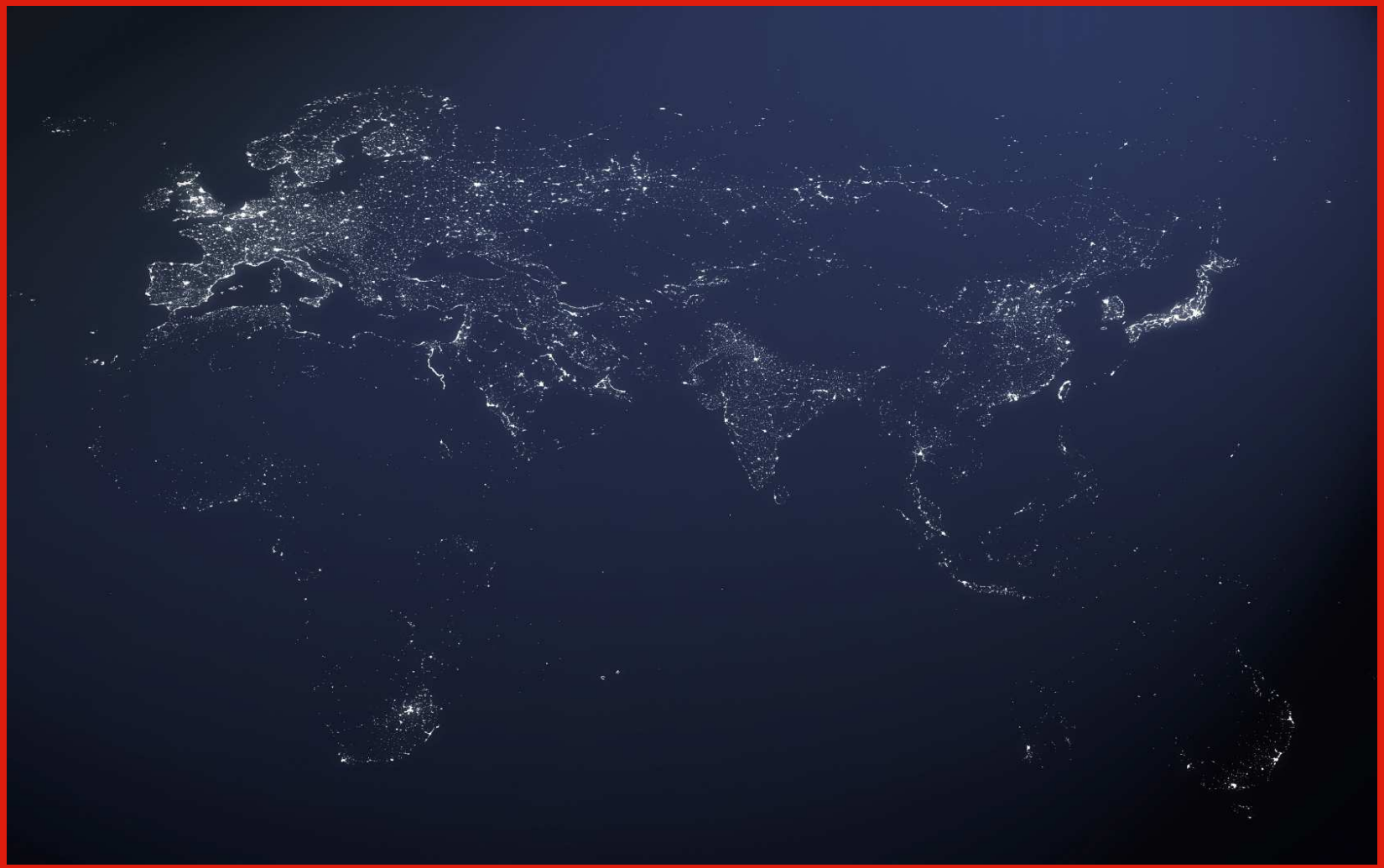
Why are efficient electric distribution networks important?



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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

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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**

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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

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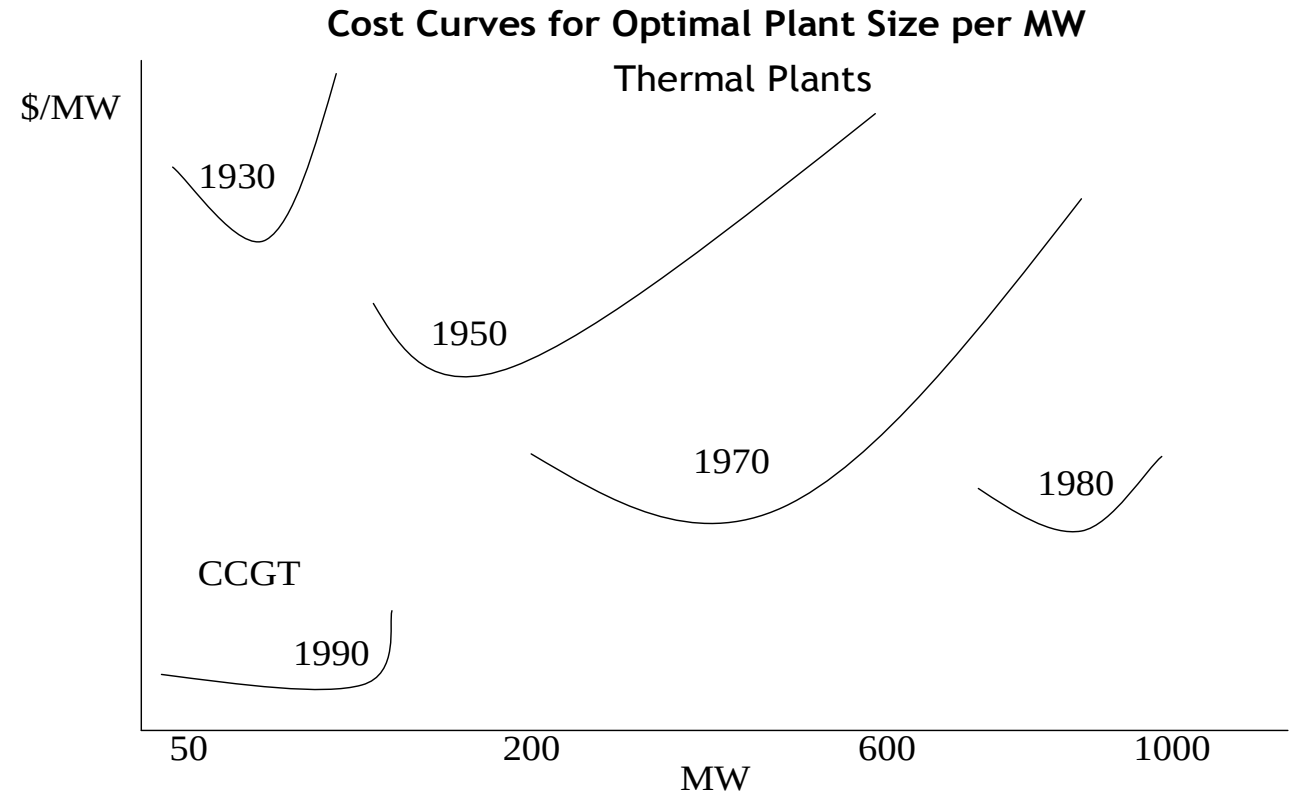
These forces are changing the industry's business model



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

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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

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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.

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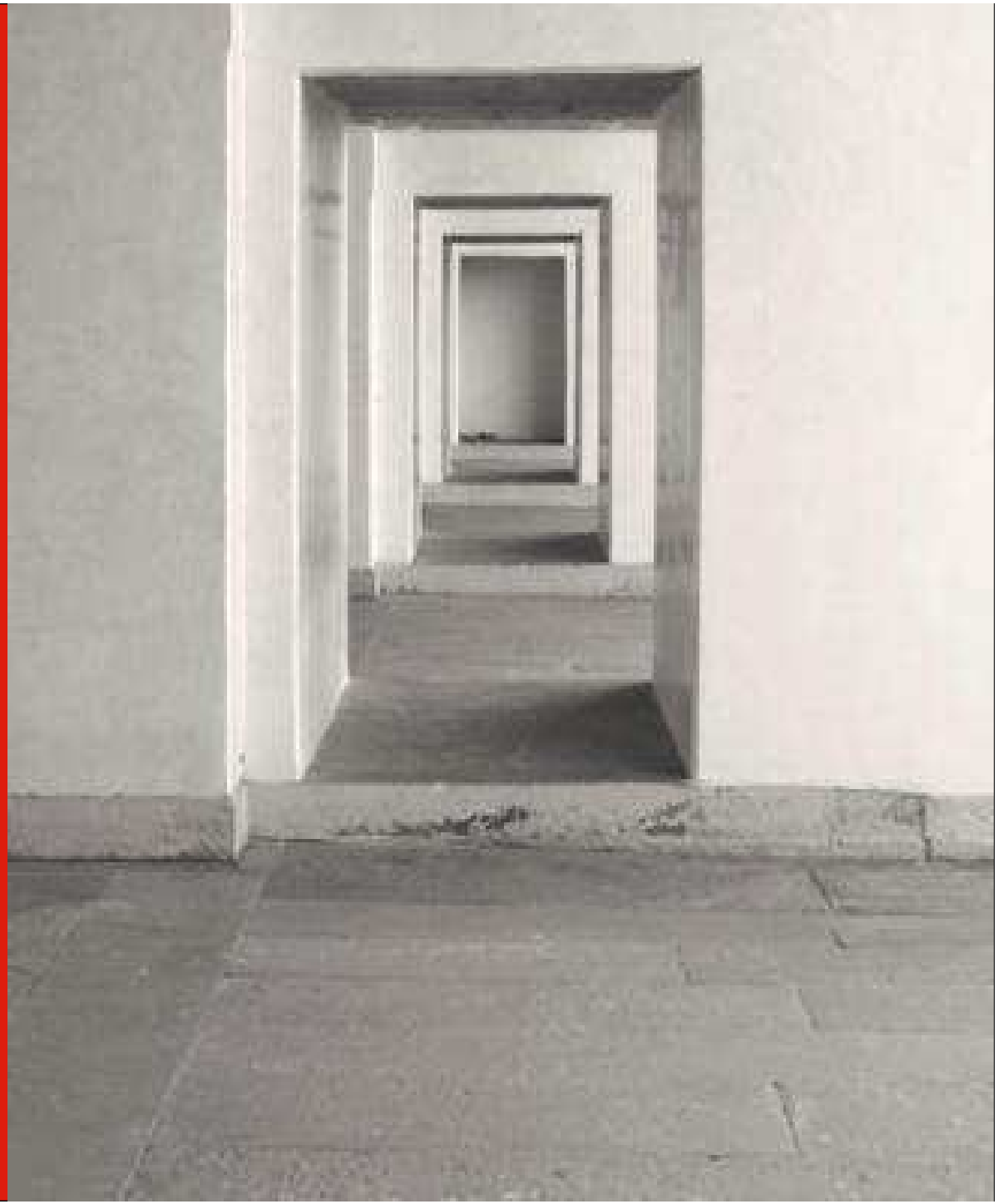
Is there a ‘best practice’ way to improve electric distribution efficiency in a developing economy?



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

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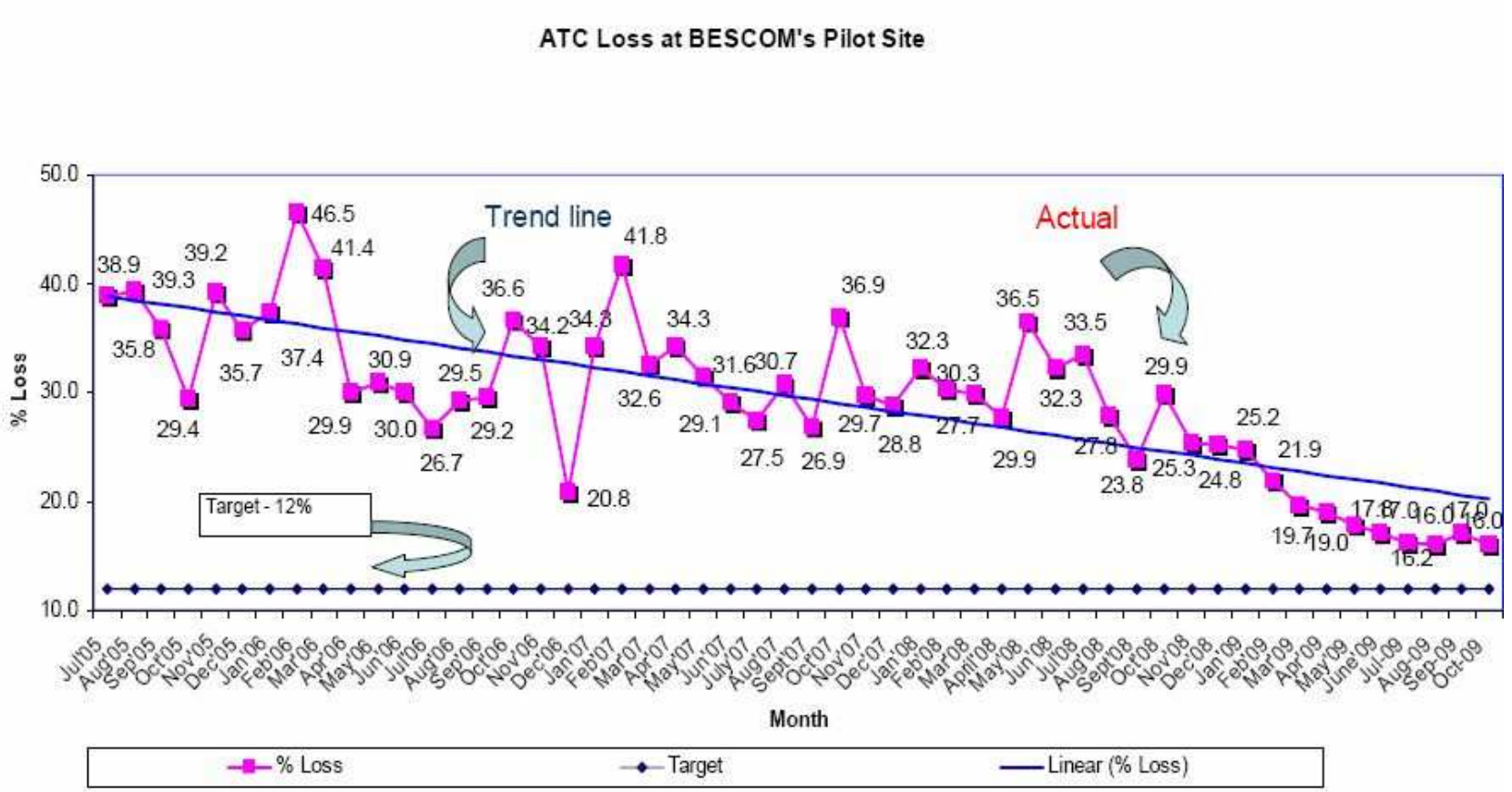
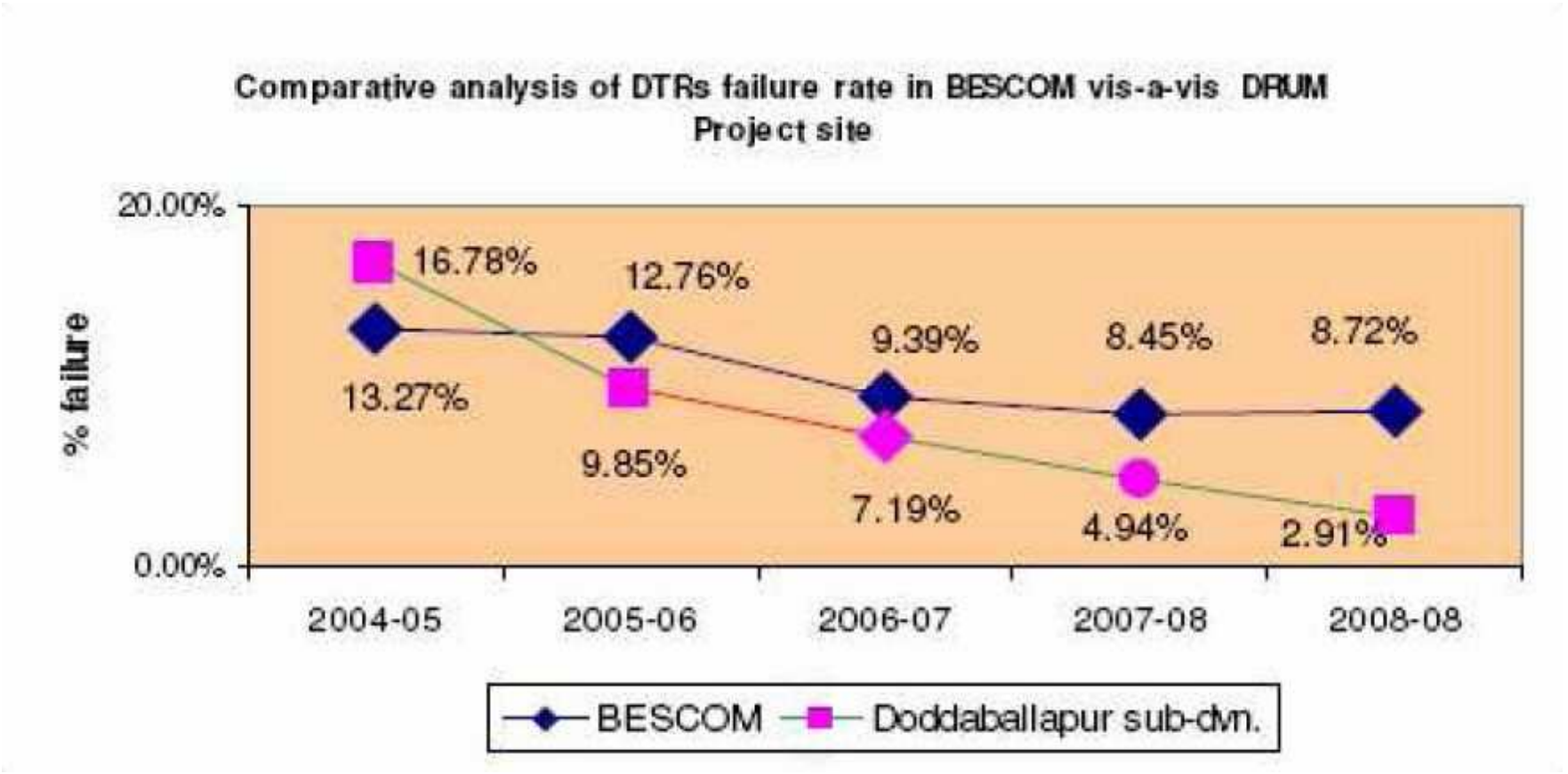
One discom cut it's AT&C losses by more than 50%



It also slashed its distribution transformer failure rate



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The Success Formula

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Begin at the end

ARC + GCR = Customer Satisfaction

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

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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

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The Model Discom & Best Practices

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The Model Discom: The Analytic Framework

People	Process	Technology
Organization Structure Work Management - Work Analysis & Staffing - Work Management Systems Compensation and Benefits Training	**Asset Management** – Planning and managing the company's investment in the physical assets used to provide high quality electric service to customers. **System Operation & Dispatch** – The activities involved in optimising the flow of electricity, incl. purchasing & trading plus economic dispatch, etc. **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. **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. **Corporate Processes** – This includes activities that enable the management of the primary business processes (above) or that are executive functions.	Distribution Network - Wires - Transformers - Capacitors - Substations - Poles - Etc. Metering Equipment O&M Equipment (trucks, tools, etc.) Computing and Telecommunications

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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	• Proven load forecasting methodology • Empirical inputs, e.g. load flow studies	• Modern IT systems • Advanced software	• Adequate staff no. & mix • Continuous training
Capital Expenditure Analysis	• Use of sound engineering-economic principles	• Modern IT systems • Advanced software	• Adequate staff no. & mix • Continuous training
Long-term Investment Plan (15 year horizon)	• Rigorous challenge & review process • Use of ROA / SVA principles • Link to capital structure management • Post-completion evaluations done	• Modern IT systems • Advanced software	• Adequate staff no. & mix • Continuous training
Short-term Capital Budget (3 yrs)	• Bottom-up link to operating budget • Pre-launch authorization required	• Modern IT systems • Advanced software	• Adequate staff no. & mix • Continuous training
Major Project Management	• Specialized project management group	• Modern IT systems • Advanced software	• Adequate staff no. & mix • Continuous training
System Mapping	• Global mapping system • Comprehensive data base	• Modern IT systems • Advanced software	• Adequate staff no. & mix • Continuous training
Maintenance, Analysis & Planning	• Reliability-based maintenance plans • Comprehensive data base	• Modern IT systems • Advanced software	• Adequate staff no. & mix • Continuous training

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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	• State estimator to estimate load flow on hourly, weekly, mo. basis to ensure 24 hour stable parallel operation with neighbouring grids	• Modern IT systems • SCADA to optimise dispatch of electricity • Remote grid stations	• Adequate staff no. & mix • Continuous training
Energy Audit and Accounting	• Energy audit & accounting of network, feeder-wise and dist'n transformer-wise monthly. • 100% reads of boundary meters • Load parameters.	• Modern IT & s/w systems • High Voltage Distribution System • Continuous update of GIS maps • Feeder wise, distribution transformer wise energy balance	• Adequate staff no. & mix • Continuous training
Operational load forecasting.	• Load forecasting (Short term) • Load flow / monitoring studies • Contingency / security analysis. • Effective outage management	• Advanced computer systems • State-of-the-art software for automated dispatch management • SCADA system	• Adequate staff no. & mix • Continuous training
Power procurement from market	• Evaluate power production & cost + cost of available power • Measurement of purchasing & trading of economical power	• Advanced computer systems • State-of-the-art software	• Adequate staff no. & mix • Continuous training
Load Management	• GIS/GPS digital mapping • Load mgmt by feeder control, DTC control, customer load control, capacitor introduction	• State-of-the-art SCADA System • Distribution automation. • GIS/GPS mapping system	• Adequate staff no. & mix • Continuous training

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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	• Maintenance manuals • Prioritize sked for life cycle maint • Reliability based maintenance plan • Veg. mgmt, periodic overhauls	• Modern IT systems • Advanced software • GIS/GPS utility map • Feedback from outage mgmt	• Adequate staff no. and mix • Continuous training
Revenue Expenditure Analysis	• Use engineering-economic principles	• Modern IT systems • State-of-the-art software	• Adequate staff no. and mix • Continuous training
Asset Outage Management and Disaster Management	• Fault detection system for 11KV feeders • Emergency load shedding schedule • Utility map integrated with SCADA	• Modern IT systems & s/w • GIS/GPS Maps • Mobile maintenance crews • Mobile transformers	• Adequate staff no. and mix • Continuous training
Building Vendor analysis	• Analyze equipment failures	• Modern IT systems • State-of-the-art software	• Adequate staff no. and mix •Continuous training
Releasing service connection	• Specialized commercial group w KPIs for time period to release a particular category of service	• Modern IT systems • State-of-the-art software • GIS/GPS maps integrated w asset& customer D/Bs	•Adequate staff no. and mix •Continuous training
Trouble Call Management	• Specialised ops group w link to assets, billing data base, complaint center and maintenance crews	• Mobile phones to field staff • Toll free no. for customers • Call processing & analysis • Mobile maintenance crews	• Adequate staff no. and mix • Continuous training

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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)	• 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.	• 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,	• Adequate staff no. & mix • Continuous training
Customer Relationship Management (CRM)	• 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	• 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	• Adequate staff no. & mix • Continuous training

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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 in formation management, procurement and inventory management.*

Process Component	Best Practice	Technology	People
Executive management	• GTG (Good to Great) principles • Effective mgmt selection, devel't & training • Emphasize quantification and measurement	• Modern IT systems • Advanced software	• Adequate no. & mix of specialized staff • Continuous training
Planning and Control, including Performance Measurement and KPIs	• Use of global performance standards • Extensive use of quantification • Extensive benchmarking • Balanced scorecard & KPIs	• Modern IT systems • Advanced software	• Adequate no. & mix of specialized staff • Continuous training
Marketing and Sales	• Marketing analysis & consumer analysis • Empirical measurement of service quality • Consumer satisfaction surveys • Stratification of markets • Key account personnel	• Modern IT systems • Statistical analysis tools • Customer Relationship Management s/w	• Adequate no. & mix of specialized staff • Continuous training
Treasury and Cash Management	• Prepayments, where feasible • Automatic deduct for commercial accounts • Cash management system • Automated cash collection centers • Lock box system	• Modern IT systems • Advanced software	• Adequate no. & mix of specialized staff • Continuous training

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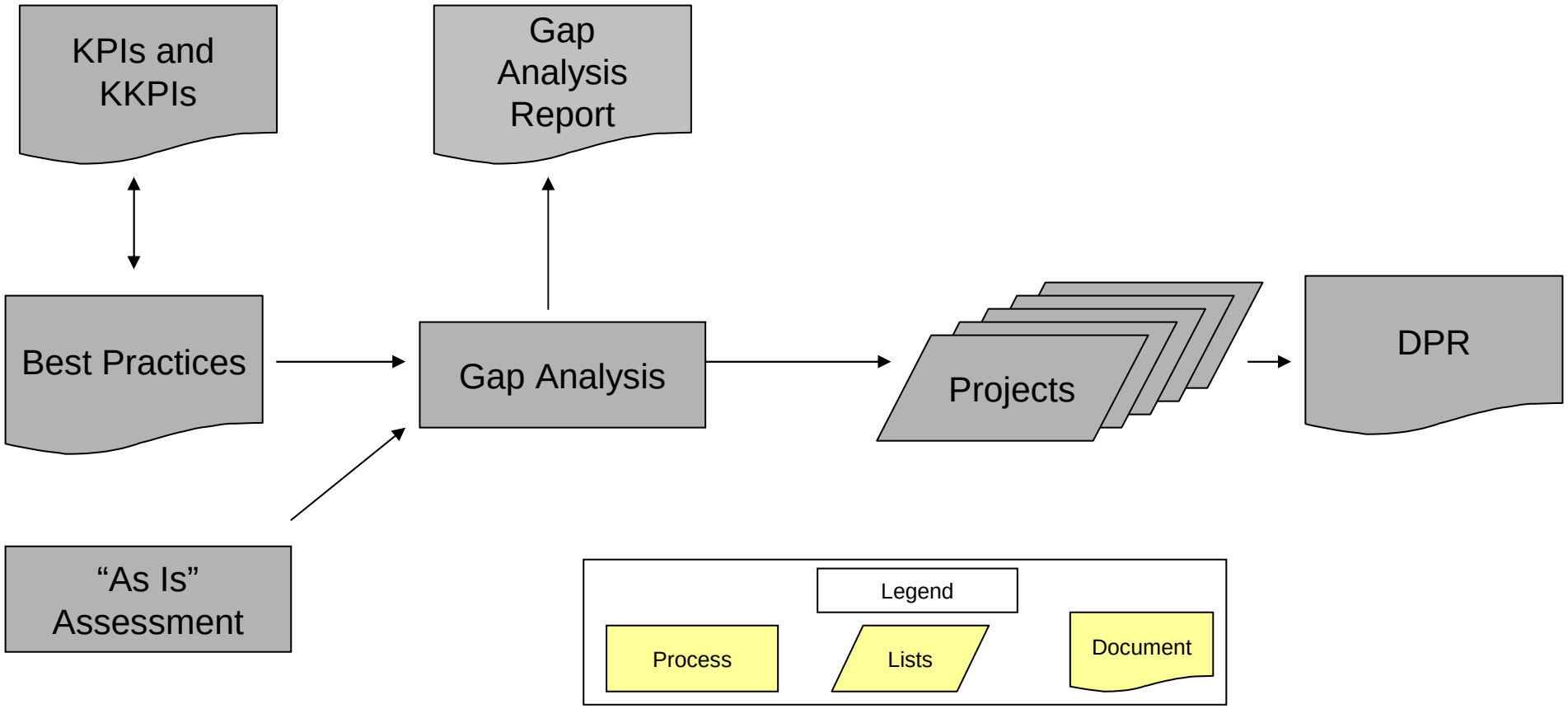
The Analytic Ingredients



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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

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Key Performance Indicators

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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

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KKPI Algorithms

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

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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**	**$\frac{\text{No of complaints resolved within time-limits}}{\text{(Total No of complaints)}}$**

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KKPI Algorithms *(cont.)*

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

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KKPI Algorithms *(cont.)*

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

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Lessons Learned

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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

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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.

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Post Script

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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

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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:

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