Demand Side Management
Concept, Options and Program Design

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Demand Side Management

- Indian utilities – energy shortage and peak power shortage.
- Supply Focussed - Build New Power Plants.
- Capital & Fuel Scarcity, Environmental Impacts, Gestation Period.
- Need for Options – Demand Side Management (DSM) & Load Management
DSM Concept

- Demand Side Management (DSM) - co-operative action by the customer & the utility(SEB) to modify the customer load
- DSM benefits utility, consumer & society
- Energy Conservation
- Fuel Switching
- Peak Clipping/Valley Filling/Load Shifting
Electric Utility Role

- Provision of Electricity to customers in the service area - supply customers with power they wish at whatever time
- Planning under uncertainty of demand
- Daily, Weekly & Seasonal Load Variation
- Conventional power planning - Demand – exogenous, uncontrollable – build new supply to meet demand
Redefining Role

- Capacity additions costly – Shortages of peak power and energy
- Low capacity utilisation of power plants – increased costs – high tariffs
- Gestation Period
- Provision of energy services (using electricity) to customers in the service area (lighting, cooling, motive power...)
Energy Flow Diagram

- PRIMARY ENERGY
- ENERGY CONVERSION FACILITY
- SECONDARY ENERGY
- TRANSMISSION & DISTRN. SYSTEM
- FINAL ENERGY
- ENERGY UTILISATION EQUIPMENT & SYSTEMS
- USEFUL ENERGY
- END USE ACTIVITIES

(ENERGY SERVICES)

- COAL, OIL, SOLAR, GAS
- POWER PLANT, REFINERIES
- Refined oil, electricity
- RAILWAYS, TRUCKS, PIPELINES
- WHAT CONSUMERS BUY
- DELIVERED ENERGY
- AUTOMOBILE, LAMP, MOTOR,
- STOVE
- MOTIVE POWER RADIANT
- ENERGY
- DISTANCE TRAVELLED, ILLUMINATION, COOKED
Utility Load shape objectives

- **Peak Clipping**
  (Reducing system peak loads)

- **Valley Filling**
  (Increase off-peak loads without affecting peak period energy and demand)

- **Load Shifting**
  (Shifting of loads to off-peak periods)

- **Strategic Conservation**
  (Reduce end-use consumption through increased efficiency)

- **Strategic Load Growth**
  (Increase end-use consumption resulting in increased sales beyond valley filling)

- **Flexible Load Shape**
Analysis of System Load Curve

- A load curve defines power vs time
- Load Factor = \( \frac{\text{Average Power}}{\text{Peak Power}} \)

System Load Factor

- Capacity Factor (plant load factor)
  \[ \text{Capacity Factor} = \frac{\text{Energy generated by a plant}}{\text{Energy generated if operating at max capacity}} \]
Classification

- **Time intervals**
  - Daily Load Curves (hourly/half hourly)
  - Seasonal (Winter/Summer/monsoon)
  - Annual Load Curves

- **User Classes**
  - Residential
  - Industrial
  - Commercial
  - Agricultural

- **End Uses**
  - Lighting, pumping, motors, heating, AC
Load Duration Curve

- Frequency Distribution of loads
- Re-arrange data to obtain cumulative number of hours where demand \( \geq \) specified value
- Plot – Load Duration curve
- Highest load period -15-20% of the hours- designated as peak
- Base Load – present for 70-80% of time
Daily Load Curve

System Load MW vs Hour

Series 1
Load Duration Curve

System Load MW

Hours

Series 1
Sample Load Duration Curve
Mumbai Electricity Load Profiles

- 21-May-09
- 26-May-11
- 21-May-13
## Electricity Supply - Indian Cities

<table>
<thead>
<tr>
<th>City</th>
<th>Average MW</th>
<th>Peak MW</th>
<th>Annual Growth rate (next decade) %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lucknow</td>
<td>553</td>
<td>750</td>
<td>6.5</td>
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<tr>
<td>Kanpur</td>
<td>348</td>
<td>580</td>
<td>5.4</td>
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<tr>
<td>Jaipur</td>
<td>446</td>
<td>771</td>
<td>10.6</td>
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<tr>
<td>Ahmedabad</td>
<td>897</td>
<td>1320</td>
<td>7.4</td>
</tr>
<tr>
<td>Surat</td>
<td>917</td>
<td>1309</td>
<td>6.6</td>
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<tr>
<td>Nagpur</td>
<td>264</td>
<td>315</td>
<td>7.6</td>
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<tr>
<td>Indore</td>
<td>229</td>
<td>391</td>
<td>10.2</td>
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<tr>
<td>Pune</td>
<td>886</td>
<td>1173</td>
<td>10.5</td>
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<td>Mumbai</td>
<td>2524</td>
<td>3605</td>
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<td>Hyderabad</td>
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<td>2134</td>
<td>8.2</td>
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<td>Chennai</td>
<td>1743</td>
<td>2291</td>
<td>5.6</td>
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<tr>
<td>Bengaluru</td>
<td>1404</td>
<td>2090</td>
<td>5.6</td>
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<tr>
<td>Kolkata</td>
<td>1773</td>
<td>2577</td>
<td>5.1</td>
</tr>
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</table>
DSM terms

- DSM Options- Options for customer load modifications
  - Technological – energy efficient motors
  - Management- good housekeeping
  - Pricing – Time of Use Tariffs

- DSM Programme = DSM option + programme structure + costs

- DSM Plan – Sum of individual DSM programmes
DSM Programmes

- Efficient Pumping Systems – Agricultural/ Municipal /Industry
- Efficient Motor-Drive Systems - Industrial
- Efficient Lighting - Commercial/Residential
- Process Improvements- Industrial
- Solar Water Heaters – Residential/Commercial
- Efficient AC – Commercial/ Residential
- Cogeneration/Captive Power- Industry/commercial
Inputs Required

- Technology Characteristics
  - Base Case and DSM option – energy consumption, peak coincidence
  - Capital, installation, O& M costs
  - Useful life
  - Present market share

- Market Profile – market size – TM/RM, market growth, diffusion rates
Market Definitions

- Equipment Stock
- Existing Surviving
- NEW
- Existing to be replaced
- RM
- TM

$t=0$  $t=N$
### DSM: Load sector vs. End use Technology mapping

<table>
<thead>
<tr>
<th>Sector Vs End use</th>
<th>Residential</th>
<th>Industrial</th>
<th>Commercial</th>
<th>Agriculture</th>
<th>Municipal</th>
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<tbody>
<tr>
<td>Lighting</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
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<tr>
<td>Ceiling Fans</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Refrigeration</td>
<td>✓</td>
<td>✓</td>
<td></td>
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<tr>
<td>HVAC</td>
<td>✓</td>
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<tr>
<td>Motor Driven Systems</td>
<td></td>
<td>✓</td>
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<td>✓</td>
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<tr>
<td>Cogeneration</td>
<td></td>
<td></td>
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<td></td>
<td>✓</td>
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<tr>
<td>Geothermal Heat Pumps</td>
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<tr>
<td>Micro-irrigation</td>
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<td></td>
<td>✓</td>
</tr>
<tr>
<td>Water Heaters</td>
<td>✓</td>
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</tbody>
</table>
Residential Sector: End-use categories: Technology Options

- CFL vs. ICL
- LED vs. ICL
- T8/T5 vs. T12 FTL

- 5 Star vs. 1 Star Split AC
- Split AC vs. Window AC

- 5 Star vs. 1 Star Refrigeration
- Deep frost (Manual Defrost) vs. Frost free

- 5 Star vs. 1 Star Lighting
- LED vs. ICL
- LED vs. ICL
- T8/T5 vs. T12 FTL

- 5 Star vs. 1 Star HVAC
- Super efficient (BLDC) fans vs. 1 Star

- 5 Star vs. 1 Star Ceiling Fan
Commercial Sector: End-use categories: Technology options

- LED
- Induction lamps
- T5 FTL

- Gas Geysers vs. Electric geysers

- Geothermal heat pumps

- Cool Storage

- HVAC

- Heat pumps

- Water Heaters
Industrial Sector: End-use categories

- Thermal storage
- HVAC units running with power from CHP plants.
- VFD (Speed control)
- Energy Efficient motors

- Gas turbine
- Steam Turbine
- Reciprocating Engine based
- Fuel cell based
- Micro-turbine based

- HPSV /LPSV /Metal Halide vs. HPMV
- Induction lamps

- Motor Driven Systems

- Lighting

- Cogeneration

- HVAC
Agricultural Sector: End-use categories: Technology Options

- **Pumps**
  - Energy efficient pumps
  - Impeller trimming
  - Parallel configuration to meet varying demand

- **Micro-Irrigation**
  - Drip Irrigation
  - Sprinkler Irrigation
Municipal Sector: End-use categories: Technology Options

- **Public Street lighting**
  - LED lights
  - Induction Lamps

- **Pumps**
  - Speed control (VFD)
  - Proper pump Sizing & piping design
## Standard Fan vs Efficient Fan

<table>
<thead>
<tr>
<th></th>
<th>Standard Fan</th>
<th>Efficient Fan</th>
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<tbody>
<tr>
<td>Power</td>
<td>70 W</td>
<td>35 W</td>
</tr>
<tr>
<td>Price</td>
<td>Rs 1300</td>
<td>Rs 2600</td>
</tr>
<tr>
<td>Life</td>
<td>10 years</td>
<td>BLDC motor</td>
</tr>
<tr>
<td>Sweep</td>
<td>1200 mm RPM</td>
<td>350-400</td>
</tr>
<tr>
<td>RPM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Similar air delivery</td>
<td>230 m³/min</td>
<td></td>
</tr>
</tbody>
</table>
Cost Of Saved Energy – Efficient Fan

![Graph showing the cost of saved energy in Rs/kWh vs. discount rate for different hours of operation. The graph includes lines for 1000, 2000, 3000, and 4000 hours of operation. The x-axis represents the discount rate, and the y-axis represents CSE Rs/kWh. Each line indicates the corresponding cost for the specified hours of operation.]
CFL vs LED

Compact Fluorescent Lamp  Light Emitting Diode
Power  14 W  6W
Price  Rs 150  Rs 1200
Life : 8000 hours  30,000 hours
Lumens/ W  50  120
Lumen output: 700 lumens
Cost Of Saved Energy – CFL vs LED
DSM – Effect on load profiles

Total peak demand savings = 20.5 kW = 20.7 kVA (@0.99 pf lag)

Energy savings = 161 kWh/day
Load Management Steps

- Analysis of Load variations
- Identification of Controllable Loads
- Selection of Control Option
- Implementation strategy
Common LM Options (SEB)

- Staggering of working hours of large consumers
- Staggering of holidays of large consumers
- Specified energy and power quotas for major consumers
- Rostering of agricultural loads
- Curtailment of demand - service interruptions (load shedding)
Load Management Options

- Direct Load Control (DLC) – Utility has control of directly switching off customer loads
- Interruptible Load Control (ILC) - Utility provides advance notice to customers to switch off loads
- Time of Use (TOU) Tariffs – price signal provided – customer decides response
DLC Control Strategies

- **Cycling** - Groups of loads switched off for short time periods to reduce system diversified demand

- **Payback control** - Groups of devices switched off for periods up to 6 hours

- Cycling preferable as payback control imposes larger than normal load when switched on
LM Options

- Cool Storage – Chilled water, Ice storage - operate compressor during off-peak
- Water pumping systems
- Cogeneration – Operating strategy
- Evaluate Process Storage possibilities
- Power pooling
DLC- India

- Central Air Conditioning - cities like Delhi, Mumbai ... VHF controlled or timer controlled - cycling
- Agricultural pumping
  - Reconfiguration of Distribution system
  - Individual controllers on pumps
  - Timer Control
- Municipal Water Pumping
Time of Use Tariff (MSEB-HT Ind., Jan 2002)

- **Off-peak**
- **Partial Peak**
- **Peak**
Example (MSEB HT Tariff-16/8/12)

- HT Industrial
  Demand charges Rs 190/kVA/month
  Energy charge Rs 7.01/kWh (Rs 6.33/kWh)

TOD – Energy charge

- 2200 hrs – 0600 hrs \((-1.00)\) 6.01
- 0600 hrs – 0900 hrs 0
- 0900 hrs – 1200 hrs 0.80 7.80
- 1200 hrs – 1800 hrs 0
- 1800 hrs – 2200 hrs 1.10 8.10
Technology Diffusion

- Even if new technology better - will not reach 100% acceptance (postponement of acceptance, supply bottlenecks, information gaps...)
- Fisher-Pry model for substitution
- \( \frac{df}{dt} = bf (1-f) \)
  where \( f \) is the fractional market share of the new improved technology
Fisher-Pry Model

- $\ln \left( \frac{f}{1-f} \right) = a + bt$
  where $a$, $b$ are constants

- Blackman’s model - Final market share not 100% but $F$
  - $\ln \left( \frac{f}{(F-f)} \right) = a + bt$

- Determine $a$, $b$ by method of least square (regression) with initial substitution data

- $a$, $b$ by analogy
<table>
<thead>
<tr>
<th><strong>Base Year</strong></th>
<th><strong>Socio-Economic Scenarios</strong></th>
</tr>
</thead>
</table>
| Information required:  
- Energy Service levels by end-uses.  
- Energy Intensities by end-uses.  
- Socio-economic indicators of energy demand. | for projected year:  
- Population growth.  
- Economic activity.  
- Levels of Energy Services (appliances saturation, etc.).  
- Energy elasticities.  

At least one socio-economic scenario is required to project future levels of ENERGY SERVICES. |

**Energy Scenarios** for projected year:

- **Frozen Efficiency Scenario**
  Maintenance of the same efficiency performance of the end-use technologies.

- **Baseline Scenario**  
  (Can also be Frozen Efficiency)  
  No-policy case: Energy efficiency improvement follows current trend.

**Technical Potential**
Successful implementation of all efficiency options in all customers.

**Economic Potential**
Successful implementation of only cost effective options in all customers.

**Market Potential**
Successful implementation of only cost effective options in only eligible customers.

**Achievable Market Potential**
Successful implementation of only cost effective options in only a realistic fraction of eligible customers.

All Energy Efficiency Scenarios consider the same projected levels of ENERGY SERVICES.
Programme Costs

- Direct Costs - costs directly associated with DSM option - include subsidy provided by utility
- Indirect Cost - Fixed + variable cost of programme
- Free Riders - Customers who would have anyway adopted - yet utility pays incentive (10-50% in US utilities)
Programme Costs

- **PC = I + A T + α CN**
  - I - Initial Programme Set-up Cost
  - A - Annual recurring programme cost
  - α - proportion of cost sharing
  - N - number of adoptions

- Energy Efficient motors I = Rs 20 lakhs, A = Rs 3 lakhs, α = 50% of incremental cost
DSM Evaluation

- Pre & Post programme metering
- Analysis of Customer Billing data
- Engineering analysis - physical based models
- Questionnaires & Survey
- Statistical Modelling - demographics, economics
Least Cost Curve for DSM
## Factors Affecting DSM

<table>
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<th>Resid</th>
<th>Agric</th>
<th>Comm</th>
<th>Ind</th>
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<tr>
<td>Revenue</td>
<td>+</td>
<td>++</td>
<td>_</td>
<td>_  _</td>
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<tr>
<td>Impact</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Savings</td>
<td>+</td>
<td>++</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>Potential</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Transaction</td>
<td>_ _</td>
<td>_ _</td>
<td>_ +</td>
<td>++</td>
</tr>
<tr>
<td>Cost</td>
<td>_</td>
<td></td>
<td>_ +</td>
<td>++</td>
</tr>
<tr>
<td>Customer Viability</td>
<td>_</td>
<td>_ _</td>
<td>++</td>
<td>++</td>
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</table>
Quantification and trend of peak demand

Quantification of peak shortage of MSEDCL for 2006-7
Quantification and trend of energy demand

Annual average unrestricted demand for 2005-6
10028 MW

Annual average unrestricted demand for 2006-7
10438 MW

Shortage

Unrestricted demand

Restricted demand

Variation of monthly average energy demand for MSEDCL
Generalised lighting end use model

Framework of model proposed for construction of end use load profiles

- Type of Household
- Usage Pattern
  - Occupants schedule of living activities
  - Daily Variation
  - Seasonal Variation
- Input data set
  - Technology characteristics
    - Different types of appliances used for Lighting
  - Power Rating of each Device (W)
- Appliance ownership data for 'S' number of sample households of each category based on floor area used
- Total no. of household samples 'S'
- Lighting energy consumption load profile for each household categorized based on floor area used
- Load Profile for one household
- Energy consumption load profiles for household samples 'S/4' of each Category
- Energy consumption load profile for state for lighting end use in the residential sector

Demographics
- Total no of households in State
- % of households categorized based on floor area
Economic analysis from different perspectives

- Economic analysis from perspective of Utilities

- Highest Power generation cost of MSPGCL = 1.81 Rs/kWh

Energy Saved by Lighting Energy Efficiency

Energy Purchased by MSEDCL

Cost of Saved Energy in Rs/kWh

Average Energy Purchase Cost in Rs/kWh

Energy Saved/ Purchased in GWh
Potential for domestic lighting energy efficiency, 2004-5

- Potential estimation for different household categories
- Potential estimation by different end use devices

A) Lighting energy efficiency potential for rural households

Peak Demand Reduction: 703 MW and Annual energy saving: 2335 MU

B) Lighting energy efficiency potential for urban households

Peak demand reduction: 663 MW and Annual energy saving: 2121 MU
Figure 1: Improvements in Refrigerator Efficiency
1972-2001

- California standard effective
- National standard effective
1974, California authorizes energy-efficiency standards (1825 kWh)

1997, first California standards take effect (1546 kWh)

Average before U.S. standards (1074 kWh)

-41%

1990 U.S. standard (976 kWh)

-74%

1993 U.S. standard (696 kWh)

2001 U.S. standard (476 kWh)

Comparison of initial cost and life cycle cost

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Equipment</th>
<th>Rating</th>
<th>Initial cost (Rs)</th>
<th>Annual Electricity Cost (Rs)</th>
<th>ALCC (Rs)</th>
<th>Cost of electricity as % of ALCC</th>
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<tbody>
<tr>
<td>1</td>
<td>Motor</td>
<td>20 hp</td>
<td>45,000</td>
<td>600,000</td>
<td>605,720</td>
<td>99.0</td>
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<tr>
<td>2</td>
<td>EE Motor</td>
<td>20 hp</td>
<td>60,000</td>
<td>502,600</td>
<td>512,700</td>
<td>98.0</td>
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<tr>
<td>3</td>
<td>Incandescent Lamp</td>
<td>100 W</td>
<td>10</td>
<td>1168</td>
<td>1198</td>
<td>97.5</td>
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<tr>
<td>4</td>
<td>CFL</td>
<td>11 W</td>
<td>350</td>
<td>128</td>
<td>240</td>
<td>53.6</td>
</tr>
</tbody>
</table>

EE- Energy Efficient, CFL- Compact fluorescent lamp, ALCC- Annualised life cycle cost
Sample Industrial Load Profile (Mumbai)

WEEKLY LOAD CURVE
ILM Research Objective

- Determine optimal response of industry for a specified time varying tariff – develop a general model applicable for different industries
  - Process Scheduling- Continuous/ Batch
  - Cool Storage
  - Cogeneration
Process Scheduling

- Variable electricity cost normally not included
- Flexibility in scheduling
- Optimisation problem – Min Annual operating costs
- Constraints – Demand, Storage and equipment
- Models developed for continuous and batch processes (Illustrated for flour mill and mini steel plant)
- Viable for Industry
Process Scheduling

- Batch processes- batch time, quantity, charging, discharging, power demand variation (load cycles)
- Raw material constraints, Allocation constraints, Storage constraints, Sequential Constraints, maintenance downtime
## Process Scheduling Summary

<table>
<thead>
<tr>
<th>Example</th>
<th>Structure</th>
<th>Results</th>
<th>Saving</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flour Mill Continuous</td>
<td>Linear, IP</td>
<td>Flat-2 shift - 25% store TOU-3 shift</td>
<td>1% 6.4% 75% peak reduction</td>
</tr>
<tr>
<td></td>
<td>120 variables</td>
<td>46 constraints</td>
<td></td>
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<tr>
<td></td>
<td>46 constraints</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mini Steel Plant Batch</td>
<td>Linear, IP</td>
<td>Flat TOU Diff loading</td>
<td>8% 10% 50% peak reduction</td>
</tr>
<tr>
<td></td>
<td>432 variables</td>
<td>630 constraints</td>
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<tr>
<td></td>
<td>630 constraints</td>
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</tr>
</tbody>
</table>
Steel Plant Flow Diagram

St. steel Scrap mix or Alloy steel scrap mix

40 T Melting Arc furnace

Convertor (only for St Steel)

Ladle Arc furnace

VD or VOD station

Bloom caster

Open store

Reheat furnace

Bloom mill

Billet caster

Open store

30 T MeltingArc furnace

Reheat furnace

Bar mill

Open store

Open store

Open store

Wire products for final finish

Reheat furnace

Wire mill

Rods, Bars for final finish
Steel Plant Optimal Response to TOU tariff

![Graph showing Steel Plant Load MW over time with optimal response to TOU tariff and flat tariff.](image)
Cool Storage

- Cool Storage – Chilled water operate compressor during off-peak
- Commercial case study (BSES MDC), Industrial case study (German Remedies)
- Part load characteristics compressor, pumps
- Non-linear problem – 96 variables, Quasi Newton Method
- MD reduces from 208 kVA to 129 kVA, 10% reduction in peak co-incident demand, 6% bill saving
Schematic of AC Plant with Cool storage
Cooling Load and Electric Demand Profiles without storage

- Max. 170 TR
- MD 207.8 kW

- Cooling Load
- Electric Demand

Time hours

KW, TR

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
With Cool Storage

The graph shows the load kW over time hours for different tariff categories and existing without cool storage. The peak load is indicated as 207.8 kW, with flat tariff at 121.7 kW, TOU tariff at 122.5 kW, and existing without cool storage at 120 kW.
Cogeneration

- Process Steam, Electricity load vary with time
- Optimal Strategy depends on grid interconnection(parallel- only buying, buying/selling) and electricity, fuel prices
- For given equipment configuration, optimal operating strategy can be determined
- GT/ST/Diesel Engine – Part load characteristics – Non Linear
- Illustrative example for petrochemical plant- shows variation in flat/TOU optimal.
Cogeneration Example

Fuel, HSD 5.9 T/h
Gas turbine -1
17.5 MW

Fuel, HSD 5.9 T/h
Gas turbine -2
17.5 MW

WHRB-1
Supp. Firing LSHS 5.6 T/h
136 T/h
Stack

WHRB-2
Supp. Firing LSHS 5.6 T/h
136 T/h

Gas turbine -2

Boiler
131.7 T/h

Fuel, LSHS 9.64 T/h

WHRB-2

SHP Steam 100 bar, 500°C
117.1 T/h
Process Load, 150 T/h
60.6 T/h
Process Load, 125 T/h
76.2 T/h
12.5 MW

HP Steam 41b, 400°C
Process Load, 125 T/h
20 T/h

MP Steam 20b, 300°C
49.5 T/h

LP Steam 5.5 b, 180°C
53.4 T/h

Deaerator

Condenser

Make up water, 357 T/h

Feed water 426.5 T/h

Process Load 40 T/h

Grid 7.52 MW

Process Load, 60 MW

BUS
Import Power from Grid with Cogeneration for a Petrochemical Plant

![Graph showing import power over time with flat tariff and TOU tariff](graph.png)

- **Import Power MW**
- **Time hours**

**Flat Tariff**
- Peak period demand: 11 MW
- Import power: 21.6 MW

**TOU Tariff**
- Import power: 17.6 MW
- Peak period demand: 0 MW
Export power to the grid with Cogeneration for a Petrochemical Plant

- Flat tariff vs. TOU tariff
- Export Power MW
- Time hours
- Peak period demand: 9.7 MW
- Integrated approach

Process demand profile, Cooling electric load profile, Steam load profile

Captive/Cogeneration power model

Grid tariff, fuel costs, Grid conditions

Optimal operating strategy of captive/cogeneration plant

Operating cost structure

Process load model

Optimal process load schedule

Modified process demand profile

Modify steam load profile for process related loads

Modify cooling electric load profile

Air conditioning (cooling) load model

Optimal cool storage
Integration of DSM with PV

100 Households
Residential loads:
Incandescent bulb
Ceiling Fan, Television
Radio/Music load,
Agricultural pumpset
Isolated system
PV- Battery
PV-Battery-DSM
Comparison of PV rating and cost
Zero Energy Buildings

www.passiv.de
(Germany/Sweden)

ECBC, Teri GRIHA – Building rating schemes
Dependent on climatic zone, share of AC space

Bayer Innovation Centre Noida
Zero Emissions Building
45 kWh/m²/year, solar PV
http://www.bayer.com/
SOLAR DECATHLON - RESEARCH AREAS

- Structural Analysis
- Materials
- Passive Architecture & Simulation
- Prefab construction
- Solar Potential & PV
- HVAC Design
- MEP System Design
- Instrumentation & Control Systems
COLLABORATION

Inter-disciplinary research – Team has students from 13 different disciplines

Diverse team consisting of students from all major programmes – PhD, M.Tech, Undergraduate (2nd, 3rd, 4th, 5th Years)

Collaboration and interfacing with industry experts
Efficiency and DSM

- Rebound Effect
- Transaction Costs
- Level Playing Field
- Needed a Paradigm Change – Focus on Energy Services
- Shortage of Supply to Longage of Demand
Case Study: Capacitor Leasing

Source: Taylor et al, 2008
BLY Schematic

CFL INVESTOR
- Procures long-life CFLs and distributes to households
- Day-to-day monitoring; Verification survey to assess lamp failure rate

HOUSEHOLD
- Pays Rs 15 for new CFL

DISCOM
- Provides access to the households for installing CFLs
- Each BLY project ~ 600,000 CFLs, up to 4 CFLs per household
- 400 million ICLs / annum replaceable, annually saving ~ 6000 MW

Source: BEE web site
Concluding Remarks

Redefining utility role

- DSM – Least cost power planning
- DSM for electricity bill reduction
- Carbon Dioxide reduction / CDM
- Cogeneration/ Trigeneration
- Process Scheduling, Benchmarking/ Target setting
- Implementation low – Transaction cost, need for pilot projects, monitoring

Thank you
References