Resource Material
On
Efficiency Improvement Measures in Distribution System

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Chapter 1

Demand Side Management

1.1 Introduction

1.1.1 Definition

Demand side management (DSM) can be defined as planning, selection, design and implementation of the measures, undertaken directly or stimulate indirectly by the utilities for achieving more efficient end use of the electricity by the customer. Essentially, DSM is implementation of efficient end-use technologies which will reduce the consumption of electricity without compromising the benefit accrued from use of electricity.

1.1.2 Benefits

By proper implementation of DSM, the utilities, the customers and the society benefit as a whole. Because of lower consumption of electricity, the peak load demand is reduced and as a result, the utilities can reduce their amount of peak power to be purchased from the wholesale spot market, thereby reducing their short term cost for supplying power. In the long run, the utilities can limit or defer construction of new power plants with the associated transmission and distribution lines, thereby saving a lot of money. In fact, a DSM program can be a much cheaper option to implement as compared to construction of new power plants. As an example, during XI plan period, a 5% reduction in energy usage through various DSM measures has been envisaged, which would translate into an avoided capacity addition of 10,000 MW thereby resulting into an avoided investment in generation, transmission and distribution sectors in the tune of 1,00,000 crores of rupees.

For the customers, consumption of reduced amount of electricity lowers their electricity bill immediately. Moreover, the energy efficient technologies have more efficient operating characteristics thereby reducing the operation and maintenance cost of these technologies. Further, these technologies tend to last longer thereby reducing the long term cost of owning these technologies. Therefore, although the initial cost of investment for deploying these technologies is higher, the savings accrued from lower electricity bill more than offsets this higher cost over the life time of these technologies.

Due to implementation of DSM programs, the society also benefits as a whole. Because of lower electricity usage, lower amount of fuel (coal, oil, gas etc.) needs to be burned to produce electricity thereby reducing carbon emissions. Thus, a successful DSM program also addresses the very pertinent issue of global warming quite effectively. In fact, DSM programs are nowadys quite an effective tool in the hand of utilities and goverments across the world to combat the threat of carbom emissions and global warming.

1.1.3 Barriers to DSM

Most economies have great technical potential for DSM. Yet there are a number of market-based and institutional barriers that must be overcome before much of this potential can be realized. The efficacy of utility DSM initiatives and, in general, of DSM strategies, is directly related to their ability to overcome the major barriers in their service territories. These two barriers are discussed in more detail below.

Market based barriers

Market barriers to energy efficiency are usually defined as characteristics of the market for an energy-related product, service or practice that help explain the gap between the actual level of investment in, or practice of energy efficiency and the increased level that would appear to be cost-beneficial for the consumer. These barriers stem from the environment surrounding the decisions and actions taken by end-users, market intermediaries, electric utilities and institutional organizations. These are usually associated with the specific perceptions and behaviors of final customers, intermediaries such as manufacturers and distributors of energy-efficient equipment and energy efficiency service providers (engineering consultants, architects, etc.), and those of electric utilities themselves. Prominent among the barriers are:

- Lack of awareness and general misinformation about the benefits (range of options and associated life-cycle savings and costs) of DSM programs and technologies;

- Lack of technical information and expertise characterized by information gaps in the sector-specific and industry specific breakdowns of energy-use patterns, insufficient technology-specific engineering data, and a scarcity of information about the availability of energy-efficient equipment;

- Lack of capital or access to financing where investment selection criteria for new equipment and the structure of financing mechanisms give priority to supply-side solutions to energy shortfalls over demand-side options;

- Inertia in established patterns of behavior and/or slow acceptance of new technologies or managerial cultures;
- Product or service unavailability, which may be the result of collusive or anti-competitive practices to hold some products (or producers) from the market in favor of others with higher profit margins or other advantages such as market shares;
- Misplaced or split incentives, where the incentives of an agent charged with purchasing energy efficiency are not aligned with the motivation of those who could benefit from the purchase.

The specific barriers faced by different categories of participants can be expressed as follows:

1. *Customers*
    - Ignorance or disbelief regarding DSM
    - Fear of loss of comfort, quality or productivity
    - Lack of knowledge about efficient equipment
    - Perceived risk of adopting a new technology
    - Lack of financial resources
    - Misperception of financial risks and return on investment
    - High up-front costs
    - Unavailibility of DSM technologies/services in regions
    - Consumerism and associated status
    - Lack of enough motivation. This stems from the following facts;
        (a) The governments do not always pass the actual, enhanced cost of electricity to the customers and as a result, they (the customers) do not always feel the necessity of energy conservation.
        (b) In most households and companies, the total expenditure on energy is often quite a small portion of the overall, total expenditure and thus, the consumers do not always feel the necessity of any energy reduction program.
2. *Intermediaries*
    - Apprehension of market and profit losses
    - Lack of information/training/know-how about DSM applications
    - Perception of financial risk
    - Lack of capital availability to carry out / introduce new efficient products
    - Third-party decisions made outside by foreign headquarters

- Limited influence on decision-making process by end-user

3. *Electric utilities*

    - Apprehension of negative rate impacts
    - Lack of sufficient financial incentive because of deregulation and restructuring
    - Lack of adequate expertise, manpower and infrastructure for running a DSM program
    - Prevailing accounting rules
    - Lack of appropriate DSM culture and know-how
    - Subsidies available from the government
    - Lack of understanding between government policy-makers and electricity company regarding the role the company must play in the development and application of national power policies

Institutional barriers

The institutional barriers refer to conditions created by the nature and scope of interventions by government and regulatory agencies to influence the marketplace according to public policy objectives and budgets. Institutional barriers are usually combined with market-based barriers and lead, for example, to:

- A lack of effort on a national level to coordinate energy efficiency actions initiated by different players (i.e., sector specific end-use data collection, dissemination of information on energy efficiency, structuring of appropriate vendor infrastructure, establishment of a national energy policy that incorporates both demand- and supply-side options, development of government incentive programs for demand-side options, etc.);

- Inappropriate pricing policies where distortions are observed in electricity prices that do not reflect marginal costs, do not provide adequate treatment of externalities, and compete with other energy sources priced according to different regulatory requirements;

- A lack of fiscal incentives for DSM investments;

- A lack of high energy performance standards and deficiencies in their enforcement;

- A lack of continuity in institutional energy efficiency incentive programs;

- The imposition of taxes and tariffs on imported manufactured goods, including energy-efficient equipment.

1.2 DSM Policy, regulation and implementation

1.2.1 Policy initiatives

For institutionalising energy conseration efforts in the country, The Government has passed the energy conservation act in 2001, and established the Bureau of Energy Efficiency (BEE), under Ministry of Power, Government of India, on March 1, 2002 to promote the efficient use of energy and its conservation. The energy conservation act empowers the Central Government and, in some instances, State Governments to:

- Specify energy consumption standards for notified equipment and appliances;
- Direct mandatory display of label on notified equipment and appliances;
- Prohibit manufacture, sale, purchase and import of notified equipment and appliances not conforming to energy consumption standards;
- Notify energy intensive industries, other establishments, and commercial buildings as designated consumers;
- Establish and prescribe energy consumption norms and standards for designated consumers;
- Prescribe energy conservation building codes for efficient use of energy and its conservation in new commercial buildings having a connected load of 500 kW or a contract demand of 600 kVA and above;
- Direct designated consumers to
  1. Designate or appoint certified energy manager in charge of activities for efficient use of energy and its conservation;
  2. Get an energy audit conducted by an accredited energy auditor in the specified manner and interval of time;
  3. Furnish information with regard to energy consumed and action taken on the recommendation of the accredited energy auditor to the designed agency;
  4. Comply with energy consumption norms and standards;
  5. prepare and implement schemes for efficient use of energy and its conservation if the prescribed energy consumption norms and standards are not fulfilled;

Under this act, the State Governments may

- Amend the energy conservation building codes prepared by the Central Government to suit regional and local climatic conditions;

- Direct every owners or occupier of a new commercial building or building complex being a designated consumer to comply with the provisions of energy conservation building codes;

- Direct, if considered necessary for efficient use of energy and its conservation, any designated consumer to get energy audit conducted by an accredited energy auditor in such manner and at such intervals of time as may be specified;

To make more provisions in the 'Energy conservation act, 2001' to undertake effective measures for conservation of energy, the Government has passed the **'Energy Conservation (Amendment) Act, 2010'** which has been notified on August 25, 2010. The amendment further strengthens the provisions for energy efficiency in buildings, appliances and equipments and has set a mechanism for incentives and penalties to energy intensive industries in lieu of complying with energy performance targets. With this amendment, there will be one Appellate Tribunal both for The Elctricity Act and the Energy Conservation Act.

To promote energy conservation and energy efficiency improvement in the power sector, Ministry of Power, through BEE, has embarked upon a range of measures for energy efficiency initiatives as discussed below.

Bachat lamp Yojana (BLY)

Under this scheme, use of long life (rated life of 6000 hours and above), high quality, energy efficient compact fluorescent lamps (CFS) is promoted as replacements for incandescent lamps (ICL) in the households by leveraging clean development mechanism (CDM[1]) benefits. CFLs consume only 1/4th to 1/5th of the energy used by ICLs to provide the same level of light. This scheme has been initiated as a public-private partnership scheme between the Government of India, private sector CFL suppliers and state level distribution electricity distribution companies (DISCOM). In this scheme, CFLs would be distributed by the investor to grid-connected residential households in exchange of an ICL and INR 15. The investor would bridge the cost differential between the market price of the CFLs and the price at which they are distributed to households through the sale of Green house gas (GHG) emission reductions achieved in their respective project areas.

Each household can get a maximum of four self-ballasted CFLs under the BLY scheme. Within a single project, approximately 700,000 CFLs can be distributed. The most common three types of ICLs in use, viz. 40 W, 60 W and 100 W have been targeted for replacement under the BLY scheme with 9-11 Watt, 13-15 Watt and 20-23 Watt CFLs respectively. It is expected that upon replacing an estimated 400 million ICLs with CFLs, emission of approximately 20 million tonnes of carbon-di-oxide (CO_2) from grid-connected power plants would be avoided thereby achieving savings in combined green house gas (GHG) emissions.

[1]Under CDM, emission-reduction projects in developing countries can earn certified emission reduction (CER) credits. These saleable credits can be used by industrialized countries to meet a part of their emission reduction targets under the Kyoto Protocol.

So far, the BLY scheme has been initialted in 16 states and 2.08 crores CFLs have been distributed (one CFL for one ICL). Also 45 CFL suppliers and 18 investor agencies have been empanelled for this scheme. The scheme is monitored by Bureau of Energy Efficiency (BEE), Ministry of Power on behalf of the Government of India after the CFL suppliers and DISCOMs enter into a tri-partiate agreement (TPA) with BEE. Till date, 15 TPAs have been signed with BEE. The BLY scheme has now been registered as a program of activity (POA) with the CDM executive board on 29.04.2010 under United Nations Framework Convention on Climate Change (UNFCCC). As a result, different states can now join this POA without time consuming registration process with CDM executive board.

Standards and labeling

Standards and labeling is a thrust area of BEE, which is aimed at energy efficiency labeling of equipments under clause (a-d) of Section 14 of Energy Conservation Act, 2001, enacted by the Central Government of India. Under this act, the Central Government has powers to:

- Direct display of labels on specified appliances or equipment [14(d)]
- Enforce minimum efficiency standards by prohibiting manufacture, sale, and import of products not meeting the minimum standards [14(c)]

The scheme was launched by the Hon'ble Minister of Power on 18 May 2006 and is currently invoked for 12 equipments/appliances given below. Out of these 12 equipments/appliances, the first four equipments/appliances have been notified under mandatory labeling regime with effect from January 7, 2010.

1. Frost free refrigerators (mandatory labeling)
2. Tubular Fluorescent lamps (mandatory labeling)
3. Room air-conditioners (mandatory labeling)
4. Distribution transformers (mandatory labeling)
5. Direct cool refrigerators
6. Induction motors
7. Agricultural pump sets
8. Ceiling fans
9. LPG stoves
10. Electric geysers

11. Colour TV sets

12. Washing machines

The Standards and labeling program seeks to:

- Introduce notification for mandatory labelling
- Expand the above list by including 20 high energy consuming end use equipments and appliances by 2012.
- Initiate check testing by RITES[2] to ensure credibility of the scheme.
- Stimulate market transformation in favour of energy efficient equipments and appliances that adhere to Minimum Energy Performance Standards (MEPS)[3].
- Conduct extensive and sustained outreach and awareness campaigns to educate consumers about the benefits of using energy efficient appliances/equipments.

Energy conservation building codes (ECBC)

The energy conseration building code (ECBC) was launched by the Government of India on May 27, 2007. Following the Energy Conservation (Amendment) act, 2010, ECBC stipulates minimum energy standards for new commercial building having a connected load of 100 kW or contracted amount of 120 kVA. The ECBC takes into account the prevailing climatic region of the country (where the building is located) for defining the norms of energy performance of the building. For this purpose, the entire country is divided into five climatic zones, namely; a) hot & dry, a) warm & humid, c) composite, d) temperate and e) cold. Although energy conservation norm for new commercial buildings is prescribed by central governments through ECBC, the state governments have the flexibility to modify ECBC suitably to meet local or regional requirements. So far, 45 ECBC expert architects have been empanelled.

Presently, this scheme is continued on a voluntary basis. In the future, this scheme is expected to be made mandatory once the following issues are resolved:

- Adequate number of manpower (architects, builders, contractors) having technical capacity to design and implement ECBC is available.
- The compliance procedures is finalized in consultation with states/ municipal agencies.

[2]RITES is a Government of India Enterprise, which provides comprehensive engineering, consultancy and project management services in the transport infrastructure sector under single roof. It is an ISO 9001 company (http://www.rites.com)

[3]MEPS is a specification containing a number of performance requirements for an energy-using device which effectively limits the maximum amount of energy that may be consumed by a product in performing a specified task. A MEPS is usually made mandatory by a government energy efficiency body and generally requires use of a particular test procedure that specifies how performance is measured (http://en.wikipedia.org/wiki/Minimum energy performance standard).

- Inputs materials required for ECBC complaint buildings are made easily available through various enabling programmes.

- Adequate level of awareness, understanding and education regarding ECBC is developed in the society.

Energy efficiency in existing buildings

In India, there is a huge potential for energy saving in the existing buildings. According to the energy audit studies carried out, there is a potential of 23% - 46% energy saving in the existing government and commercial buildings through efficient implementation of ventilation, lighting, cooling, refrigeration etc. However, this potential is largely untapped due to various reasons. To address this, a scheme for implementing energy efficiency mechanisms through ESCO[4] mode of operation has been initiated by The Government of India on several prestigious government buildings. Also, another scheme for funding of investment grade energy audits (IGEA[5]) in government buildings has been initiated by BEE. Further, in order to further accelerate the energy efficiency activities in the commercial building sector, BEE developed a Star rating programme for office buildings. This rating is based on the actual performance of a building in terms of its specific energy usage in kwh/sqm/year. The programme rates office buildings on a 1-5 Star scale, with a 5 Star labeled building being the most efficient. Presently, buildings with a connected load of 100 kW or above are considered for this Star rating scheme. So far,

- Hon'ble President of India has launched an initiative '**ROSHINI**', in which BEE is to take up energy efficiency measures of entire President estate.

- In 35 central government buildings and 400 buildings in various states, investment grade audit has been initialted.

- Star rating programme has been initialted for goverment buildings and shopping malls and so far, 136 buildings have been found eligible for the award of BEE star label.

- 89 Energy Service Companies (ESCO) have been empanelled and accredited with BEE. This will eneable the ESCOs to successfully bid for energy efficiency projects and also for arranging finance for executing such projects.

- BEE has enetered into an MOU with employee state insurance corporation (ESIC) for enhancing energy efficiency in ESIC owned/operated hospitals, residential colonies and commercial buildings throughout the country.

[4]discussed in subsection 1.7.4 in page 86.
[5]discussed in subsection 1.5.5 in page 61.

DSM in agricultural sector (Ag-DSM)

In our country, approximately 27% of electricity consumption takes place in the agricultural sector. Further, most of this electricity is used for running agricultural pump sets, which are generally of poor efficiency. Therefore, if more efficient pump-sets are used, the consumption of electricity would decrease without any loss of performance. In fact, according to some studies, there is a potential of saving roughly 62 billion units of electricity annually by replacing 20 million inefficient pump sets, which, in turn, would translate into savings of approximately 18,000 crores of rupees annually. Obviously, this amount of savings would result into reduction of subsidy burdens of various states by the same amount. However, because of very low and highly subsidized agricultural tariff, the agricultural consumers do not have any incentive to replace the inefficient pump sets and simultaneously, the utilities are not able to recover the cost of electricity supplied to this sector. To address these twin problems, the Government of India has approved a scheme for market driven agricultural DSM which is to be implemented by BEE, Ministry of Power.

Under this scheme, the efficiency upgradation of the agricultural pump sets would be carried out an ESCO or distribution company. Towards this objective, preparation of detailed project reports (DPR) has been initiated by BEE in 5 states, namely, Maharashtra, Gujarat, Haryana, Punjab & Rajasthan. Out of these, two pilot Ag DSM projects were launched at Mangalwedha subdivision of Solapur Circle in Maharashtra and at Anand in Gujarat. For the project in Solapur, the potential of savings is 40% by replacing inefficient pump-sets with star rated pump sets and the expected internal rate of return (IRR)[6] is 19% which can go up to 23% with CDM benefits. Further, DPR preparation is in progress in two distribution companies (DISCOMS) in the state of Madhya Pradesh. Also, selection of agencies for preparing DPR in the states of Andhra Pradesh and Karnataka is in progress. BEE is also developing a methodology for Ag-DSM under CDM to make it more financially attractive. In this scheme, ESCO or utility would invest for replacing inefficient pumps with star rated pump sets on a rural pump set feeder on which supply quality enhancements (such as feeder segregation & High Voltage Direct Supply (HVDS)) have already been carried out. This measure will lead to lower energy supply on the feeder resulting into lower amount of subsidy paid be the state governments. Part of this savings in subsidy would be paid back to the ESCO/utility on an annual basis over a period of time to cover the investment made for upgrading the pump sets.

DSM in municipal sector

Municipal bodies are spending a significant portion of their budgets for purchasing electricity to provide local public services such as street lighting, water supply, solid waste management, sewage treatment & disposal etc. The cost of the electricity for providing these services sometimes constitute more than 50% of the annual budget of the municipality and if proper DSM measures can be adopted, this cost can be reduced by at least 25%. To achieve this, the Givernment of India,

[6]discussed in subsection 1.7.2 in page 79.

through BEE has initiated a program for undertaking investment grade audit and preparation of DPR in 175 municipalities and urban local bodies (ULB) throughout the country. Further, ESCOs are being encouraged to implement the projects with the help of large financial institutions. So far, 64 DPRs have been prepared which would be forwarded to the ULBs for implementation through ESCO mode. It is expected that by these measures, approsimately 2000 MW of avoided capacity would be achieved during XI^{th} plan.

Energy efficiency in small and medium enterprises (SMEs) sector

In India, large numbers of small and medium enterprises (SMEs) such as dairy units, rice mills, textiles, brass, foundries, refractories, bricks, utensils, ceramics, glass etc. are considered to have significant potential of energy savings. Many of these SMEs exist in clusters in various states of the country. To assess this energy conservation potential, BEE has initiated diagnostic studies in 25 clusters for preparing cluster specific energy efficiency manuals. These studies would provide information on energy consumption norms, energy efficient processes and technologies, best practices, case studies, gaps in current skills and knowledge for implementing energy efficient projects etc. for each sub-sector of any SME. Subsequently, these studies would be expected to provide directions to design energy conservation projects programmes in the SMEs. BEE will also undertake training/capacity building of local service providers who will be able to provide local services for setting up energy efficiency projects in various clusters.

Strengthening institutional capacity of SDAs scheme

State Designated Agencies (SDA) are statutory bodies set up by various states to implement energy conservation measures at the state level. The SDAs have three major roles, namely;

- As a development agency
- As a facilitator
- As a regulator or enforcing body

Most of the states have notified SDAs in the last three years and 32 states have designated their agencies so far. Under this scheme, a uniform energy conservation action plan (ECAP) is developed for building the institutional capacities of the SDAs so that they are able to perform their roles satisfactorily in their respective states. In 31 states, ECAPs have already been developed and in almost all the states, the implementation of ECAP is under way. Towards this goal, Ministry of Power has approved roughly rupees 49.47 crores during XI plan which has already been disbursed among the SDAs. As a result, the SDAs have reported avoided capacity addition of roughly 1092.5 MW (verified) during 2007 - 2010. In part II of the scheme, approximately rupees 20.82 crores has been approved by Ministry of Power for taking up further energy conservation projects in the states. In fact, according to a study, there is a deficit of 73093 MU of energy in all the states combined and simultaneously, the total potential of energy saving is 75364 MU (in all the states combined). Thus, if the energy conservation measures can be implemented properly, the entire energy deficit can be wiped out.

Contribution to state energy conservation fund (SECF) scheme

State Energy Conservation Fund (SECF) is a statutory requirement under Section 16 of the energy conservation act 2001. It is also one of the key elements of ECAP. Under this scheme, Ministry of Power has approved rupees 70 crores for BEE in 2009-10, who, in turn, will disburse this money to the states for investing in energy efficiency projects during last three financial years of XI plan, i.e. 2009-10, 2010-11 and 2011-12. So far, this fund has been disbursed to those states (total 16 in number[7])which have created their respective SECFs and also finalised the rules and regulations for operating the SECFs. Also, the SDAs will be encouraged to develop a pool of financially sustainable activities (such as training program, fees for service etc.) to augment the SECFs.

National energy conservation awards, 2010

Ministry of Power, Government of India has institutionalised a scheme to give national recognition through annual awards to those entities[8] which have undertaken special efforts to promote efficient use of energy, thereby reducing its consumption. These annual awards help to build and raise awareness that the energy conservation palys a major role in our effort to reduce global warming through energy savings. These awards are presented by the top most dignitaries of Government of India in a function organized on 14th December[9] every year and were given for the first time in 1991. In the last 12 years of the awards (i.e. during 1999-2010), the participating entities collectively have saved rupees 13399 crores per year[10] and the investment made by them for energy efficiency projects were recovered in 20 months proving the fact that energy conservation is always the least cost option.

National certification examination for energy managers and energy auditors

The Government of India has mandated the passing of the National level examination as the minimum qualification for certified enery managers and energy auditors. These enery managers and energy auditors are expected to play a major role in reducing energy consumptions of an organisation by effective management and implementation of energy efficiency measures. To create the pool of certified energy managers and auditors, BEE has been conducting National

[7]These states are: Andhra Pradesh, Rajasthan, Chhatisgarh, Karnataka, Tamil Nadu, Haryana, Uttarakhand, Punjab, Kerala, Gujrat, Nagaland, Arunachal Pradesh, Goa, Mizoram, Tripura and West Bengal.

[8]These entities include: Industrial units(Large/Medium/Small scale), Hotels & Hospitals Buildings, Office Buildings, Shopping Mall Buildings, Zonal Railways, State Designated Agencies, Municipality, Aviation and Thermal Power Stations.

[9]This day is observed as 'National Energy Conservation Day' every year.

[10]In energy terms, 14535 MW of electrical power, 27 lakhs kilolitre of oil, 91 lakh metric tonnes of coal and 22 billion cubic meters of gas were saved.

Certification Examination since May 2004. This certification examination has been rated from "very good" to "excellent" by the candidates. To keep pace with the latest developments in the area of energy efficiency and conservation, the syllabus and coverage of the examination has been revised in 2010. From the 10 examinations helod during 2004 - 2010, 8013 Certified Energy Managers have been declared to be qualified and out of these 8013 candidates, 5726 candidates have also been declared to be qualified as Certified Energy Auditors.

National mission for enhanced energy efficiency (NMEEE)

To tackle the problem of climate change, The Honorable Prime Minister of India has released National Action Plan on Climate Change in June 2008. This action plan involves eight national missions among which, one is National Mission for Enhanced Energy Efficiency (NMEEE). This mission seeks to create a conducive policy and regulatory regime to foster and grow innovative, and sustainanble business enterprises to unlock the market for energy efficiency opportunities, which is believed to be worth rupees 74,000 crores. This mission was considered by the Prime Minister's council on climate change on August 24, 2009 and subsequently, has been approved by the cabinet on June 24, 2010. The Ministry of Power and BEE have been entrusted with the implementation of this mission. After the successful implementation of this mission, it is estimated that by 2014-2015,

- Annual fuel savings would be in excess of 23 million tonnes of oil equivalent
- Cumulative avoided capacity addition would be approximately upees 19,000 crores
- Carbon-di-oxide emission would be reduced by approximately 98 million tonnes annually.

For successful implementation of NMEEE, the following four mechanisms have been designed:

1. **Perform Achieve and Trade (PAT):** It is a market based mechanism to enhance the cost competitiveness of the energy efficiency projects in the "designated consumers"[11]. The PAT mechanism has the following major components:
    - For each industrial plant, depending on its prevailing energy intensity, a specific energy consumption (SEC)[12] target is set which mandates by which percentage the plant would reduce (from the current SEC value) its energy intensity over a period of three years.
    - Once the goal is set, the designated consumers would make conscious effort to improve their energy efficiency.
    - Tradable energy saving certificates (ESCerts) would be credited to those designated consumers who exceed their target SEC. These ESCerts can be sold to those consumers who have failed to achieve their targets.

[11] 685 industrial units in 9 energy intensive sectors have been notified as "desiganted consumers". These 9 sectors are: Aluminium, Iron & still, Cement, Chlor Alkali, Thermal Power Plants, Textiles, Railways, Fertilizers and Pulp & Paper.

[12] Specific energy consumption = energy use/output of the plant

- The designated consumers, who have failed to achieve their targets, would have to compensate for their failure by purchasing these ESCerts. If they fail to do so, they might attract a penalty.
- The ESCerts can be traded on a bilateral basis or on a common platform such as an energy exchange.

2. **Market Transformation for Energy Efficiency (MTEE):** The goal of this mechanism is to make the energy efficient appliances more affordable by leveraging various international financial instruments, including CDM. The various activies described above such as BLY, ECBC, Ag-DSM, Municipal-DSM, Standards & labeling, Energy efficiency in existing building & SME sector are all part of this MTEE mechanism.

3. **Energy Efficiency Financing Platform (EEFP):** This mechanism aims to enable the financing the energy efficiency projects by capturing future energy savings. The different initiatives under this mechanism include:

   - Tax exemptions for the profits and gains made by the ESCOs and venture capital funds (VCF).
   - Reduction of value added tax (VAT) for energy efficient equipments.
   - Provision of partial risk guarantee fund (PRGF) for commercial banks which give partial coverage of risk exposure for the loans distributed against the energy efficient projects. A small fee will be charged by the fund from those seeking the risk coverage.
   - Promotion of ESCO through accredition by CRISIL[13]/ICRA[14].
   - Establishment of Energy Efficiency Services Limited (EESL)[15] by Ministry of Power.

4. **Framework for Energy-Efficient Economic Development (FEED):** This mechanism aims to provide fiscal incentives and policy measures for wider adoption of energy efficiency measures in the society. The various initiatives under this mechanism include:

   - Promotion of public procurement of energy efficient products.
   - Financial assistance to lenders through PRGF and VCF.

[13]Credit Rating and Information Services of India Ltd. (CRISIL) is a global analytical company which proides ratings, research, and risk and policy advisory services. It is the largest credit rating agency in India (http://www.crisil.com).

[14]ICRA Limited is an independent and professional Investment Information and Credit Rating Agency in India. It was formerly known as Investment Information and Credit Rating Agency of India Limited. It was set up in 1991 by leading financial/investment institutions, commercial banks and financial services companies and presently is a Public Limited Company (http://www.icra.in/).

[15]EESL is a joint Venture of NTPC Limited, PFC, REC and POWERGRID for facilitating implementation of energy efficiency projects. It will lead also the market related activities of NMEEE. It has been registered under the companies Act, 1956 on 10th December 2009 and the commencement of business certificate has been obtained on 11th February 2010 (http://www.eesl.co.in/website/about.aspx).

Painting competition on energy conservation, 2010

This competition is aimed at motivating the children towards energy conservation and offers them a chance to express their creativity in this regard. Under this campaign, a painting competition on energy conservation is conducted at school, state and national level. The competition is first conducted at the school level and two best paintings from the participating schools are included in the state/UT level competition concerned. Subsequently, first two winners from each state/UT are invited to participate in the national competition.

All these above policy measures have already started bearing fruits. As already mentioned, during XI plan period, a target of 10,000 MW of avoided capacity (through adoption of various DSM measures) has been envisaged. Against this target, the actually achieved avoided capacity from 2007-08 to 2010-11 is 7415.98 MW (verified, upto 31.12.2010). Out of this, the verified avoided capacity during 2009-10 is 2868.01 MW, the details of which is given in Table 1.1 below[16]. The provisional, avoided capacity achieved during the last quarter of 2010-11 is 250 MW.

Table 1.1: Avoided capacity achieved during 2009-10 through DSM measures (verified)

Programmes	Electricity saved (MU)	Avoided generation (MW)	Fuel saved (MTOE)
Standard & labelling	4350.92	2179.31	1.3625
Industry EC awards	2450.60	358.60	2.005
Energy saving - SDA	1874.25	304.59	0.5875
Building	21.06	3.08	0.0066
BLY	24	22.43	0.0075
Total	**8720.83**	**2868.01**	**3.969**

1.2.2 Role of various stakeholders

For effective implementation of energy efficiency programmes, the three stakeholders, namely, consumers, government and electric utilities must play a major and active role.

Consumers

The role of the consumers for successful implementation of DSM programs is very important. After all, it is the consumers who would ultimately switch off the appliances and save energy. Further, they can save energy by using energy efficient appliances. However, due to several factors, these two actions are not often practiced to their full potential.

[16] In this table, the acronym MTOE stands for Million tonne of fuel equivalent.

- **Absence of sustained habit:** Consumers are generally aware about the beneficial effects of energy efficiency. However, sustaining a habit of always switching off the lights, fans etc. (when not in use) has been proven to be difficult.

- **Apathy of the consumers:** Sometimes, the consumers are not really worried about their overall energy bills. This may be due to small energy bills (as compared to their incomes) or their convenience of passing on the bill to somebody else[17].

- **Helplessness of the consumers:** Sometines, the consumers are helpless as the efficient appliances are not simply manufactured or provided. For example, some architects give more importance to the appearances of the buildings they design and in this process, they soemtimes ignore the issue of energy efficient design.

- **Information barrier:** Sometimes, even the educated consumers are not aware about the true potential of energy savings by the use of energy efficient appliances. Moreover, even if they are aware about this savings potential, they do not have adequate information about the vendors for purchasing energy efficient appliances. Further, the appliances always have a purchase price tag but do not have any energy consumption price tag[18]. Therefore, it is often very difficult for the customers to compare between the ownership costs of two appliances.

- **Transaction barrier:** Sometimes, the consumers are unsure about the quality of newer products or do not have adequate amount of time to locate and contact the vendors for upgrading their appliances.

- **First cost barrier:** Generally, the energy efficient appliances cost more to purchase. Sometimes, the customers do not have access to adequate fund to cover this higher cost and hence, are forced to opt for less energy efficient appliances.

- **Lack of easy financing:** Often, the poor customers are unable to pay upfront the higher cost of the energy efficient gadgets. Moreover, they tend to put much more imporatnce on the present expenditures than on the future expenditures. Therefore, if they have option to pay in instalments, they would be more encouraged to use energy efficient appliances.

Governments

Government can play a very major and active role in promoting increasing use of energy efficient equipments in the society. In fact, the various policy initiatives discussed in subsection 1.2.1 amply substantiate the active role the Government of India is playing for encouraging energy efficiency in this country.

[17]For example, in an office building, many times the employees are not careful about switching off the ACs, lights, fans etc. (when not in use) as the electricity bill would ultimately be paid by the organisation, not by the individual employees.

[18]The cost of energy for operating the appliance.

Electric utilities

Active particiaption of electric utilities is very important for the success of any DSM program. In fact, the utilities can help to reduce the barriers faced by the consumers by a proactive role. Towards this direction, they can;

- Educate the customers about the benefits of energy savings by inserting information broachers or fact sheets with the monthly bills, operating consumer information centres and organising seminars.
- Carry out research to identify the best energy efficient products and thereby act as providers of know-how about energy efficient equipments and their suppliers.
- Act as an enabling agent to assist in the delivery of such equipments to the consumers.
- Act as a mediator to bargain for reduced price of the energy efficient products. If sufficient number of consumers are interested to install a particular type of energy efficient product, the utility, on behalf of the customers, can bargain with the manufacturer (of the product) for a reduced price. Sometimes this reduction (discount) can be as high as 40%.
- Provide easy loan facility (at a small interest) or rebate to the customers for procuring the energy efficient equipments. Subsequently, the utilities can recover this monet through adjusted monthly bills. This is a very important step to help the small and poor customers as they get loans from the commercial financial institutions at a very high interest.

By all the above measures, the utilities can reduce their electricity demand specially at the time of peak loading hours or at the time of shortages.

1.2.3 DSM regulations

For effective implementation of DSM, an enabling regulatory environemnt is necessary. In this regard, Maharashtra Electricity Regulatory Commission (MERC) has taken a very proactive role through its directives. These directives can be classified under four categories:

1. **Regulatory directives:**
    - In January 2002, MSEB was directed to set aside 2% of the billed revenue from agriculture (HT&LT) and street lighting category.
    - In March 2005, MSEB was directed to submit detailed first phase plan of energy conservation (EC) within one month.
    - In April/May 2005,
        (a) BEST, REL and TPC were directed to undertake DSM measures.
        (b) Supply to hoardings and floodlights were banned.

(c) All the costs incurred on implementation of DSM measures were allowed to pass through ARR[19].

- In the tariff order of April 2007,

  (a) Distribution utilities were directed to have proposals on EC and energy efficiency (EE) in their long term power purchase plan.

  (b) Distribution utilities were directed to take up load research on a sustained basis and as an integral part of operations.

  (c) Distribution utilities were directed to take up EC and EE through appropriate DSM initiatives on a sustained basis and as an integral part of operations.

  (d) Riterated that all costs incurred on implementation of DSM measures were allowed to pass through ARR.

2. **Load management directives:**

   - In May 2005, BEST, REL, TPC and MSEDCL were directed to enforce load management charge of Rs. 1.0 per kwh if the consumption is more than the prescribed limit and give a rebate of Rs. 0.5 per kwh if the consumption was below the prescribed limit. This measure was enforced during two peak months (April & May 2005).
   - Net amount collected as load management charge by the above measure would be used for promotion and implementation of EC, EE and DSM.
   - By the above measure, approximately Rs. 700 million was collected.
   - Utilities were asked to plan and run a comprehensive consumer awareness program, which was conducted during March - June 2007.

3. **Tariff directives:** Since its inception in August 1999, the commission has undertaken several initiatives to encourage efficient consumption. Some of these initiatives are:

   - Time of Day (TOD) tariffs for several categories.
   - Power factor penalties/incentives.

     (a) Incentives for PF more than 0.95 (maximum of 7% rebate in energy charges).

     (b) Penalty for power factor less than 0.9 (1% increase in energy charges for every 0.01 drop in power factor).

   - In the tariff order of October 2006, additional supply charges were introduced to compensate for the expenditure on costly power purchases, which was being utilised to mitigate load shedding in specified categories and regions
   - To foster energy efficiency, reduction in additional supply charge allowed to the extent of reduction in consumption over the last year's consumption incorresponding period.

[19] ARR is explained in subsection 1.7.2 in page 79.

- Higher tariff for certain categories of customers.
- Utilities were asked to reduce the cost of power purchase by 2% through DSM measures.
- Expanded scope of TOD tariff for MSEDCL customers having a load of more than 20 kW.
- Introduced TOD for Mumbai city since October 2006.
- Gradually increased the difference between peak and off-peak tariff.
- The commission made effort to reduce the consumption by increasing tariff steeply as follows:
  (a) For residentail customers consuming more than 300 units per month, the rise in tariff was approximately 24% whereas for consumers consuming more than 500 units per month, the rise in tariff is approximately 28%.
  (b) For commercial sector customers consuming more than 500 units per month, the rise in tariff was approximately 49% whereas for consumers consuming more than 1000 units per month, the rise in tariff is approximately 64-68%.
  (c) For low tension and high tension customers, the hike in tariff was in the range of 33-84%.

4. **Capacity building initaitves:**
   - The commission established a DSM cell[20] in MERC in April 2006.
   - Pending preparation of DSM plan, the commission worked with the utilities to plan and implement EE pilot/demonstration projects in lighting and water pumping areas on 'ad-hoc' basis.
   - The commission initiated a study to develop and institutionalise DSM bidding mechanism so that ESCOs[21], equipment vendors etc. could be contracted by the utilities to implement DSM projects.
   - Memorundum of Understanding (MOU) were signed with California Energy Commission, California Public Utilities Commission and Lawrence Berkeley National Laboratory to develop MERC and utility capacity for load research, DSM and integrated resource planning.

Currently, many other states such as, Jharkhand, Gujarat, J&K etc. has formulated their DSM regulations and in the near future, they are also expected to play a major role in the same line of MERC in wider adoption of DSM measures in their respective states.

[20]DSM cell is cescribed in the next subsection.
[21]ESCO is described in point 5 in page 90.

1.2.4 DSM cell

According to electricity regulations formulated by various states and central agencies, for effective execution of DSM programs, formulation of DSM cell is a mandatory one. The constitution, role and responsibilities of a DSM cell as defined in these regulations are as follows:

- Every Distribution Licensee shall, constitute DSM Cell within one month of adoption of these regulations.
- The DSM Cell so constituted shall be provided with necessary authority and resources so as to execute the functions assigned to it under these Regulations.
- The DSM Cell shall be responsible for:
  1. Load research and development of baseline data
  2. Formulation of DSM Plan
  3. Design and development of DSM projects including cost benefit analysis[22], plans for implementation, monitoring & reporting and for measurement & verification
  4. Seeking necessary approvals to DSM Plan and individual programmes
  5. Implementation of DSM programmes
  6. Any other additional function that may be assigned by the Commission from time to time
- The constitution of DSM cell varies from utility to utility. Some of the example are:
  1. In Gujrat, the DSM cell constitutes of one officer not below the rank of Superintending Engineer, two Officers not below the rank of Deputy Engineer, five officers not below the rank of Junior Engineer and three numbers of clerical staff.
  2. In Reliance Energy Limited (REL), the cell is headed by an Assistant Vice President who, in turn, is assisted by four junior management cadre executives.
  3. In BEST[23], the DSM cell is a three member (one Deputy Chief Engineer, one Superintendent Engineer and one Assistant Engineer) team. All the members of the team are Electrical Engineers/diploma while one of them is also BEE Certified Energy Auditor. The Superintending Engineer is responsible for monitoring and verification activities and Assistant Engineer for implementation of ongoing DSM projects.

[22] The cost benefit analysis is discussed in subsection 1.7.5 in page 94.
[23] Brihan Mumbai Electric Supply & Transport Undertaking

1.2.5 DSM action plan

The DSM action plan largely constitutes of the various following steps:

1. **Taking stock of the current situation**

   In this, the prevailing situation in the electric utility is assessed. The data generated by this process are essentially related to the existing status of the system, its performance and operational costs. It is important to understand the actual situation, which will then serve as a benchmark for comparing the advantages and costs of alternative solutions incorporating DSM programmes. As a result, these data are very important for DSM initiative since they help to unearth a reservoir of untapped possibilities in terms of energy efficiency. Below, different types of information required in this step are given. It is to be noted that it is not an exhaustive list, rather it gives an overview of the different factors which should be considered during DSM planning.

   - Proportion of the different primary energy sources used for electricity production
   - Growth perspectives for prices and fossil fuel supply conditions for power stations
   - Capacity of each power station, annual production, the year it was established, production costs
   - Portion of electricity production through independent sources
   - Urban/rural/average electrification rate
   - Annual rate of electricity exported/imported
   - Efficiency of metering and billing systems
   - Advance planning for equipment and long-term marginal production costs
   - Power station maintenance conditions and expected lifespan
   - Stock status in power stations by category
   - Conversion output of power stations
   - Rate of use of power stations
   - Relative losses in transmission and distribution networks
   - Losses in transformers and alternators
   - Losses related to network operations
   - Appropriateness of transformer sizes for the load
   - Condition and suitability of conductor section for the load
   - Quality of power distributed over the network

2. **Develop end-use demand forecasting**

   When preliminary information about the utility's current situation has been compiled, the planner can begin an initial analysis. In this process, forecasting by end-use is an essential pre-requisite for effective DSM planning and implementation. Mid-term and long-term forecasts of power demand variations play a very important role in the development of a DSM programme. In fact, if these forecasts are not available, they must be prepared at the beginning of the DSM programme planning activity since load-curve modification objectives must be based on them. It is important to note that electricity companies often plan and implement DSM programmes after a demand-forecasting exercise. It is especially important in economies where per capita consumption is low and growth rates in electricity demand are high, so that macro-economic and technical parameters can be treated separately. The different aspects of an effective end-use forecasting are as follows:

   - Estimates of current electricity consumption and peak demand should be carried out sector-wise (residential, commercial, industrial, public utility) and according to end-use (e.g. motive power, lighting, cooking, etc.) and finally, load curves should be derived for each sector and end-use.
   - Current consumption and peak demand should be calibrated to macro-economic variables (households, industrial output, floor space, etc.) using estimates of the efficiency of the current technologies used to meet each end-use.
   - Future electricity consumption and peak demand should be estimated by separately changing macro-economic variables, stock-turnover and additions, fuel share and end-use technology efficiency.
   - The impacts of DSM programs can be estimated by varying fuel share and endues efficiency.

   In this regard, it is important to remember that the actual nature of demand has two components:

   - The demand or load, which represents the power that is instantaneously provided or absorbed by the network and is measured in MW (megawatts). Demand values determine the quantity and the functioning mode of the power-generating equipment used to meet the demand.
   - Energy consumption, which represents the demand for energy during a given period (hour, day, month or year) and is measured in kWh (kilowatt hours).

   For effective DSM planning, both these components should be forecasted. Various methods for demand forecasting are discussed in subsection 1.4.6 in page 53.

3. **Identify target sectors and end-uses**

From the exercise of forecasting of end-use demand, it is possible to identify the sectors and end-uses that account for the largest power consumption and peak loads, or will do so in the future. Specifically, those sectors and end-uses should be targeted for DSM implementation where where DSM programmes are most likely to make a difference or have the highest benefit to utilities - e.g. where losses are high, or tariffs are below the cost of new supply.

4. **Define load-shape objectives**

   After the current and projected load-curves for each sector and end-use are established, it is important to establish the target load-curve modification objectives for effective planning of a DSM programme. This is important from the point of view of the utility as it helps to determine the effects that will be beneficial to the financial and operational status of the company. Fig. 1.1 shows the different load-curve modification objectives. These load-curve modification objectives include the following.

   - *Peak clipping:* It involves reducing the peak demand for electricity at specific periods and is one of the most traditional means for load management. Peak clipping is generally considered to be reducing peak loads through the electricity company's direct control on equipment used by the consumer or through tariff clauses whereby a consumer curtails his load at certain hours of the day. This procedure not only offers the possibility of reducing the need for installing additional power plants, but it also allows to reduce the operational costs of power stations and, to a certain extent, the dependency on fossil fuels (such as natural gas, heating oil) for generating electricity.
   - *Valley filling:* It involves increasing the load during off-peak hours, which proves to be particularly interesting in cases where the long-term marginal production costs are less than the selling price of electricity. Under these conditions, adding loads at a reasonable rate helps to reduce the overall cost price of electricity. For instance, one of the ways of increasing energy consumption during off-peak hours (valley filling) is to design buildings with thermal storage facilities, which can generate demand during off-peak hours or to offer special rates (tariff clauses) favouring load increases during off-peak hours only.
   - *Load shifting:* As the name suggests, it involves shifting peak period loads to off-peak hours. The most common applications of this measure are related to heating and air-conditioning. Shifting load demands associated with thermal storage involves load shifting related to conventional electricity applications (for example, building heating by electric convectors).
   - *Strategic conservation:* This is one of the non-traditional approaches to load management and involves activities undertaken by electricity companies for the purpose of directly reducing the end consumption. Besides being a load management activity, it also involves a decrease in sales as well as modifications in the way electricity is used.

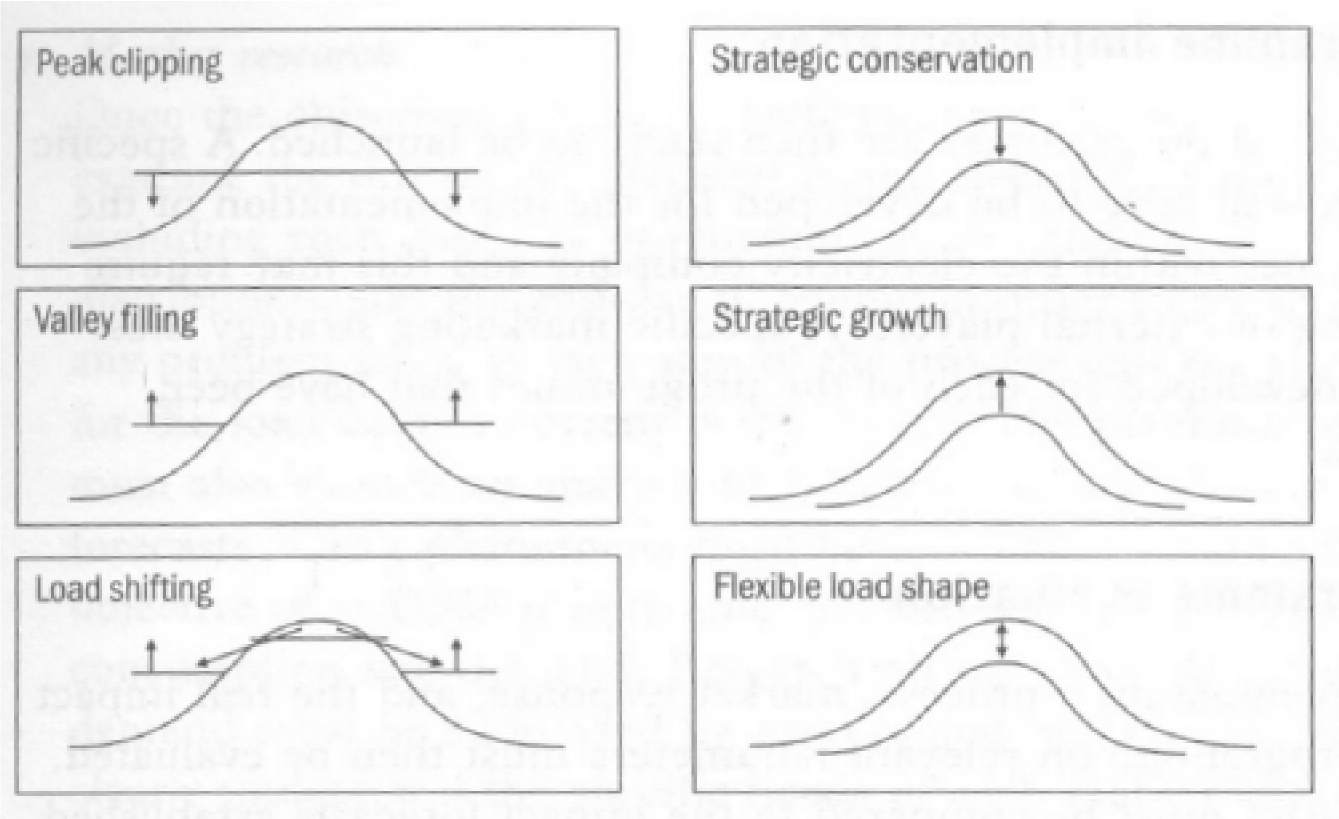

Figure 1.1: Load curve modification objectives

It is easy to understand the 'strategic' aspect of conservation since most electricity companies are unlikely to want a decrease in their sales.

- *Strategic growth:* This objective results in an overall increase in sales. This is also one of the non-traditional approaches to load management. It may mean an increased use of electricity on the energy market through the development of new applications (electric cars, microwave technologies, automation). In some cases, an increase in the use of electric energy can be motivated by national objectives in terms of reducing the use of fossil fuels in countries where hydro-electric resources are significant.

- *Flexible load shape:* This is third non-traditional form of load management and it addresses problems related to the reliability of demand forecasts. Electricity companies are never guaranteed to balance their production capacity with the expected demand. They must make sure that they can curtail a consumer's load demand if need be (either for an immediate need or as a constituent for their energy reserves), in exchange for various incentives. The customer must then produce his own electricity or use other energy sources to meet his demands.

The purpose of the first three traditional forms of load management is to level the load curve of general electricity demands. It is, in fact, much easier for an electricity company to provide power in conditions where the load is consistent most of the time than to try to regulate its production in order to constantly find ways to follow load-curve variations. It is for this simple reason that electricity companies should set up programmes to help stabilize the load curve, inasmuch as possible, in order to reduce operational costs and the costs of kilowatt-hour production. In addition, valley filling has the advantage of increasing power sales, enabling to compensate for the losses incurred during peak clipping.

The three non-traditional approaches to load management share the same objective: making the load profile as consistent as possible. However, it should be noted that these methods cannot be systematically applied to all situations. There may be variations by country or utility.

During this analysis, the planner must also identify situations where there are two peak demand periods instead of one. In fact, in several countries or regions, the daytime peak period is as significant as the evening peak period. Fig. 1.2 shows an illustration of such phenomenon. This phenomenon has far reaching consequences on the design and cost-effectiveness of DSM programmes since the end-users during the two peak demand periods may not the same. During the day, the peak period is often generated by the industrial, institutional, and business sectors whereas the evening peak is largely attributed to the residential sector. To reduce its peak demand, the electricity company must design energy efficiency programmes that address both types of end-users. As a rule, programmes designed to have an impact on the load curve for two peak periods are more costly than those designed for one peak period.

5. **Program Selection and Design**

   Based on the identified load-curve modification objectives, the planner can formulate a first set of observations and a preliminary strategy for load-curve management. To this end, a grid is often prepared, illustrating the relationship between the energy end-use and the objectives of load-curve modulations. From this grid, for any particular load curve modification objective, the potential end-uses which are acceptable to the customers or which can be deferred can be identified. An example of this grid for residential sector is shown in Table 1.2. This table allows the planner to rapidly propose load-curve management strategies and programmes for the residential sector. Similarly, the planner should also examine other activity sectors in order to identify the end-uses and measures that have the potential to contribute to DSM programme objectives.

6. **Select potential technologies**

   Once the planner has finished preparing the inventory of targeted end-uses, he must make an inventory of the appropriate technologies to be used for each of the end-uses in order to meet

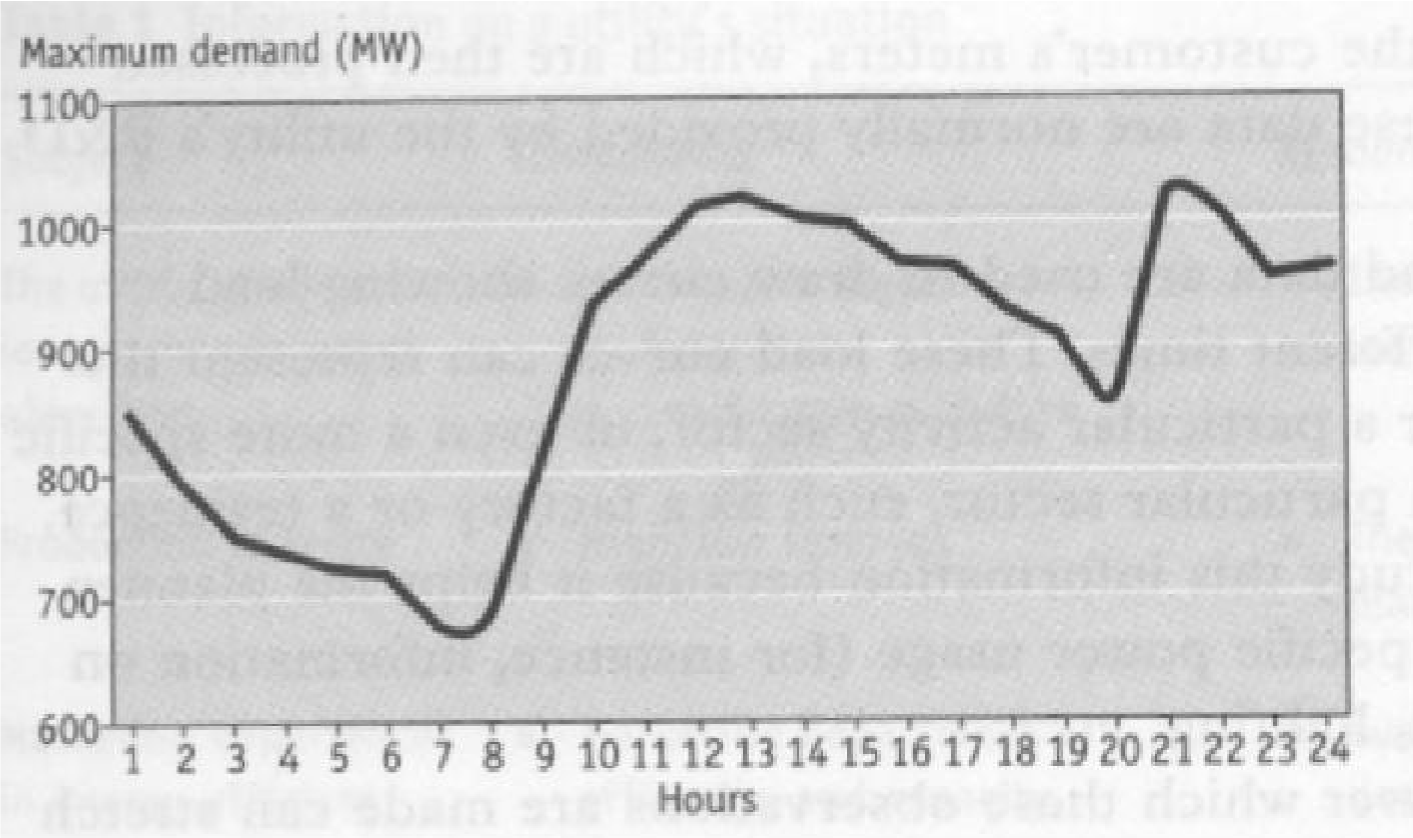

Figure 1.2: Illustration of two peaks

the established load objectives. This component is essential because a particular technology can be totally appropriate for a particular type of end-use and not necessarily produce the desired effects on the load-curve modification objectives. For example, improving the thermal insulation of a hot water tank definitely reduces electricity consumption, but will not shift the demand to an off-peak period. Programming the tank so that it does not operate during peak periods would be, in this case, the best technological alternative.

The inventory of available technologies can again be examined with the help of a grid. as shown in Table 3. This grid includes a list of end-uses with the related available technologies that could be incorporated into a DSM programme. An example of such a grid for residential sector is shown in Table ??. It should be noted that similar tables would have to be prepared for each market sector, as the technological solutions vary from one sector to another.

It is often appropriate to consider the different technologies individually and then as a group in order to study their combined impact on the load curve. The effects of a particular option can sometimes reduce the effects of another type of technology. For instance, the use of an interior sensor to detect whether a room is occupied or not will reduce the amount of time the lights are on and could reduce a customer's interest in installing more energy-efficient lamps. On the other hand, certain technologies combined with others can noticeably increase the overall impact without causing any significant increase in the implementation costs.

Table 1.2: Load – curve modification objectives for end-users in the residential sector

Load-curve Modification Objectives	End-uses								
	Heating	*Air-conditioning*	*Domestic water heating*	*Lighting*	*Refrigeration*	*Cooking*	*Dish and clothes washing*	*Heating and filtering of swimming Pool Water*	*Miscellaneous*
Peak clipping	■	●	●	___	___	___	___	●	■
Valley	■	___	■	___	___	___	___	___	■
Load shifting	■	___	●	___	___	___	___	■	■
Strategic conservation	●	●	●	■	■	■	■	■	■
Strategic increase	■	■	■	___	___	■	___	___	■
Modulation	■	■	●	___	___	___	___	___	■

● Strongly recommended
■ Occasionally recommended
___ Not or rarely recommended

Once the most suitable technological strategies are identified, it is often advisable to complement available information about them with additional market surveys. These surveys will help to prepare an inventory of the technologies available on the local market, including information on how they are distributed, whether they are readily available and, if not, when they can be made available, as well as whether the industry can guarantee the availability of spare parts and the maintenance of the equipment. These market surveys involve meeting equipment manufacturers and distributors as well as power sector professionals, research centres, architectural firms, electrical equipment installers, and others who are familiar with the electrical equipment used on the market.

The information that should be obtained during these meetings includes, among other things, the following:

- Type of available technology: standard/high efficiency
- Technological capacity range (kW)
- Technological efficiency for various capacities
- Cost of standard or more efficient technologies for various models and capacities

Table 1.3: Potential technologies for end-uses in residential sector

End-use	Technologies									
	Insulation (roof, walls, floors)	Double windows and doors	Window treatment	Insulation of ducts and pipes	Indoor air quality	Heating blanket for water	Passive solar heating	Natural Lighting	High-efficiency central heat pump	Geothermal heat pump
Heating	●	●	●	■	—	●	●	—	●	●
Air-conditioning	●	●	●	■	—	—	●	—	●	●
Domestic water heating	—	—	—	■	—	—	—	—	—	■
Lighting	—	—	■	—	—	—	■	●	—	—
Refrigeration	—	—	—	—	—	—	—	—	—	—
Cooking	—	—	—	—	—	—	—	—	—	—
Dish and cloth washing	—	—	—	—	—	—	—	—	—	—
Heating and filtering of swimming pool water	—	—	—	—	—	—	■	—	—	—

● Strongly recommended
■ Occasionally recommended
— Not or rarely recommended

- Installation costs for these technologies
- Customs duty on imported technologies
- Whether availability or when they can be made available
- Spare parts
- On-site maintenance
- Guarantees or warranties.

If certain technologies prove to be of interest to DSM but are not readily available locally, the DSM planner will conduct additional research to determine the best way to make them available through local distributors. This additional research will allow the planner to establish strategies effecting a change on the market and ensuring the availability of equipment that is deemed Important for the load-curve modification objectives.

7. **Identify sources of financing**

   In any DSM programme, financing is needed for individual projects undertaken by participants. Several options exist nowadays for financing DSM projects. The details of these options are discussed in subsection 1.7.4 in page 86.

8. **Review Cost Sharing and Viability Options**

   Cost sharing in a DSM programme should try to maximize viability for each partner (participant, utility, and government). If current tariffs are below the marginal cost of new power supply options, it is financially viable for the utility to share in the cost of the efficient technology and maximize participation in the programme. The wider the differences between tariff and the marginal cost, the higher the utility investment can be, which in turn leads to a higher participation rate. There may also be situations where average prices or marginal costs do not reflect external environmental and social costs, and DSM is in the national interest. In this case , governments themselves can invest public funds into efficiency projects and DSM programs, or design some other means of closing the incentive gap by favouring DSM technologies, using measures such as tax credits or consumption taxes or by providing direct financial incentives to the participants. For example, some governments will be making energy efficiency and DSM the cornerstones of their greenhouse gas reduction strategy under the Kyoto protocol.

9. **DSM cost/benefit analysis**

   The benefits and costs of a DSM program will be different for each partner involved in the program - the energy user (participant), the agency or power utility running the program, and society at large as represented by a strategic planner or government. The direct benefits of a DSM program are the energy savings achieved (e.g. kWh/yr) and the peak demand reduction. The value of these savings to an energy user depends on the energy tariff (electricity price and demand charges). There are also possible maintenance or labour saving benefits associated with the efficient technology. The value of these same savings to the power utility and to society at large depend on the 'avoided' or long run marginal cost of new energy supply (e.g. a power plant and/or transmission line). This avoided cost is the energy cost for the next kW of capacity added to the system. The avoided cost depends on whether the savings are at peak or off peak times (as measured by the coincidence factor), and whether there is current excess capacity. All parties benefit if energy costs escalate in real terms over time.

   Each DSM programme should be evaluated as to its viability from different perspectives - society, utility, consumer, and contractor (if used in the programme). Using estimates of the up front and annual costs and benefits for each partner, internal rates of return (IRR) and net present value (NPV)[24] can be calculated. These measures allow a DSM programme to

[24]IRR and NPV are explained in subsection 1.7.2 in page 79.

be compared both with power supply options and with other investment options. Further details of cost benefit analysis of a DSM program is given in subsection 1.7.5 in page 94.

10. **Marketing of the DSM program**

    One of the major functions of DSM programmes is to disseminate new ideas and knowledge encouraging consumers to adopt behavioural changes in the way they use energy. Behavioural modifications can be induced through information dissemination programmes or by introducing better adapted rates that foster energy efficiency. These strategies can help alter behaviour patterns, causing consumers to use their equipment in a more energy-efficient manner, to reduce wastage or to become conscientious in their purchase of electrical appliances and equipment. According to this last approach, DSM programmes will promote the use of more efficient technologies - such as high energy-efficiency motors, low consumption lamps, heat pumps, added insulation or other energy-efficient technologies. The technological aspect of the programme may also be an incentive for consumers to install improved control systems for existing equipment. Peak load regulating systems or other control systems such as programmable thermostats are examples of equipment that could be promoted by the programmes.

    Several marketing strategies may influence the consumer's choice. They can be divided into six categories.

    (a) ***Information and public awareness programmes:***

        The objectives of this program are:

        - To improve public awareness of energy efficiency
        - To improve consumer perceptions of the electricity company's services

        Some of the examples of this category are:

        - Information leaflets included with electricity bills
        - Brochures
        - Information programmes
        - Exhibitions
        - Postal publicity

    (b) ***Direct intervention by electricity companies at the consumer level:***

        The objectives of this program are:

        - To directly install energy efficient equipment at consumer premises
        - To help the consumer better understand DSM programmes and encourage him to participate through one-to-one meeting

        Some of the examples of this category are:

        - Energy audits

- Direct installation of equipment
- Exhibitions/stalls
- Inspection services

(c) ***Intervention through business allies:***

The objectives of this program are:

- To increase the electricity company's programme on marketing and implementation capacities
- To make use of the door-to-door networks of business allies

Some of the examples of this category are:

- Advertising and marketing
- Training
- Certification
- Product selection for sales/services
- Joint marketing
- Banner programmes
- Displays at distributor outlets

(d) ***Advertising and promotion:***

The objectives of this program are:

- To improve public awareness of energy efficient technologies
- To influence consumer habits

Some of the examples of this category are:

- Mass media (radio, television, and newspapers)
- Advertising at sales outlets

(e) ***Price signals:***

The objectives of this program are:

- To provide price signals through price tariffs that reflect the real production costs in order to obtain the desired response on the market

Some of the examples of this category are:

- Time-of-use tariff
- Off-peak tariff
- Seasonal tariff
- Promotional tariff
- Conservation tariff

(f) ***Direct incentives:***

The objectives of this program are:

- To reduce the cost of technologies
- To improve short-term market penetration

Some of the examples of this category are:

- Low or interest-free loans
- Financial support for desired results
- Financial support for installation and modifications
- Financial support for purchasing
- Repurchasing programmes

Once the particular sector of activity and client group is identified, the electricity company will try to implement a combination of several marketing strategies promoting its DSM programmes. In choosing suitable marketing strategies, the company must take into account the specific features of the consumer group it wishes to target including the consumers' income and education levels, their consumption habits, their awareness & interest in available technologies and their attitude and motivation for adopting energy efficient technologies. The company should also try to study in detail the aspects that might have a direct bearing on the consumers' capacity and interest to invest. This exercise involves an assessment of the consumers' financial status, of their level of motivation to purchase services and equipment intended to increase energy efficiency, and their perception of the expected benefits with respect to the investments required. Other external factors such as economic conditions, the cost of energy, deregulation, regulatory environment, available technologies, applicable tax credits and other financial incentives might also have an influence on the consumers' choice.

Choosing the right strategy or combination of strategies will also depend on factors related to the objectives of the programme, to the market context or to the electricity company's situation. The main factors are as follows:

- The utility's expertise and experience and how it deals with its clientele
- The present rate of market penetration by DSM technologies
- Receptivity and support provided by regulatory authorities
- Expected benefits and the cost of the utility and consumer
- Obstacles in the way of implementation.

When choosing a combination of marketing strategies, the electricity company must try to reduce any barriers, which could slow down the use of energy-efficient technologies on the market. Below given are examples of combined strategies that can be applied to various market sectors.

(a) ***Residential:***
   - Public awareness programmes
   - Direct installation of equipment
   - Banner campaigns with retailers

(b) ***Coomercial:***
   - Information in specialized publications
   - Activities with interest groups
   - Concerted action with distributors

(c) ***Industrial:***
   - Personalized technical counselling
   - Research and development

When selecting these marketing approaches, the biggest challenge for the electricity company is to decide upon a strategy that will ensure a high rate of consumer participation.

11. **Identify Local Socio-Economic and Environmental Impacts**

Most DSM programs provide indirect economic and environmental benefits as well as reducing emissions and other impacts from power supply facilities. For example, employment is created in the energy services industry and consumer savings are reinvested in other goods or services. These impacts can be estimated using "input/output" or other economic models. Indirect environmental impacts might include the benefits of accelerated removal of CFCs from air conditioners, or a plan to establish a disposal facility for used fluorescent lamps.

12. **Program Implementation**

Implementation of any DSM program requires a core DSM staff or 'cell[25]' within a power utility to develop a plan for the program and manage its implementation, even if consultants are hired for both aspects of the program.

A DSM implementation plan should have the following elements:

- Staffing plan and job descriptions for different aspects of the program ¡V contracting, marketing, supervision, monitoring and evaluation.
- Standard contracting procedures for direct installation, marketing, and standing offers or bidding procedures for energy service companies.
- A promotion/marketing plan to maximize participation.

[25]The DSM cell is discussed in subsection 1.2.4 in page 24.

- A schedule of activities with participation targets for each year of the program.
- A budget and expenditure plan.
- A monitoring/evaluation plan including verification protocols, templates for customer bill analysis, and participant surveys.

13. **Monitoring and evaluation**

Energy Measurement and verification (M&V) is defined as the process of measuring and verifying both energy and cost savings produced as a result of the implementation of DSM measures. The need for cost effective M&V has become critical because of reduced government funding of energy conservation measures and the increased funding of these programs by the private sector through energy savings performance contracting and demand side management (DSM). Effective M&V is the only means of determining if the contractor is performing well, and to check DSM measures are generating the expected level of cost savings. This process will determine how much the government has saved, and how much the government must pay the contractor.

A good M&V practice should have the following features:

- The reporting of savings should consider all effects of a project. M&V activities should use measurements to quantify the significant effects, while estimating all the other factors.
- Where judgements are made about uncertain quantities, M&V procedures should be designed to under-estimate savings.
- M&V reports should be as accurate as the M&V budget will allow.
- M&V costs should normally be small relative to the monetary value of the savings being evaluated.

Energy or demand savings are determined by comparing measured energy use or demand before and after implementation of an energy savings program. In general:

$$\text{Energy savings} = \text{Base year energy use} - \text{post retrofit energy use} \pm \text{adjustments}$$

In the above expression, the 'adjustments' term in this general equation brings energy use in the two time periods to the same set of conditions. Conditions commonly affecting energy use are weather, occupancy, plant throughput, and equipment operations required by these conditions. Adjustments may be positive or negative. Adjustments are derived from identifiable physical facts. The adjustments are made either routinely such as for weather changes, or as necessary such as when a second shift is added, occupants are added to the space, or increased usage of electrical equipment in the building. Adjustments are commonly made to restate baseyear energy use under post-retrofit conditions.

For determining the 'energy use' in the above expression, one or more of the following techniques can be used:

- Utility or fuel supplier invoices or meter readings.
- Special meters isolating a retrofit or portion of a facility from the rest of the facility. Measurements may be periodic for short intervals, or continuous throughout the post-retrofit period.
- Separate measurements of parameters used in computing energy use. For example, equipment operating parameters of electrical load and operating hours can be measured separately and factored together to compute the equipment's energy use.
- Computer simulation which is calibrated to some actual performance data for the system or facility being modeled.
- Agreed assumptions or stipulations of energy conservation measure (ECM) parameters that are well known. The boundaries of the savings determination, the responsibilities of the parties involved in project implementation, and the significance of possible assumption error will determine where assumptions can reasonably replace actual measurement. For example, in an ECM involving the installation of more efficient light fixtures without changing lighting periods, savings can be determined by simply metering the power drawn by the lighting circuit before and after retrofit while assuming the circuit operates for an agreed period of time. This example involves stipulation of operating periods, while equipment performance is measured.

The 'adjustment' in the above expression can be of two types:

(a) ***Routine***

In this case, adjustments are made for changes in parameters that can be expected to happen throughout the post-retrofit period and for which a relationship with energy use/demand can be identified. These changes are often seasonal or cyclical, such as weather or occupancy variations. There are generally four basic options for deriving routine adjustments.

i. *Partially measured retrofit isolation:* In this case, only the key parameters of an ECM affected system are measured. Savings are determined by field measurement of the key performance parameter(s) which define the energy use of the ECM's affected system(s) and/or the success of the project. Measurement frequency ranges from short-term to continuous, depending on the expected variations in the measured parameter, and the length of the reporting period. Parameters not selected for field measurement are estimated. Estimates can ba based on historical data, manufacturer's specifications, or engineering judgment. Documentation of the source or justification of the estimated parameter is required. The plausible savings error arising from estimation rather than measurement is evaluated. A typical example of this option includes a lighting retrofit where the power drawn by the lighting system is the key performance parameter that is measured periodically. The operating hours of the lights are estimated based on building schedules and occupant behavior.

ii. *Retrofit isolation:* In this case, all parameters of an ECM are measured. Savings are determined by field measurement of the energy use of the ECM-affected system. Measurement frequency ranges from short-term to continuous, depending on the expected variations in the savings and the length of the reporting period. Typical example includes the application of a variable speed drive and controls to a motor to adjust pump flow. The electric power taken by the drive is measured with a kW meter installed on the electrical supply to the motor, which reads the power every minute. In the baseline period this meter is in place for a week to verify constant loading. The meter is in place throughout the reporting period to track variations in power use.

iii. *Whole facility:* In this case, all parameters of a facility which has adopted the ECM are measured. Savings are determined by measuring energy use at the whole facility or sub-facility level. Continuous measurements of the entire facility's energy use are taken throughout the reporting period. A typical example includes multifaceted energy management program (involving both gas and electricity) affecting many systems in a facility. The energy use is measured with the gas and electric utility meters for a twelve month baseline period and throughout the reporting period.

iv. *Calibrated simulation:* In this case, savings are determined through simulation of the energy use of the whole facility, or of a sub-facility. Simulation routines are demonstrated to adequately model actual energy performance measured in the facility. A typical example includes a multifaceted energy management program affecting many systems in a facility but where no meter existed in the baseline period. Energy use measurements, after installation of gas and electric meters, are used to calibrate a simulation. Baseline energy use, determined using the calibrated simulation, is compared to a simulation of reporting period energy use.

(b) ***Non-routine***

In this case, adjustments are made for changes in parameters which cannot be predicted and for which a significant impact on energy use/demand is expected. Non-routine adjustments should be based on known and agreed changes to the facility. These are also commonly called 'baseline adjustments'. Non-routine baseline adjustments are determined from actual or assumed physical changes in equipment or operations. Examples of situations often needing baseline Adjustments are:

- Changes in the amount of space being heated or air conditioned.

- Changes in the amount or use of equipment.
- Changes in environmental conditions (lighting levels, set-point temperatures, etc.) for the sake of standards compliance.
- Changes in occupancy, schedule or throughput.

Baseline Adjustments are not needed where:

- The variable is included in the mathematical model developed for the project.
- Changes affect a variable that was stipulated in the M&V Plan. For example, if the number of ton-hours of cooling were stipulated for a chiller efficiency ECM, an increase in the cooling ton-hours will not affect the savings determined by the agreed simplified method, though actual savings will change.
- Changes occur to equipment beyond the boundary of the savings determination. For example if the boundary includes only the lighting system, for a lighting retrofit, addition of personal computers to the space will not affect the savings determination.

Base year conditions need to be well documented in the M&V Plan so that proper adjustments can be made. It is also important to have a method of tracking and reporting changes to these conditions. This tracking of conditions may be performed by one or more of the facility owner, the agent determining savings, or a third party verifier. It should be established in the M&V Plan who will track and report each condition recorded for the base year and what, if any, other aspects of facility operation will be monitored. On the other hand, where the nature of future changes can be anticipated, methods for making the relevant non-routine baseline adjustments should be included in the M&V Plan.

1.3 Distribution Business Opportunities to enhance DSM

1.3.1 Imperatives of distribution business

This issue has already been discussed in subsection 1.1.2 in page 5.

1.3.2 Improvement in power distribution system through DSM

The improvement in power distribution system achieved through DSM is quite self evident. As DSM helps to reduce the demand of electricity, with wider of adoption of DSM, the flow of current through the feeders reduces. This, in turn, reduces the I^2R losses and also improves the voltage profile of the system. Further, with reduced electricity demand, it is easier to control the difference between the generation and demand and as a result, the frequency of the system is better regulated within the acceptable limits.

1.3.3 Method of motivating and empowering the distribution engineers

The importance of motivating distribution engineers and building their morale for successful operation of the DISCOM can not be overstated. In fact, without adequate level of motivation and morale among the employees, no organisation can hope to survive in today's world. In this regard, Admiral Ernest J. King, the celebrated World War II Navy leader, aptly said "Men are as nothing without morale. It is a state of mind where there is confidence, courage and zeal among people united together in a common effort." Therefore, morale of the employees serves as the foundation for increasing the productivity of the workforce which can be enhanced through motivation and empowerment.

It is a general belief among the managers that when they are delegating jobs to their subordinates, they are empowering their employees. However, empowerment is more than simple delegation. It is giving the employees the authority, training and resources to make decisions for themselves within defined boundaries. Through these affirmative actions, employees gain the power, confidence and potential to both grow individually and strengthen the company.

The ability to motivate employees to improve morale and productivity is a crucial managerial skill. There are several 'soft' ways to motivate and empower the engineers to improve their morale and productivity.

- **Communicate with them fully:** Give all avaialble information regarding any new project or endeavour to all the employees concerned. After all, the people who would be actually handling the task, would like to have full knowledge of the issues involved. Do not hold back any information.

- **Give praise, recognition and rewards:** True, sincere appreciation of anybody who has done a good job or taken a good initiative goes a long way to boost his morale and motivation level. It also sets a very positive example to others. As a token of the recognition, some small gift or award can be given to that person in front of his peers.

- **Rotate employee's job and responsibility:** Employees who are rotated are challenged to learn new skills and become proficient in them. In this way, they grow and become more valuable employees. With broader interests and more know-how, they aren't as likely to leave the company and look for another job. The practice of job rotation also makes the company more flexible – absentees do not seriously disrupt service and other productive activities.

- **Encourage employees to find solution of problems:** Encouraging the employees to be solution creators instead of problem creators goes a long way to motivate them. When the employees communicate a problem, it should be looked at as an opportunity to empower the employees. If the supervisors ask the employees how they would solve the problem, express the confidence that the employees are the person to solve the problems, give the employees the tools to solve the problem, and follow up with them, the employees are empowered to find solutions of problems in the future and make the team more productive.

- **Solicit opinions from the employees:** Many times during our busy work day, we find it difficult to ask for opinions from our employees. However, just the act of asking for their opinions makes the employees feel that their inputs are valued and motivates them to accomplish more.

- **Assign task according to their levels:** It is necessary for the supervisors to learn the employees' skill, experience, and motivation levels for performing workplace tasks and then assigning the task and following-up based on the findings. For example, one may need to follow up more frequently with an employee who is fairly new to the project or organization as opposed to the 'veteran' employee who doesn't need much follow-up. It is to be noted that the most skilled employee may not be the most motivated for performing the task you request.

- **Delegate tasks:** Delegation is one of the most powerful motivation tools for empowering employees in the workplace. The sheer act of delegating a task shows that a supervisor/manager has the confidence in the employees that they can do the job. It is important for the supervisors to make sure that they understand the task to be delegated so that they can clearly and concisely communicate to the employees the ways for for accomplishing the task and subsequently, they hand off 'ownership' of the task to the employees. Delegation is providing the employees with ownership of the task, providing the tools for successfully completing the task, expressing the reward and consequences for completing the task and following up accordingly.

- **Encourage ideas:** Ideas are the lifeblood of any organization, department, and team. It is vital to create a safe environment for the employees to share their ideas. It is very imporatnt to remember that the idea that doesn't make sense today, might be exactly the solution which would be required in future. It is also extremely important to give the employees due credit for the ideas they express. Nothing will decrease employee motivation and dry up the flow of ideas quicker than having managers take credit for their employees' ideas. If the employees are rewarded publicly for the good ideas they suggest, the employees would fell quite motivated and the flow of ideas from motivated employees will increase with each public recognition.

- **Select an employee of the month:** This practice has become fairly commonplace in business and industry, particularly in retailing. While management usually chooses the recipient of an honor based on appraisals or excellence in customer service, sometimes employees themselves nominate and vote for the person they deem is most deserving. The awards need not be expensive, but should be accompanied by publicity such as posting the name on bulletin boards, placing names on plaques and sending letters to the homes.

- **Convert exceptional employees into part-time trainers:** When an exceptional employee is asked to help the company as a trainer, the person serves as a role model for other employees. By showing enthusiasm, being patient and criticizing constructively, an experienced individual can quickly orient new employees and instruct them on what it takes to provide top service. Not only is service quality and speed achieved more quickly with such programs, busy supervisors are able to carry out their duties with less stress.

- **Involve employees in goal setting:** If the employees are involved in the goal setting process, they will be far more motivated to achieve those goals. Involving them in the goal setting process also makes the goal believable for them. Once the employees feel ownership of the goals, they will be motivated to move quickly to help accomplish those goals.

- **Assign leadership roles to employees:** Leadership comes at all levels and doesn't require a title. If the employees' skills are alligned with proper leadership opportunities with adequate training (in the areas of opportunities), the employees feel empowered to step up to new opportunities.

- **Motivate the employess to embrace mistakes:** Without mistakes, there is no growth. Allowing the employees to make mistakes allows them to grow, be creative, and provide them a vehicle for empowerment. It is quite important to create a safe work environment so that when your employees make mistakes, they are not punished. Rather, the mistakes the employees make should be used as learning experiences. Allowing the employees to tackle the task again based on their learning experience would give them a new sense of empowerment and make them confident that the management will support them when they try something new.

- **Motivate the employees to run the meetings:** One of the best ways to motivate and empower your employees is to involve them in running your meetings. Once the agenda is set by the supervisor, there are many opportunities for the supervisor to act as a leader to let the employees run portions of or the entire meeting. For this purpose, it would be necessary to take the time to work with the designated employees ahead of time so that they are confident with the assigned meeting tasks. Of course, during the meeting, the supervisor is there to support the employees and help with any sections of the meeting that may provide a challenge for them.

1.4 DSM - Tools and Techniques

1.4.1 Role of DSM cell

Already described in subsection 1.2.4 in page 24.

1.4.2 DSM planning, methodology and implementation

Already described in subsection 1.2.5 in page 25.

1.4.3 Integrated Resource Planning - Distributed generation and DSM

Integrated Resource Planning (IRP) considers all means to provide energy services, including energy efficiency and customer-generated resources as well as traditional sources of supply. Integrated resource planning is an approach to energy planning. It is based on the view that what human beings want – as individuals and as societies – is not energy per se but the services that energy provides. Development requires, therefore, an increasing level of energy services to satisfy basic needs more fully, to improve the quality of life, to increase production and to advance development.

Thus, the level of energy services must be taken as the measure of development, rather than the magnitude of energy consumption and supply. One way that the level of energy services can be improved is to increase energy consumption – this requires an increase of energy supplies. Another is to increase the efficiency with which end-use devices utilize energy – this requires efficiency improvements. Further, an increase of energy supplies can be achieved either from conventional sources or from decentralized generation including renewable sources. The additional constraint that the sources should be environmentally sound can lead to the restriction that the centralized sources should be “clean” (clean coal, natural gas, hydro) and that the decentralized sources should be renewable (biomass, biogas and producer gas), wind, small hydel and solar). Such an abundance of possibilities implies that a central task is to arrive at a mix of sources to increase energy services that satisfies an objective. IRP is an approach to identify the mix of “clean” centralized, decentralized renewables and efficiency improvements that will meet the demand for increasing energy services for instance at least cost or least environmental impact. In fact, electric utilities that practice IRP modify their supply-side planning process by integrating programs and activities intended to influence the amount and timing of consumers’ electricity purchases.

The primary aspects of IRP can be defined as:

- IRP is the process of meeting customers’ needs for electrical energy.
- IRP considers a broad range of supply-side and DSM options in a balanced manner.
- The objective is to secure the lowest long-term electricity cost consistent with the quantity and quality of electric service desired by consumers.

IRP encompasses traditional generation and transmission capacity planning, but it is broader. IRP undertakes to meld the consideration and implementation of demand-side and supply-side options for assuring adequate capacity to meet increases in demand. The result of IRP is a plan that most economically maximizes efficiency and customer satisfaction.

The demand side options for IRP are:

- **Consumer energy efficiency** such as energy efficient construction programs, energy efficient appliances, duct repair, and geothermal heat pumps.
- **Utility energy conservation** such as demand response programs.
- **Rates** such as TOU and others.
- **Renewables** such as solar heating and cooling, photovoltaics, passive solar design, and daylighting.

The supply side options for IRP are:

- **Conventional power plants** such as fossil fuel, life extensions of existing plants, and hydro/pumped storage.
- **Non-utility owned generation** such as cogeneration, independent power producers, and distributed generation.
- **Purchases** such as requirement transactions, coordination transactions, and competitive bidding.
- **Renewables** such as biomass, geothermal, solar photovoltaic and thermal-electric, and wind.

IRP approach

The basic approach to IRP constitutes the following steps:

- Defining the objectives of doing IRP.
- Constructing demand scenarios incorporating the objectives defined in the above step.
- Listing of all the options of providing the energy services, making sure that the options are not restricted only to centralized supply options but also include saving options as well as decentralized supply options.
- Costing all the options on a common basis, ensuring that environmental costs (pollution controls, emission fees, etc.) are included in the costing.
- Estimating the potential contribution of each of these options of saving and generation to a supply mix.

- Ranking the options according to increasing cost.
- Counting the cheapest option of the first element of the supply mix, then the next more expensive option, and so on until the energy requirements are met, in which case the resulting cost-supply staircase yields a least-cost mix.

Characteristics of IRP

A good IRP exercise must have the following characteristics:

- It must provide benefits to utilities' primary stakeholders, i.e., customers, investors, and society.
- It must be able to make the trade-offs required between the conflicting interests of these stakeholders.
- It must anticipate the future in light of the many types of uncertainties utilities face today.

The three groups affected by IRPs are the electricity customers; the utility's investors, members, or the voting constituency; and society. At times the interests of one group, or even a subset of a group, may conflict with the interests of the larger group or with those of other stakeholders. "Least cost" for customers means a resource plan that minimizes the cost for their desired amount and quality of electric service. Investor interests are served when resource plans promote the utility's long-term financial health. Societal interests are served both by adequate and reliable power supply and delivery and by resource plans that are environmentally sensitive and promote economic growth. A successful integrated resource plan balances conflicting interests and determines acceptable trade-offs between cost reduction, risk, and the service preferences of the utility's stakeholders.

A benefit of integrated resource planning is that it helps manage stakeholder risks. The explicit consideration of a portfolio of both demand-side and supply-side resources mitigates the uncertainties of serving a diverse and changing electricity market. Considering a variety of options also permits customers to achieve enhanced value from their electric service while allowing utilities to better compete in the energy marketplace.

The list of uncertainties that must be taken into account when developing an IRP is a long one. Future economic conditions are difficult to forecast; customers' responses to prices and their willingness to participate in DSM are also difficult to anticipate; new technologies may not develop as projected; and purchased power sources may not be available or able to meet delivery requirements. In fact, an IRP exercise can face uncertainties in; a) Load growth, b) New construction lead times, c) Regulatory climate, d) Competition, e) Availability and reliability of purchased power, f) Adequacy of transmission network, g) Customer acceptance and participation in DSM, h) Environmental compliance, i) Fuel price and supply, j) Capital availability and cost, k) Customer adoption of new technology, l) Construction costs, m) Economic conditions, n) Energy policy decisions.

Practical IRP

The potential impacts of these and other uncertainties are reduced when the resource planning process itself is fluid and when the resulting resource plans are flexible and diversified. An IRP is not a one-time effort; instead, as external events unfold and change, the plan should be modified accordingly. It recognizes changes in the utility industry and the specific internal and external environments in which utilities operate. IRP is iterative. It builds on previous resource plans and adapts to new expectations of future circumstances. A flexible and diverse resource plan is better able to satisfy customer needs and will better enable the utility to succeed in the increasingly competitive and uncertain energy markets.

A good, practical integrated resource planning process will evaluate supply-side and demand-side options in a manner consistent with company, regulatory, and customer objectives. The process should reflect the impacts of DSM on load and energy forecasts. A wide variety of supply-side options should also be evaluated when selecting resources to satisfy future requirements. The IRP process should give explicit consideration to price elasticity effects. The process should provide for price feedback loops to closely link the DSM planning process, the generation and transmission capacity planning process, and the financial planning process.

1.4.4 Barriers to DSM

Already described in subsection 1.1.3 in page 6.

1.4.5 Metering and Tariff

DSM measures can also be implemented by using an effective time varying tariff structure. In this tariff structure, the electricity prices are kept high during peak hours and lowered during off-peak hours. The objective is to reduce peak loads and/or shift loads from peak to off-peak periods thereby reducing the operating cost of the utilities and bringing down the consumer bills.

There are mainly three types of time varying tariff structure used throughout the world. These are:

1. Time of use (TOU) pricing. It is also known as time of day (TOD) pricing.
2. Critical peak pricing (CPP)
3. Real time pricing (RTP)

These three types of tariff structure are discussed in more detail below.

Time of use (TOU) pricing

In TOU pricing, the electricity orice varies by the time of the day, being higher during the peak periods and lower during the off-peak periods. The simplest rate involves just two pricing periods, one during peak periods and the other during off-peak periods. Fig. 1.3 shows an illustration of a two period TOU (or TOD) pricing scheme. Other more complex rate structures having one or more shoulder periods are also possible. TOU tariffs can also be implemented on a seasonal basis, in which, the prices vary on a seasonal basis. For instance, a summer-peaking electricity business may charge a higher price during summer months as comapred to the off-peak winter months.

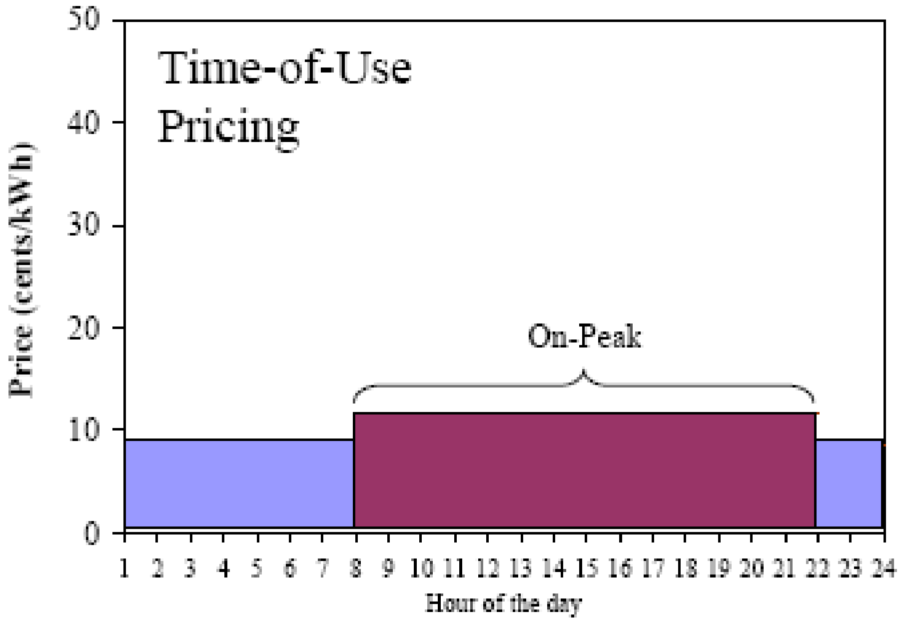

Figure 1.3: Illustration of Time-of-Day (TOD) pricing

In this pricing scheme, the size of the price differential between the peak and off-peak hours should be set in suach a way that the customers perceive real price signals that motivate them to switch off appliances and equipment during peak periods. However, it must be noted that if significant number of customers participate in the TOD program, the revenue of the utility may be negatively impacted. Therefore, ideally, the TOU prices should be appropriately set to achieve two goals: a) the customers, who participate in the TOU program, should receive a reduced electricity bill as an incentive and b) the utility should be able to maintain the same or similar level of revenue. Achieving these two goals simultaneously can be difficult and therefore, depending on the customer behaviour, the TOU prices should be appropriately set.

In the world, several countries, such as Australia, New Zealand, USA etc., TOU prices have been used for many years. In India also, TOD prices have been adopted in several states.

Critical peak pricing (CPP)

Under this pricing scheme, customers are generally charged with TOU scheme for most part of the year. However, during a relatively small number of high critical peak periods, in which the cost of electricity supply is inordinately high[26], the customers are charged with a much higher critical peal price. An illustration of the CPP is shown in Fig. 1.4.

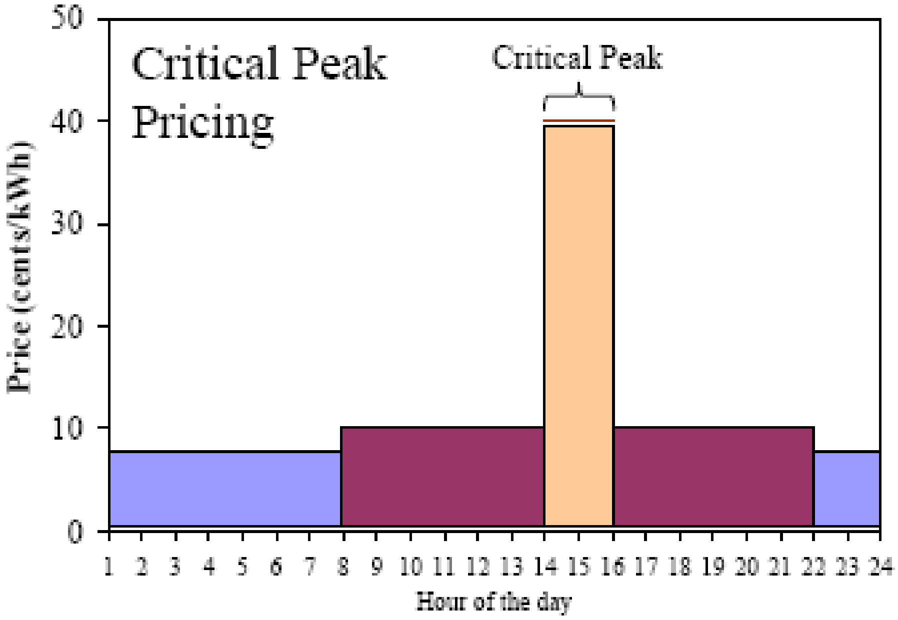

Figure 1.4: Illustration of Critical peak pricing (CPP)

There is a mjor difference between the TOU and CPP schemes. While the TOU scheme is typically designed to be in place for 6 to 10 hours during every day of the year or season, the periods or days in which the CPP would be effective are not desinged in the tariff in advance. Instead, CPP is dispatched as needed, on relatively short notice (varying from a maximum of about 24 hours to a minimum of about two hours in advance of the actual event). In some circumstances, shorter or even no advance notice is also possible.

There is another point worth noting. In CPP, the difference between the price during the critical peak periods and that during other times is very important for CPP to make any significant impact in load reduction. As the critical peak periods occur quite infrequently, the impact of CPP on electricity bill is quite low and therefore, the motivation (on the part of the customers) to change their consumption behaviour can be quite low. Basically, CPP is intended for reducing firm peak load reductions. Some studies have indicated that for CPP to make any significant contribution towards reducing the firm peak loads, a price differential of at least 10 times between the CPP and the off-peak price is required.

Several variations of CPP is also possible. These are:

- **Fixed-period CPP (CPP-F)**: In CPP-F, the time and duration of the price increase are predetermined. However, the days when the CPP would be applicable are not predeter-

[26]This can be due to the threat to system reliability triggered by contingencies or high prices faced by the retailers in procuring power from the power market.

mined although the maximum number of days per year (for applying CPP) is also usually predetermined. CPP-F events are typically called on a day-ahead basis.

- **Variable-period CPP (CPP-V)**: In CPP-V, the time, duration, and day of the price increase are not predetermined. CPP-V events are usually called on a day-of basis. CPP-V is typically paired with load control devices such as communicating thermostats that allow automatic responses to critical peak prices.
- **Critical peak rebates:** In these programs, customers remain on fixed tariffs but receive rebates for load reductions which they produce during critical peak periods.

Real time pricing (RTP)

In RTP, prices vary continuously during the day, directly reflecting the wholesale price of the electricity, as opposed to the TOU or CPP that are largely based on preset prices. An illustration of the RTP is shown in Fig. 1.5. In competitive electricity markets, the retail price periods are linked to the settlement periods in the wholesale market. The direct interconnection between the retail prices and the wholesale prices introduces price responsiveness in the retail market.

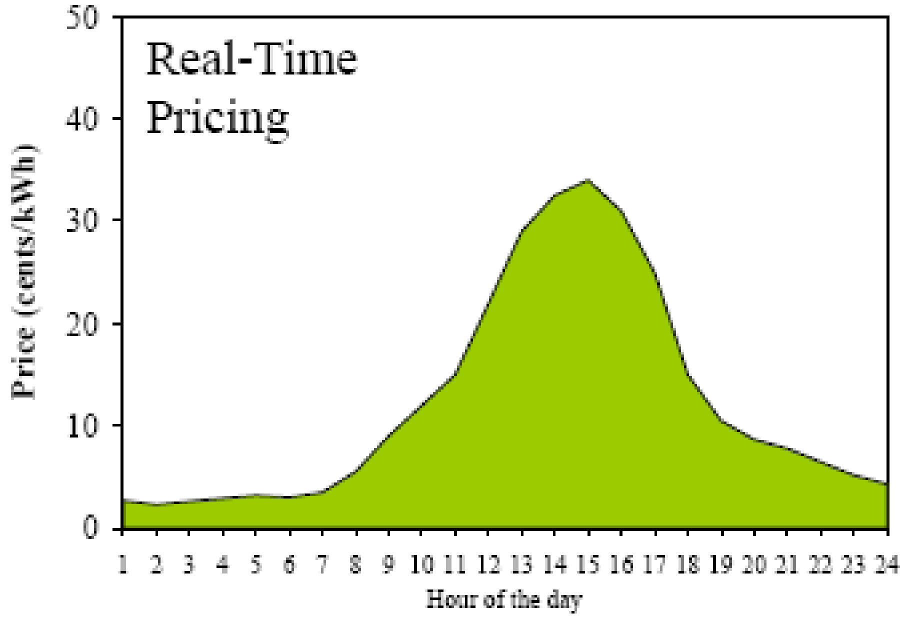

Figure 1.5: Illustration of Real time pricing (RTP)

Several versions of RTP are in existence in the world. These are:

- **Day-Ahead Real Time Pricing (DA-RTP):** In DA-RTP, customers are given one-day notice of the prices for each of the next day's 24 hours. This gives customers time to plan their responses, such as shifting load to off-peak hours or using onsite generation (if available) thereby reducing the net demand from the utility.

- **Two-Part Real Time Pricing:** In two-part real time pricing, only a portion of the electricity purchased by a customer is subjected to retail prices directly linked to the prices in the wholesale market. In this tariff design, the customers pay either the off-peak or on-peak charges upto the corresponding baseline levels of electricity consumption. These baseline levels are constructed using the historical consumption patterns of the customers. Beyond these baseline values, the customers are charged with RTP. On the other hand, if the actual consumption goes below the baseline level, the customers are given some rebate. An illustration of the two part RTP is shown in Fig. 1.6. This pricing scheme is generally used for only large commercial and industrial customers who have detailed information about past energy usage that can be used to construct an historical baseline. The baseline level can help the customers to achieve savings in their electricity bill by shifting their electricity usage from peak to off-peak hours.

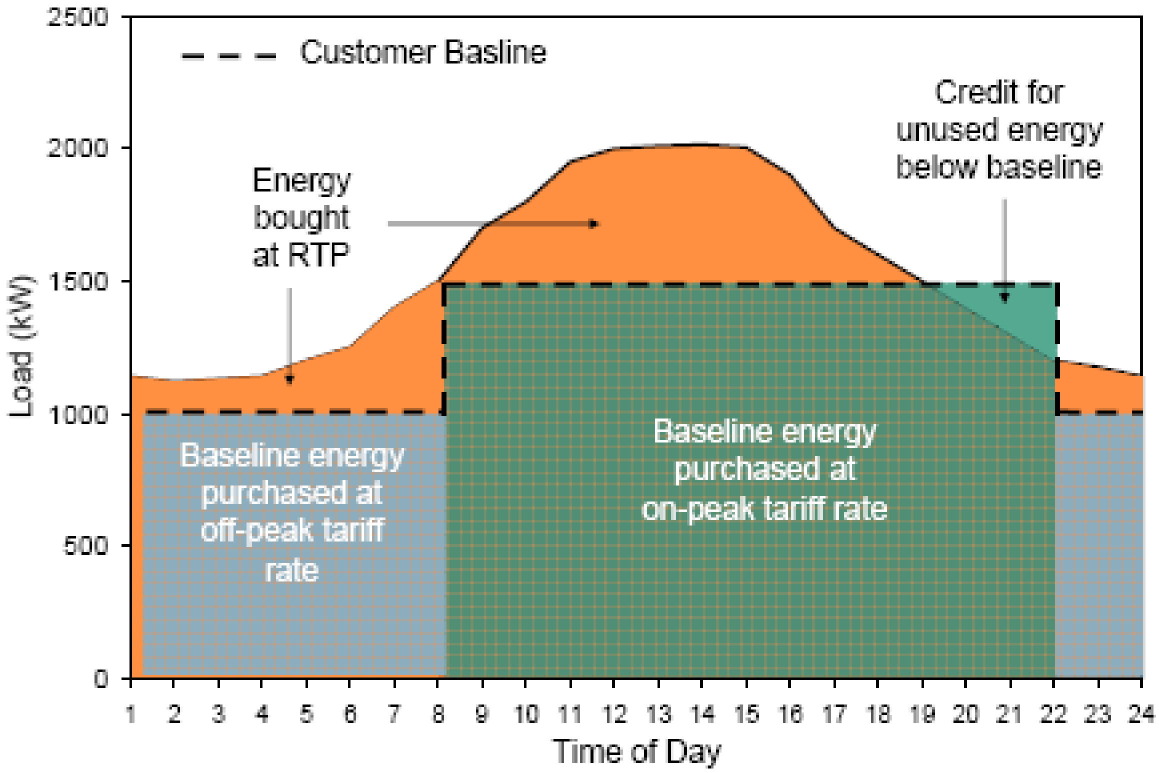

Figure 1.6: Illustration of two-part real time pricing

Out of the three tariff structures discussed above, TOU is mostly used in India. For successful implementation of the TOU tariff, TOU meters are used, which are more costly as compared to the normal meters. In several states in our country, TOU (TOD) pricing scheme is already in existence.

1.4.6 Load forecasting for rural/urban areas and use of forecasting data for DSM

Mid-term and long-term forecasts of power demand variations play a very important role in the development of a DSM programme. However, this exercise is not generally an integral part of the DSM planning process. In fact, demand forecasting is an exercise that every electricity-generating company should carry out regularly in order to assess its future equipment requirements. However, if these forecasts are not available, they must be prepared at the beginning of the DSM programme planning activity since load-curve modification objectives must be based on them. It is important to note that electricity companies often plan and implement DSM programmes after a demand-forecasting exercise.

Different methods, which are mostly used nowadays, are:

1. Extrapolation
2. Statistical approach
3. Econometrical method
4. End-use analysis
5. Strategic analysis
6. Combined methods

Demand forecasts are also very important for evaluating DSM programmes. The planner will want to determine, with as much precision as is possible, the impact of various components of a DSM programme on the future load curve of the network.

Some forecasting methods are better adapted to the needs of the DSM programme planner. In fact, the last three methods listed above (end-use analysis, strategic analysis, and combined methods) are the most appropriate because they are based on an in-depth and detailed forecast of load and consumption. The following is a brief description of these three methods.

- **End-use analysis:** The end-use analysis method requires a detailed understanding of the ways electricity is used in each sector of activity. For instance, in the residential sector, power consumption and peak demand are clearly determined for different purposes (heating or air-conditioning, kitchen appliances, washing machines, etc.).

  This forecasting method is based on the principle that power consumption for a particular purpose is equal to the average consumption for this particular purpose multiplied by the number of customers. Applying this approach to every category of energy use and in every sector of activity allows an estimation of the amount of energy required for the entire network. This method is advantageous to the DSM planning process because it allows electricity companies to clearly determine the energy consumed for a particular end-use.

This facilitates a quick evaluation of the impact of the energy efficiency measures. However, the method's biggest disadvantage is that it requires a detailed understanding of end-use in terms of quantity, quality, and level of use. Here, forecasting must be based on a large amount of data collected at the end-user's level.

- **Strategic analysis:** The strategic analysis method combines elements included in the end-use analysis explained above together with econometrical factors. In this approach, the variables for market penetration and the estimated end-uses are based on surveys of customer preferences (their choice of technology, their criteria for choosing a particular product, and criteria upon which decisions are made with respect to investments). This approach takes such things into consideration as energy costs and the performance of new technologies on the market. The information by way of such an analysis provides the DSM planner with a clear vision of current and future electricity markets.

- **Combined method** Combined methods have been developed to improve the capacity of models to incorporate the effects of technological and economic factors in the demand-forecasting process. These methods have been made even more accurate by adding economic variables such as the income of customers and the cost or capital investment required to improve forecasting models. In some cases, combined methods tend to add complementary equations to already-existing econometrical models. These types of forecasting models are currently the most popular amongst North American electricity companies. As with the end-use analysis method, combined methods also require a significantly large database.

The output of any load forecast exercise of most of the utilities includes a forecast of the annual energy sales (in kWh) and the annual peak demand (in KVA or kW). During the forecasting exercise it is worthwhile to forecast the annual energy sales first and then use the forecasted energy sales in determining the annual peak demand forecast after analysing the annual load factor. Since the annual energy sales data is the integration of the hourly loads during the year, it is less prone to weather and other spurious effects. A category / end use process specific forecasting method could be adopted by utilities to forecast the energy consumption. Also, a combination of different forecasting techniques could be used to suit the availability of data and information. The profile of annual and daily demands could be determined based on historic data. The load demands at other periods (seasonal variations and minimum loads) shall be derived based on the annual peak demand and past pattern of load variations.

The best way of modelling the demand from DSM perspective, is based on scenario analysis which compares different combinations of technological option to provide the same level of energy services. The different scenarios could be constructed and differentiated according to the level of projected energy service growth (i.e. high, medium, low) and the degree of implementation of energy efficiency improvements like diffusion of energy efficient technologies, DSM options etc.

The starting point to estimate the potential for various DSM options is to construct at least two end use scenarios, a baseline scenario (scenario without diffusion of energy efficient technologies and DSM options) and an energy efficient scenario which considers improvements in end use efficiencies and possible DSM options. However one can include some efficiency improvements in baseline scenario as well based on the assumption that some efficiency improvement will happen naturally without any specific market intervention to stimulate such improvements. The scenario which dose not considers the improvement in end use energy efficiency at all and thus maintaining the current levels of energy efficiency is called as "Frozen Efficiency Scenario".

The energy efficient scenario can be derived from the set of efficiency improvements / DSM options in several end uses and sectors or for one end use measure. This efficient scenario can consider the possible technical improvements in equipments, processes and buildings that can be introduced in the projected year. However potential for DSM / energy efficiency improvement can be characterised in different ways, one way is to estimate the hypothetical savings that could be achieved if all the systems could be converted instantaneously, whereas other way is to estimate the savings that could be achieved if retiring systems were replaced with more efficient one. To asses the diffusion of energy efficient technologies in place of retiring system various technology forecasting tools could be used.

1.4.7 Benefits of DSM

Already described in subsection 1.1.2 in page 5.

1.5 Distribution system losses and linkage to DSM

1.5.1 AT&C loss definition

For quantifying the total loss in the distribution system, concept of Aggregate Technical and Commercial (AT&C) loss is used. AT&C loss captures technical as well as commercial losses in the network and is a true indicator of total losses in the distribution system. It is basically the difference of total amount of energy supplied by the utility and the equivalent amount of energy corresponding to the actual revenue earned.. AT&C loss has three components, namely, a) technical loss, b) commercial loss and c) shortage of revenue due to non-realisation of total billed demand. A small example will help to illustrate the point. Let,

Total amount of energy input by an utility to its system (A) = 1000 units

Total amount of energy billed (B) = 750 units

Therefore, total technical and commercial loss (C) = A - B = 250 units (25%)

Actual revenue collection with respect to B = 95%

Thus, equivalent amount of energy corresponsing to actual revenue collection (D) = 0.95*B = 712.5 units

Hence, AT&C loss = A - D = 287.5 units (28.75%)

1.5.2 Technical loss

The technical loss in the distribution system is basically the I^2R losses in the feeders and the transformers. Various causes for enhanced technical loss are discussed below.

Lengthy Distribution Lines

The primary and secondary distribution lines in rural areas are by and large radially laid and also, usually extend over long distances. This results in high line resistance and therefore high I^2R losses in the line.

Low Voltage at transformers and consumer's premises

In the rural areas and small scale industrial areas, the bulk of the load consists of induction motor loads. Now, if the input voltage to the induction motor (available at the premise of the load) is reduced, the motor draws more current to maintain its output. As a result, higher I^2R loss takes place in the feeder supplying the induction motor load. For a voltage drop of 10%, the full load current drawn by the induction motors increase by about 10% thereby increasing the I^2R in the feeder by about 20%.

Distribution transformers not Located at load centre

Often, in the secondary distribution system, the distribution transformers (DT) are not located centrally with respect to the loads. As a result, the farthest consumers obtain an extremely low voltage even though a reasonably acceptable voltage level is maintained at the transformers secondaries. This again leads to a higher line losses as explained above.

Over-rated distribution transformers

In many cases, the rating of the installed DTs is quite high as compared to the maximum KVA demand of the loads they serve. The iron losses of an over-rated DT is also unnecessarily high. As a result, the overall I^2R loss in the system increases.

Low power factor

In most of the low tension (LT) distribution circuit, the power factor (PF) ranges from 0.65 - 0.75. If the PF of a load is low, then it draws more reactive current thereby causing the magnitude of the current flowing in the feeder (supplying the load) to increase. This, in turn, causes more I^2R loss in the feeder.

Bad workmanship resulting in poor contacts at joints and connections

Bad Workmanship contributes significantly towards increase in distribution losses. Specifically, the following points are noteworthy:

- Joints are a source of power loss. Therefore the number of joints should be kept to a minimum. Proper jointing techniques should-be used to ensure firm connections.
- Connections to the transformer bushing-stem, drop-out fuse, isolator, LT switch etc. should be periodically inspected and proper joint ensured to avoid sparking and heating of contacts.
- Replacement of deteriorated wires and services should also be made timely to avoid any cause of leakage and loss of power.

The technical loss can be reduced by addressing all the above issues. Further, use of high voltage distribution system (HVDS) and amorphous transformers can also reduce the technical loss to an appreciable extent.

1.5.3 Commercial loss

The commercial losses take place due to non-metering of the actual consumptions. These are mainly due to:

- Metering inefficiency including defective meter
- Wrong applications of multiplying factors
- Defects in CT and PT circuits
- Pilferage by manipulating or by passing of meters
- Theft by direct tapping and hooking

The commercial losses can be reduced by several steps. These are:

- Use of accurate and appropriate range of meters with reference to the connected load
- Use of tamper proof, electronics meters for all levels, if possible
- Undertaking of energy audit to identify high-loss locality
- use of automatic meter reading (AMR) system
- Prompt reading, bill preparation and its delivery supported by consumer friendly bill payment mechanism, consumer should have several options of paying their monthly bills like through banks, credit cards, internet, cheque drop boxes, etc.
- Reducing the billing cycle and concerted effort to liquidate arrears

- Prompt release of new connections
- Prevention of theft and pilferage by;
    1. Conducting regular and surprise visits at the high loss localities by the vigilance team
    2. Imposing heavy fines on the customers indulging in theft
    3. Supply of electricity at high voltages to the nearest point of consumption so that theft by hooking can not take place
    4. Housing the meter in a separate box thereby making it inaccessible to the customers

1.5.4 Energy accounting to assess losses

For detailed assessment of losses, energy accounting is carried out. The broad objectives for energy accounting are as follows:

- Identification of areas of high technical losses and to take steps to reduce the same.
- Identification of areas where commercial losses are very high and to take remedial steps.
- Pinpointing areas where theft of energy by direct tapping is rampant and take steps to plug up the leakages.

Basically, there are two methods for energy accounting. These are:

- **Direct method**: In this method, losses are found on the basis of difference of units sent out and received at the end of each element in the power system. The main advantage is that it is straightforward and simple. The major constraints are that it requires metering of very high class of accuracy and the difficulty in simultaneous reading of meters. Due to the use of CT & PT of very high ratios, the multiplying factors are very large and any small variation will result in large discrepancy.
- **Indirect method**: The losses are determined by simulation of the network on a computer. Even in this system, metering at critical points in the system for operating parameters such as power factor, coincident fact, or load factor, loss factor and hourly load data is required to be used in simulation.

The energy accounting is carried out in different phases. These phases are:

- Accountng in EHT (220 KV and 132 KV): This provides the losses in the EHT lines. These losses can be taken as technical losses as theft of power is very remote at these voltage levels.
- Accounting in 33 kV lines: This provides the losses in 33 kV lines. These losses can also be taken as technical losses as theft of power is also quite remote at 33 kV lines.

- Accounting in 11 kV lines: This provides the losses an each 11 KV feeder, consisting of technical and commercial losses.

- Accounting in distribution transformer: This provides the losses in the LT network under each distribution transformer. The losses comprises of both technical and commercial Losses.

Basically, in the accounting process, the energy exported from the sending end and the energy received at the receiving end are measured. These readings are compared every month and the energy losses are arrived at as the difference between the two readings. Now, among the various parts of a power grid discussed above, EHT lines are not considered a part of the distribution system. Therefore, we will not discuss about the accounting procedure in EHT lines in detail. The remaining three phases are now discussed in more detail below:

Accountng in 33 KV lines

The salient features are as follows:

- Meters shall be provided for all 33 KV feeders emanating from EHT substation, i.e., 220 KV substation or 132 KV substation.

- Either provide a meter on LV side of each power transformer immediately to assess the demand and energy handled by the substation or, provide metering for individual 11 KV feeders emanating from all substations.

- The loss calculation procedure is as follows:

  1. Let the number of units sent out on 33 kV feeder at the EHT (132/33 kV) substation be X.
  2. Let us asume that this feeder is supplying two 33/11 kV substations.
  3. Ket D1 be the number of units recorded on LV side of power transformers at the first 33/11 kV substation and let D2 be the sum of units sent out on all 11 kV feeders from the second 33/11 kV substation.
  4. Let there be a HT customer connected at 33 kV level which consumes a demand of D3 units.
  5. The total losses on 33 KV feeder and the 33/11 KV transformers are = X - (D1 + D2 + D3).

Accountng in 11 KV lines

For accounting in 11 kV lines, there are two methods.

Method 1 Install energy meters on all 11 KV feeders (if not already done). Energy sent out on each of 11 KV feeder or a group of feeders controlled by a single breaker may be obtained from the energy meter provided on the breaker at Substation. The energy billed for all services other than the agricultural services is available from the billing records. In the case of urban feeders, the difference between the units sent out and units billed give the technical and commercial losses. For rural feeders the difference between the energy sent out and the energy billed gives the agricultural energy sales plus technical and commercial losses.

In the absence of energy meters for agricultural services, agricultural consumption has to be estimated. However, estimation of agricultural consumption is often disputed as it varies widely with cropping pattern, depth of ground water, acreage, season etc. Therefore, for estimating the agricultural consumption, meters are fixed to at least 5% load points of the total agricultural services. Perhaps, a more realistic approach may be to identify distribution transformers feeding exclusively agricultural services and provide metering at those transformers to arrive at the consumption in agricultural sector in the area under consideration. However, this method is comparatively more lengthy, time consuming and costly.

Method 2 Install energy meters on all distribution transformers supplied by the feeder. The energy sent out from each distribution transformer for the current month may be computed from the meter readings. The difference between the energy sent out on the feeder and sum of the energy sent out on all the distribution transformers supplied by the feeder gives technical and commercial losses of the feeder. This is a rigorous method but very expensive. It may be performed on one urban feeder and one rural feeder in each district. This method helps in the analysis of low voltage network losses also as meters are provided on the LV side of the distribution transformer.

Accountng in low voltage network

In this case also energy losses can be calculated by two methods. In the first method, energy sent out from the distribution transformer is measured by providing an energy meter. In the second method, it is estimated. These two methods are described below.

Method 1 Meters are to be provided on LV side of the distribution transformer to obtain the amount of energy sent out. Energy billed for different class of customers supplied by the distribution transformer is computed from the billing records. The energy sales on each distribution transformer can be automatically computed if the customer-billing database is linked with the database of location of distribution transformers. The difference between the energy sent out and energy billed gives the technical and commercial losses of the LV network.

Method 2 In this method, energy meter is not installed and the energy sent is estimated by taking readings of current and voltage at peak load with tong tester. The energy sent out is 3 x Current in Amps. X Voltage (Phase - Phase) x Load Factor x Power Factor. The load factor and power factor are estimated by taking sample readings and considering the load characteristics. Rest of the procedure is same as Method 1. This method does not require any additional investment and can be performed as a part of maintenance of the transformer.

It is to be noted that the amount of losses arrived at by the accounting procedure is not a very accurate figure but can at best indicate only a range of value owing to the foolowing reasons:

- High cost of metering at EHT & HT points. As meters are to be connected using instrument transformers for stepping down the current and voltages to the levels acceptable by meters, the errors in the CT & PT together with errors in meters add up to inaccuracies. Further, the high multiplying factors cause to magnify even small errors in registration of reading.

- Simultaneous reading of all meters at every metering point is not possible unless an expensive automatic system is provided.

- Near impossibility of reading meters at all consumers at one time as each distribution utility has a vast number of consumers spread over a huge area. Also, the distribution utilities have different meter reading cycles such as monthly, bi-monthly, tri-monthly etc., by grouping number of services.

- For services with defective meters, the consumption has to be estimated which, in turn, adds up to the inaccuracies.

- Assessed consumption of unmetered services such as agriculture, has large bearing on the overall T&D losses.

1.5.5 Energy auditing to reduce losses

Investment Grade Energy Audit (IGEA) is a process of accounting & analyzing the present energy consumption to identify potential energy saving possibilities through implementation and adoption of specific energy efficient methods, measures and technologies. IGEA Report is a detailed report defining the various energy conservation measures, related energy and energy cost saving, investment required for implementation of the measures and its payback.

The broad objective of IGEA is to review the present energy consumption scenario, monitoring and analysis of the use of energy and explore the energy conservation options in various load centers of the building including submission of a detailed project report containing recommendations for improving energy efficiency with cost benefit analysis and technical specifications for any retrofit options with the list of suppliers / manufacturers of energy efficient technologies .

The scope of the work includes a detail study survey, review the present energy consumption scenario, analysis of the use of energy and explore the energy conservation options in various load centers of the building including submission of a Detailed Project Report (DPR) containing recommendations for improving energy efficiency with cost benefit analysis, and technical specifications for any retrofit options with the list of suppliers/ manufacturers of energy efficient technologies.

The scope of work for various sectors are detailed below:

1. ***Electrical Distribution System***

   - Review of present electrical distribution like Single Line Diagram (SLD), transformer loading, cable loading, normal & emergency loads, electricity distribution in various areas/floors etc.
   - Study of Reactive Power Management and option for power factor improvement.
   - Study of power quality issues like Harmonics, current unbalance, voltage unbalance etc.
   - Exploring the Energy Conservation Opportunities (ENCON).

2. ***Lighting System***

   - Review of present lighting system, lighting inventories etc.
   - Estimation of lighting load at various locations like different floors, outside (campus) light, pump house and other important locations.
   - Detail lux level survey at various locations and comparison with acceptable standards.
   - Study of present lighting control system and recommend for improvement.
   - Analysis of lighting performance indices like Lux/m^2, lux/watt, lux/watt/m^2 and comparison with norms of high rise buildings.
   - Exploring the Energy Conservation Options (ENCON) in lighting system.

3. ***Heating, Ventilation & Air-Conditioning (HVAC) System***

   - Review of present HVAC system like central AC, window AC, split AC; package AC, water coolers, and air heaters etc.
   - Performance assessment of window AC, split AC and package AC system.
   - Performance assessment of chillers, cooling towers, air handling units (AHUs) and cold insulation system of central AC.
   - Analysis of HVAC performance like estimation of energy efficiency ratio (EER i.e. KW/TR), specific energy consumption (SEC) of chilled water pumps, condenser water pumps, AHUs etc and comparison of the operating data with the design data.
   - Exploring the energy conservation options (ENCON) in HVAC system.

4. ***Diesel Generator (DG) Sets***

   - Review of DG set operation

- Performance assessment of DG sets in terms of specific fuel consumption (SFC i.e. KWH/liter).
- Exploring the energy conservation options (ENCON) in lighting system.
- Exploring the energy conservation options (ENCON) in DG sets.

5. ***Water Pumping System***

- Review of water pumping, storage and distribution systems.
- Performance assessment of all major water pumps i.e. power consumption vs. flow delivered, estimation of pump efficiency etc.
- Exploring the ENCON in water pumping system.

6. ***Thermic Fluid Heaters/Boilers***

- Performance assessment of hot water generators or thermic fluid heaters like estimation of efficiency etc.
- Exploring the ENCON options in this systems.

7. ***Motor Load Survey***

- Conducting the motor load survey of all drives to estimate the % loading.
- Exploring the ENCON options in electric drive system.

The deliverables in the DPR are:

- Methodology adopted for the study.
- Present energy scenario of the building.
- Detail analysis of the data obtained through field visits, trial measurements by portable gadgets, discussion with concerned personnel etc.
- Recommendations for energy saving options in all possible areas with cost-benefit analysis.
- Technical Specifications for any retrofit options,
- List of suppliers/manufacturers of energy efficient technologies

1.5.6 Linkage of DSM to quality of supply issues

DSM has both beneficial and bad effects on power quality. On one hand, with the reduction in demand, the overall voltage level in the distribution system improves[27]. On the other hand, use of CFL and variable speed drives introduces increasing level of harmonics in the grid. Therefore, with the adoption of DSM measures, some other methods of improving the power quality of the supply may also sometimes be required to be implemented.

[27] Discussed in detail in subsection 1.3.2 in page 41.

1.6 Fundamental of DSM applications

1.6.1 Energy auditing for large customers

For any industry, one of the topmost components having huge potential for cost savings is its energy use. The energy Audit would give a positive orientation to the energy cost reduction, preventive maintenance and quality control programmes which are vital for production and utility activities. Such an audit programme will help to keep focus on variations which occur in the energy costs, availability and reliability of supply of energy, decide on appropriate energy mix, identify energy conservation technologies, retrofit for energy conservation equipment etc. Basically, energy audit is the key to a systematic approach for decision-making in the area of energy management. It attempts to balance the total energy inputs with its use, and serves to identify all the energy streams in a facility. It quantifies energy usage according to its discrete functions. Industrial energy audit is an effective tool in defining and pursuing comprehensive energy management programme.

As per the Energy Conservation Act, 2001, energy audit is defined as “the verification, monitoring and analysis of use of energy including submission of technical report containing recommendations for improving energy efficiency with cost benefit analysis and an action plan to reduce energy consumption”. In general, energy audit is the translation of conservation ideas into realities, by lending technically feasible solutions with economic and other organizational considerations within a specified time frame.

Basically, there are 10 steps in the energy audit of large customers. Out of these 10 steps, steps 1-2 constitute the pre-audit phase, steps 3-9 constitute the audit phase and step 10 is the post audit phase. The details of these steps are as follows:

Step 1: This step involves planning, organisation and informal interview with energy manager and/or production / plant manager. The purpose and deliverables of this step are:

1. Resource planning and establishing/organizing an energy audit team
2. Organizing instruments & time frame
3. Macro data collection (suitable to type of industry).
4. Familiarization of process/plant activities.
5. First hand observation & assessment of current level operation and practices.

Step 2: In this step, brief meeting / awareness programme with all divisional heads and persons concerned is conducted for 2-3 hours. The purpose and deliverables of this step are:

1. Building up cooperation

2. Issue questionnaire for each department

3. Orientation, awareness creation

Step 3: This step involves primary data gathering, process flow diagram & energy utility diagram. The purpose and deliverables of this step are:

1. Historic data analysis, baseline data collection

2. Preparation of process flow charts

3. System diagram of all service utilities (example: single line power distribution diagram, diagrams of water, compressed air & steam distribution circuit).

4. Annual energy bill and energy consumption pattern. Towards this goal, refer manual, log sheet, name plate as well as conduct interview.

5. Collection of design data, operating data and schedule of operation.

Step 4: In this step, initial surveys and monitoring of different facilities are conducted. The purpose and deliverables of this step are:

1. Collection of more and accurate data by surveying motors, insulation and lighting facilities with portable measuring instruments.

2. Confirm and compare operating data with design data.

Step 5: In this step, detailed trials /experiments are conducted for selected energy guzzlers. The purpose and deliverables of this step are:

1. Experiments for

    - 24 hours power monitoring (maximum demand, power factor, kWh etc.).
    - Capturing load variations trends in pumps, fans, compressors etc.
    - Determining efficiencies for boiler, furnace etc.

Step 6: In this step, analysis of energy use is conducted. Through this study, balance of materials and energy is establoshes and further, loss/waste of energy is established.

Step 7: This step involves identification and development of energy conservation (ENCON) opportunities. The purpose and deliverables of this step are:

1. Identification & consolidation of ENCON measures
2. Conceive, develop, and refine ideas
3. Review the previous ideas suggested by unit personal
4. Review the previous ideas suggested by energy audit, if any
5. Use brainstorming and value analysis techniques
6. Contact vendors for new/efficient technology

Step 8: In this step, cost benefit analysis is carried out. The purpose and deliverables of this step are:

1. Assess technical feasibility, economic viability and prioritization of ENCON options for implementation
2. Select the most promising projects
3. Prioritise by low, medium, long term measures

Step 9: In this step, initially documentation is carried out and subsequently, reporting & presentation to the top management are done.

Step 10: In this step, implementation and follow up actions are carried out. Basically, the ENCON recommendation measures are implemented and to monitor the performance, action plan and schedule for implementation are made with subsequent follow up and periodic review.

1.6.2 DSM strategies

There are several strategies by which the objectives of DSM can be achieved. These are discussed below.

Maximum demand control

The reduction of maximum demand can be achieved in several ways.

1. **Rescheduling of large loads:** In any factory, if the large electric loads and equipments are used in different shifts, then the peak demand for this factory would be reduced. Through this practice, the factory would be benefitted by a lower bill corresponding to lower peak demand. The utility also benefits for obvious reasons as it has to make provision for supplying lower peak demand.

2. **Building up of storage capacities:** By building up proper storage facilities for products, materials, hot and cold water, electricity can be consumed during the off peak periods thereby reducing the maximum demand. For example, if high capacity geyser is used, then adequate amount of hot water can be produced and stored during off peak hour for consumption at the appropriate time. Similarly, in several sectors, ice are used in large quantities to preserve the products. Ice is generally made during the lean (off peak) period and stored in large quantities and thus, the maximum demand is reduced.

3. **Shedding of non-essential loads:** When the maximum demand is about to reach a pre-set limit, temporary shedding of some non-essential loads will help to reduce it. In the simplest form, a demand monitoring system will trigger an alarm and thereafter, the loads are switched off manually. In the more sophisticated implementation, an automatic demand monitoring system will switch off the non-essential loads autimatically in a pre-determined sequence once a pre-set limit of maximum demand is reached.

4. **Operation of diesel generator sets:** When small captive generation facilities such as diesel generator (DG) sets are used, it is prudent to operate them for those periods when the demand is about to reach its peak value. In this case, the maximum demand to be supplied from the grid would reduce to a large extent thereby saving a considerable amount of money on account of peak demand charges.

Power factor correction

As already mentioned, if the power factor (PF) is low, the magnitude of current increases. To accommodate this increased current, the rating of the equipments as well as the size of the connecting cables also increase, thereby increasing the capital cost. Further, if low power factor is maintained at the load terminal, penalties have also to be paid to the electric supply authorities. Therefore, it is very important that a high power factor (in the range of 0.95 to 0.98) is maintained at the premises of the loads. This can be achieved by connecting power factor correction capacitors across large induction motor loads and making suitable arrangements for switching OFF and ON these capacitors along with the induction motor loads. For large establishments such as factories, a synchronous condenser can be used as a capacitor.

High PF has several advantages. For same amount of load, higher PF translates into lower kVA. Thus, if the maximum is contracted on the basis of kVA, maximum demand also decreases. Further, with lower amount of current because of high PF, undue heating of cables and the equipments also reduce resulting into more efficient operation of the system. Also, with reduced current, voltage drop in the feeders reduce and hence, the load voltage improves. Moreover, as load kVA reduces, the kVA loading of transformers, cables and other equipments also reduce thereby providing capacity relief. In fact, a high value of PF can help any utility to utilize its full capacity. Lastly, because of reduced kVA loading, the ratings of different equipments such as transformers, cables, switchgears etc. also can be reduced thereby saving on capital expenditure.

1.6.3 End use technologies and energy efficient appliances

Apart from the above strategies, if attention is given to following end use technologies, significant amount of reduction in electricity use can be achieved.

Motors

Up to 70% of electricity use in industry goes through motors and motor driven systems. Examples of motor driven systems are pumps, fans, compressors, conveyors and crushing/mixing. Often these systems can be designed and controlled more efficiently. Good maintenance of the system components can save up to 10% of the energy costs. As another example, in a pumping system, improvements to the motor, drive, drive control, pump, and transmission system can improve efficiency by 30%-70%. Moreover, if the efficiency of the motor operations are enhanced through the following means, significant savings in electricity use can be achieved.

- **Motor idling:** Motor idling is a very common feature of industrial usage. In many instances, motors are left on when there is no actual productivity work being done. Depending on circumstances, up to 50% full load current may be taken by idling motors particularly when still connected to gear trains and belt drivers. The most direct power savings can be obtained by shutting off idling motors, thereby eliminating no-load losses. While the approach is simple, in practice it calls for constant supervision or automatic control. Often, no-load power consumption is considered unimportant. However, the idle no-load current is frequently about the same as the full-load current. An example of this type of loss in textile mills occurs with sewing machine motors that are generally operated for only brief periods. Although these motors are relatively small (1/3 horsepower), several hundred may be involved at a plant. A switch connected to the pedal can provide automatic shutoff.

- **Motor replacement:** Normally motor replacement will occur because existing units are beyond economical repair. Perhaps In some cases, repairs are still carried out because of the cost of the new motor. This is particularly true in case of over-sized motors. However, in these motors, both power factor and efficiency are adversely affected and with long periods of idling, matters become worse. A policy should be instituted through the factory to ascertain what the actual full load demands on a particular motor are. This should be done for every motor in the works. Having logged these loads, the actual capacity of the motors should be compared with the figures. The stock of motors should be reviewed to see if there is a possibility of switching motors so that the large motors which are under-loaded (or oversized) can be replaced by smaller capacity motors available in the factory. If this is possible, then only a few small motors need be bought to fill vacancies. However in some cases, because of the problem of mountings and short peak loads, motors cannot be replaced by smaller units. In this cases replacement by improved efficiency motors should be considered taking advantage of development of energy-efficient motors.

- **Use of energy efficient motors:** As the efficiency of standard motor at low loading is poor, its operating performance gets reduced considerably. If the delta to star change-over option is not suitable for improving the efficiency, replacement of existing standard motor with energy efficient motor could be very viable. The conditions which increase viability of installing energy efficient motors are as follows:

  1. Standard motor operating at low load is replaced by a lower rated (HP) energy efficient motor
  2. Operational hours are high (nearly continuous)
  3. Standard motor is old, number of rewindings are more and frequent

  The efficiency of the energy efficient motor is almost constant at all percentage loadings. Normally, this option is suitable for the motors with rated capacity below 50 HP. The efficiencies of standard motors above 50 HP rating are almost similar to that of energy efficient motors. In many cases, though the initial cost of energy efficient motor is 15 to 20% higher than the standard motor, the simple payback period is less due to the savings accrued. There are several factors which need to be looked into while deciding the economic viability of the energy efficient motrors. These are:

  1. The load in terms of power factor, maximum load and the variation of loads on the standard motors. From this, hopefully, some idea of average loading can be established.
  2. How the standard motor of the required capacity compares at the average load with the energy efficient motor.
  3. Times and hours of operation during the year.
  4. Electricity tariffs, including KWh rates and maximum demand charges.

  Typical cases of motor replacement by energy efficient motors have shown that the pay - back periods[28] are between 6 months and 2-1/2 years, depending on whether the motor is being run continuously over the year or in shingle shift.

- **Conversion of Delta connection to Star connection:** The induction motor with a percentage loading below 50% generally operates at lower efficiency in delta connection mode. This efficiency at low loading can be improved by converting delta connection into star connection. In star connected mode, the rated output of motor drops to 1/3rd of delta configuration without affecting performance and as a result, the percent loading increases as compared to delta mode. The reported savings due to this conversion varies from around 3% to 10%. This option does not require any capital investment and is one of the least cost options available for the energy conservation in induction motors. Though the margin of

[28]Described in subsection 1.7.2 in page 79.

saving due to this option is low, but as the plant installations normally have hundreds of motors, converting most of the under-loaded motors in the plant would result into considerable savings.

Some motors operate on step loading and some on continuously variable load. The motors which operate on step loading, techno-economic feasibility of Delta-Star automatic change-over switch is to be worked out. To illustrate this, let us take an example of a a machine with an induction motor which performs three operations in its operating cycle resulting into motor loading of 25%, 40% & 80%. in this case, permanent delta to star conversion is not possible. An automatic delta-star change-over controller could be installed here which will connect the motor in star mode in 25% & 40% motor loading conditions and in delta mode in 80% loading condition. For the applications where starting torque requirement is high but otherwise the load is low, automatic delta to star conversion can give significant energy savings.

- **Using soft starters:** Soft starters, which have solid state electronic components, are used to control the input voltage according to the torque required by the driven equipment. Thus, at almost all the load, the motor operates at same efficiency and power factor. This results in smooth starting of the motors by drawing lower current and thus avoiding the high instantaneous current normally encountered by the motor. Starting current and torque are directly related to the voltage applied while starting the motor. By reducing the line voltage when the motor is started, soft starter reduces the starting inrush current and eliminates the high impact or jerk starts that causes mechanical wear and damage. Soft starters are useful in cases where motors operate with high impact loads. Some of the applications are cranes, conveyors, hoists, compressors, machine tools, textile machinery, food processing machinery etc.

- **Re-winding of motors:** It is common practice in industry to rewind burnt-out motors. The population of rewound motors in some industries exceed 50% of the total population. Careful rewinding can sometimes maintain motor efficiency at previous levels, but in most cases, losses in efficiency result. Rewinding can affect a number of factors that contribute to determining motor efficiency: winding and slot design, winding material, insulation performance, and operating temperature. For example, a common problem occurs when heat is applied to strip old windings; in this case, the insulation between laminations can be damaged, thereby increasing eddy current losses. A change in the air gap may affect power factor and output torque. Some of the other factors which affect the efficiency of a re-wound motor are:

    1. If the core loss is increased as a result of improper burnout, the motor will operate at a higher temperature and possible fail prematurely.
    2. If the stator turns are reduced, the stator core loss will increase. These losses are a

result of leakage (harmonic) flux induced by load current and vary as the square of the load current.

3. When rewinding a motor, if smaller diameter wire is used, the resistance and the I^2R losses will increase.

However, if proper measures are taken, motor efficiency can be maintained, and in some cases increased, after rewinding. Efficiency can be improved by changing the winding design, though the power factor could be affected in the process. Using wires of greater cross section, slot size permitting, would reduce stator losses thereby increasing efficiency. However, it is generally recommended that the original design of the motor be preserved during the rewind, unless there are specific, load-related reasons for redesign.

The impact of rewinding on motor efficiency and power factor can be easily assessed if the no-load losses of a motor are known before and after rewinding. Maintaining documentation of no-load losses and no-load speed from the time of purchase of each motor can facilitate assessing this impact. For example, comparison of no load current and stator resistance per phase of a rewound motor with the original no-load current and stator resistance at the same voltage can be one of the indicators to assess the efficacy of rewinding.

- **Belts:** Closely associated with motor efficiency is the energy efficiency of V-belt drives. Several factors affecting V-belt efficiency are:

  1. Over belting: A drive designed years ago should be replaced with higher-rated belts, with resulting increase in efficiency.
  2. Tension: Improper tension can cause efficiency losses of up to 10 percent. The best tension for a V-belt is the lowest tension at which the belt will not slip under a full load.
  3. Friction: Unnecessary frictional losses will result from misalignment, worn sheaves, poor ventilation, or rubbing of belts against the guard.
  4. Sheave diameter: While a sheave change may not be possible, in general, the larger the sheave, the greater the drive efficiency.

  Substitution of the notched V-belt (cog belt) for the conventional V-belt offers attractive energy savings. The V-belt is subjected to large compression stresses when conforming to the sheave diameter. The notched V-belt has less material in the compression section of the belt, thereby minimizing rubber deformation and compression stresses. The result is higher operating efficiency for the notched V-belt.

  Further, with conventional V-belts, the efficiency for power transmission is low as high frictional engagement exists between the lateral wedge surfaces of the belts which cause less power transmission and thus, higher power consumption takes place for the same work to be done by the load. However, with flat-belts, this frictional engagement is on the outer pulley diameter only. V-belts contain higher bending cross section and large mass which cause higher bending loss. Also, as each groove of the pulley contains individual V-belt, the tension between the belt and the pulley distributes unevenly which causes unequal wear on the belt. This leads to vibrations and noisy running and hence reduces power transmission further. The consequences could be bearing damage also. This problem can be solved by using energy efficient Flat-belt. With the flat belt drive, the frictional engagement and disengagement is on the outer pulley diameter, not on the lateral wedge surface as in the case of the V-belt. As a result, wear on the belt is less and hence the life of the flat belt drive is higher than V-belt. Some of the applications where conversion of V-belts with flat belts is much effective are compressors, milling machines, sliding lathes, rotary printing presses, stone crushers, fans, generators in hydroelectric power plants etc.

- **Use of variable speed drives (VSD):** The largest potential for electricity savings with variable speed drives is generally in variable torque applications, for example in centrifugal pumps and fans, where the power requirement changes as the cube of speed. Constant torque loads are also suitable for VSD application.

- **Use of multi-speed motors:** Motors can be wound such that two speeds, in the ratio of 2:1, can be obtained. Motors can also be wound with two separate windings, each giving 2 operating speeds, thereby giving a total of four speeds. Multi-speed motors can be designed for applications involving constant torque, variable torque, or for constant output power. Multi-speed motors are suitable for applications, which require limited speed control (two or four fixed speeds instead of continuously variable speed), in which cases they tend to be very economical. They have lower efficiency than single-speed motors.

Refrigeration

There might be large savings to achieve in refrigeration plants. This counts for plants in industry. To achieve this, it must be ensured that the plant does not work, when there is no need for refrigeration. This especially counts for freezers, which are only in use during production. Cold stores for storing goods must of course run constantly.

Many refrigerating plants have too low evaporation temperatures and too high condensation temperatures. This leads to high electricity consumption. The evaporator temperature should not be lower than the demand. Clean evaporators ensure that enough cooling effect is obtained. The condensers must be kept clean as well. The thermostatic control of condenser cooling should also be as low as allowed by the data for the plant.

Some refrigeration plants utilize the condenser heat for space heating or-hot water. This is a good solution, but only if the condenser temperature isn't raised to get hot air or water. Instead it is more profitable to install a heating element for the last heating.

Replacement of motor, and perhaps transmission between motor and compressor, might raise the efficiency. At last the design of the plant might be bad, which results in too high electricity consumption. This is especially seen, if the original plant has been enlarged to meet a higher refrigeration need.

There exist various methods to regulate the performance of the refrigeration plant as described below.

- **Cold insulation:** Insulate all cold lines / vessels using economic insulation thickness to minimize heat gains and choose appropriate (correct) insulation.

- **Building envelop:** Optimise air conditioning volumes by measures such as use of false ceiling and segregation of critical areas for air conditioning by air curtains.

- **Building heat loads minimisation:** Minimise the air conditioning loads by measures such as roof cooling, roof painting, efficient lighting, pre-cooling of fresh air by air- to-air heat exchangers, variable volume air system, otpimal thermo-static setting of temperature of air conditioned spaces, sun film applications, etc.

- **Process heat loads minimisation:** Minimize process heat loads by way of:

  1. Flow optimization
  2. Increasing heat transfer area to accept higher temperature coolant
  3. Avoiding wastages like heat gains, loss of chilled water, idle flows.
  4. Adopting frequent cleaning / de-scaling of all heat exchangers

- **Other actions at the refrigeration plant:** These include,

  1. Ensuring regular maintenance of all A/C plant components as per manufacturer guidelines.
  2. Ensuring adequate quantity of chilled water and cooling water flows and avoiding bypass flows by closing valves of idle equipment.
  3. Minimizing part load operations by matching loads and plant capacity on line and adopting variable speed drives for varying process load.
  4. Making efforts to continuously optimize condenser and evaporator parameters for minimizing specific energy consumption and maximizing capacity.

Lighting systems

About 17% of energy generated in our country is consumed for lighting and illumination. This area provides a major scope to achieve energy efficiency at the design stage, by incorporation of modern energy efficient lamps, luminaires and gears, apart from good operational practices. The different lighting options available today are:

- **Incandescent lamps:** These are the least expensive to buy but are the most expensive to operate. The range of lumen/watt produced by these lamps is 8-18 with an average value of 14 lumen/watt. The color rendering index (CRI[29]) of these lamps is excellent. They have a typical life of 1000 hours and their typical applications are in homes, restaurants, general lighting, emergency lighting.

- **Fluorescent lamps:** The range of lumen/watt produced by these lamps is 46-60 with an average value of 50 lumen/watt. The CRI of these lamps is good. They have a typical life of 5000 hours and their typical applications are in Offices, shops, hospitals, homes.

- **CFL:** CFL are the most significant lighting devices developed for homes in recent years. They combine the efficiency of fluorescent lighting with the convenience and popularity of the incandescent fixtures. The range of lumen/watt produced by these lamps is 46-70 with an average value of 60 lumen/watt. The CRI of these lamps is very good. They have a typical life of 8000-10,000 hours and their typical applications are in Offices, shops, hospitals, hotels, homes.

- **High pressure mercury (HPMV) lamps:** The range of lumen/watt produced by these lamps is 44-57 with an average value of 50 lumen/watt. The CRI of these lamps is fair. They have a typical life of 5000 hours and their typical applications are for general lighting in factories, garages, car parking, flood lighting.

- **Halogen lamps:** The range of lumen/watt produced by these lamps is 18-24 with an average value of 20 lumen/watt. The CRI of these lamps is excellent. They have a typical life of 2000-4000 hours and their typical applications are for display, flood lighting, stadium exhibition grounds, construction areas.

- **High pressure sodium vapour (HPSV) lamps:** The range of lumen/watt produced by these lamps is 67-121 with an average value of 90 lumen/watt. The CRI of these lamps is fair. They have a typical life of 6000-12000 hours and their typical applications are for general lighting in factories, ware houses, street lighting.

- **Low pressure sodium vapour (LPSV) lamps:** These are the most efficient artificial lighting, having the longest service life, and maintain their light output better than any other lamp type. They work in some ways like fluorescent lights and is used where color is not so important. The range of lumen/watt produced by these lamps is 101-175 with an average value of 150 lumen/watt. The CRI of these lamps is poor. They have a typical life of 6000-12000 hours and their typical applications are for roadways, tunnels, canals, street lighting.

[29]The color rendering index (CRI) (sometimes called color rendition index), is a quantitative measure of the ability of a light source to reproduce the colors of various objects faithfully in comparison with an ideal or natural light source. Light sources with a high CRI are desirable in color-critical applications such as photography and cinematography.

- **High intensity discharge (HID) lamps:** These lamps provide the longest service life and the highest quality of any lighting type. They are commonly used for outdoor lighting and in large indoor areas. These lamps and fixtures can save 70%-90% of lighting energy when they replace incandescent ones. The three most common types of HID lamps are the mercury vapor, metal halide, and high-pressure sodium lamps.

By following some good practices, considerable savings in electricity use can be achieved. These are:

- **Installation of CFLs in place of incandescent lamps:** Compact fluorescent lamps are generally considered best for replacement of lower wattage incandescent lamps. Quite a few small industries have used CFLs to cut down lighting loads by as much 20-25%.

- **Installation of metal halide lamps in place of mercury/sodium vapour lamps:** Metal halide lamps provide high color rendering index when compared with mercury & sodium vapour lamps. These lamps offer efficient white light. Hence, metal halide is the choice for colour critical applications where, higher illumination levels are required. These lamps are highly suitable for applications such as assembly line, inspection areas, painting shops, etc. Small fabrication shops where colour rendering is more critical are good candidates of the metal halide lamps.

- **Use of HPSV lamps where colour rendering is not critical:** It is recommended to install HPSV lamps for installations with wide open spaces , street lighting, yard lighting, etc where color rendering is not critical.

- **Installation of LED panel indicator lamps in place of filament lamps:** Panel indicator lamps are used widely in several industries for monitoring, fault indication, signaling such as looms, dyeing, glass, ceramic, food processing, metal working industries. Conventionally filament lamps are used for the purpose, which has got the following disadvantages:

    1. High energy consumption (15 W/lamp).
    2. Failure of lamps is high (operating life less than 10,000 hours).
    3. Very sensitive to the voltage fluctuations.

    Recently, the conventional filament lamps are being replaced with Light Emitting Diodes (LEDs). The LEDs have the following merits over the filament lamps:

    1. Lesser power consumption (Less than 1 W/lamp).
    2. Can withstand high voltage fluctuation in the power supply.
    3. Longer operating life (more than 1,00,000 hours).

High-efficiency LEDs provide white light, and the technology is improving as manufacturers devise products with higher light output and energy efficiencies, and lower cost per unit output. With efficiencies of only 5 lumens per watt in the mid-1990s, present day LEDs are moving towards 100 lumens per watt (compared to 0.1 lumen per watt for a flame-based lantern). Commercially available 1-watt W LEDs require 80 percent less power than the smallest energy-fcompact fluorescent lamps and can be run on rechargeable batteries charged by a solar array the size of a paperback novel. Such LEDs could actually deliver more light to tasks than even 100-watt light bulbs.

- **Light distribution:** Energy efficiency cannot be obtained by mere selection of more efficient lamps alone. Efficient luminaires (light fixtures or light fittings) along with the lamp of high efficacy achieve the optimum efficiency. For achieving better efficiency, luminaires that are having light distribution characteristics appropriate for the task should be selected. The luminaires fitted with a lamp should ensure that discomfort glare and veiling reflections are minimised. Installation of suitable luminaires, depends upon the height - low, medium & high Bay. Luminaires for high intensity discharge lamp are classified as follows:

  1. Low bay, for heights less than 5 metres.
  2. Medium bay, for heights between 5 - 7 metres.
  3. High bay, for heights greater than 7 metres.

- **Light control:** The simplest and the most widely used form of controlling a lighting installation is "On-Off" switch. The initial investment for this set up is extremely low, but the resulting operational costs may be high. This does not provide the flexibility to control the lighting, where it is not required. Hence, a flexible lighting system has to be provided, which will offer switch-off or reduction in lighting level, when not needed. The following light control systems can be adopted at design stage:

  1. **Grouping of lighting system:** In this option, lighting systems are grouped which can be controlled manually or by timer control. This is to provide greater flexibility in lighting control.
  2. **Optimum usage of day-lighting:** Whenever the orientation of a building permits, day lighting can be used in combination with electric lighting. This should not introduce glare or a severe imbalance of brightness in visual environment. Usage of day lighting (in air conditioned sections such as tool rooms, laboratories) will have to be very limited, because the air conditioning load will increase on account of the increased solar heat dissipation into the area. In many cases, a switching method, to enable reduction of electric light in the window zones during certain hours, has to be designed.

3. **Installation of microprocessor based controllers:** Another modern method is usage of microprocessor / infrared controlled dimming or switching circuits. The lighting control can be obtained by using logic units located in the ceiling, which can take pre-programme commands and activate specified lighting circuits. Advanced lighting control system uses movement detectors or lighting sensors, to feed signals to the controllers.

4. **Installation of "exclusive" transformer for lighting:** In most of the industries, lighting load varies between 2 to 10%. Most of the problems faced by the lighting equipment and the "gears" is due to the "voltage" fluctuations. Hence, the lighting equipment has to be isolated from the power feeders. This provides a better voltage regulation for the lighting. This will reduce the voltage related problems, which in turn increases the efficiency of the lighting system.

5. **Installation of servo stabilizer for lighting feeder:** Wherever, installation of exclusive transformer for lighting is not economically attractive, servo stabilizer can be installed for the lighting feeders. This will provide stabilized voltage for the lighting equipment. The performance of "gears" such as chokes, ballasts, will also improved due to the stabilized voltage. This set up also provides the option to optimise the voltage level fed to the lighting feeder. In some locations, during the non-peaking hours, the voltage levels are on the higher side. During this period, voltage can be optimised, without any significant drop in the illumination level.

6. **Installation of high frequency (HF) electronic ballasts in place of conventional ballasts:** New high frequency (28-32 kHz) electronic ballasts have the following advantages over the traditional magnetic ballasts:

   (a) Energy savings up to 35%

   (b) Less heat dissipation, which reduces the air conditioning load

   (c) Lights instantly

   (d) Improved power factor

   (e) Operates in low voltage load

   (f) Less in weight

   (g) Increases the life of lamp

   The advantage of HF electronic ballasts out weigh the initial investment (higher costs when compared with conventional ballast). In the past the failure rate of electronic ballast in Indian Industries was high. Recently, many manufacturers have improved the design of the ballast leading to drastic improvement in their reliability. The life of the electronic ballast is high especially when, used in a lighting circuit fitted with a automatic voltage stabiliser.

Compressed air

Compressed air is used in almost all types of industries and accounts for a major share of the electricity used in some of the plants. It is utilized for a variety of end-uses such as pneumatic tools and equipment, instrumentation, conveying, etc. and is preferred in industries because it is more convenient and safe. It is a handy medium for transmitting energy and is often referred to as the fourth utility. However, it is not always used in the most efficient manner. It is used to operate mechanical equipment and power tools, to pressurize, to clean etc. Some industries have specific applications such as paint spraying and bottle forming.

Compressed air energy consumption is dependant upon the size and nature of the load, the efficiency of the distribution system and the performance characteristics of the motor being used to drive the compressor. Therefore, many of the efficiency issues under energy efficient motors and drives also apply here.

There are several issues in compressed air systems, which, if properly attended, can enhance the efficiency of the system further. These are:

- Leaks can cost a fortune. Therefore, a good housekeeping should be in place.
- Do not use compressed air where an alternative (e.g. low pressure air supply) would exist.
- If the pressure is higher than necessary, then savings can be made by reducing the pressure.
- Pipe bends, junctions and valves may increase pressure loss in the system.
- Dryers and filters are vital for some compressed air applications. However, they cause significant pressure and energy losses on the system and should be maintained rigorously.
- The system should have sufficient storage to allow the compressor to run smoothly.

Use of energy efficient equipments and pumping system:

The issue of energy efficient equipments has already been discussed in detail in subsection 1.2.1 in page 11. Further, by enhancing the efficiency of the industrial pumping system, significant savings in energy cost can be achieved.

1.6.4 Metering and tariff

Already described in subsection 1.4.5 in page 48.

1.7 Financial analysis of investment for distribution improvement and DSM

1.7.1 Factors affecting financial analysis

For the success of any DSM project, proper financial analysis is necessary. Towards this goal, several factors as discussed below need to be considered:

- Assessment of correct cost of power delivery
- Assessment of correct power savings, i.e., benefits
- Assessment of correct gestation period for project implementation
- Assessment of correct cost of project implementation
- Other factors dependant on the project implementation site

1.7.2 Tools for financial analysis

There are several tools for financial analysis. These tools can be classified into two categories, namely: a) traditional methods and b) time adjusted method. The detailed description of these two categories of methods are given below.

Traditional methods

In the traditional methods, the present and future cash flows are treated equally, i.e. the time value of money is ignored. These methods include average rate of return (ARR) technique and pay back period method.

1. ***Average rate of return (ARR:)***

   The Average Rate of Return Method of evaluating proposed capital expenditure is also known as the accounting rate of return method. It is based upon accounting information rather than cash inflows. There is no unanimity regarding the definition of the rate of return. There are a number of alternative methods of calculating ARR, but the most common is as follows:

   $$ARR = \frac{\text{Average annual profits (or income) after tax}}{\text{Average investment over the life of the project}}$$

   There are two variants of the accounting rate of return: (a) Original Investment Method, and (b) Average Investment Method.

   - Original investment method: Under this method average annual earnings or profits over the life of the project are divided by the total outlay of capital project, i.e., the original investment. Thus ARR under this method is the ratio between average annual profits and original investment made.

- Average investment method: Under average investment method, average annual earnings are divided by the average amount of investment. Average investment is calculated, by dividing the original investment by two or by a figure representing the mid-point between the original outlay and the salvage of the investment. Generally accounting rate of return method is represented by the average investment method.

The **accept-reject rule** for this method is as follows:

- As a criteria for accepting or rejecting a particular project alternative (as in DSM case), the ARR is compared to a pre-defined or a minimum required rate of return, known as a cut-off rate. A project is accepted (rejected) if the ARR is higher (lower) than the cut off rate. As a means of comparison between two or more alternatives, the one with a higher ARR is chosen (provided that it is higher than the cut off rate).

The advantages of this method are:

- It is very simple to understand and use.
- Rate of return may readily be calculated with the help of accounting data.
- It gives due weightage to the profitability of the project if based on average rate of Return. Projects having higher rate of Return will be accepted and are comparable with the returns on similar investment derived by other firm.
- It takes investments and the total earnings from the project during its life time.

The limitations of this method are:

- It uses accounting profits and not the cash-inflows in appraising the projects.
- It ignores the time-value of money which is an important factor in capital expenditure decisions. Profits occurring in different periods are valued equally.
- It considers only the rate of return and not the length of project lives.
- The method ignores the fact that profits can be reinvested.
- The method does not determine the fair rate of return on investment. It is left at the discretion of the management. So, use of arbitrary rate of return cause serious distortion in the selection of capital projects.
- The method has different variants, each of which produces a different rate of return for one proposal due to the diverse version of the concepts of investment and earnings.

2. ***Pay back period:***

   Pay back period is defined as the time which is required for the cash inflows from a capital intensive project to be equal to the initial investment of the project. This period is usually expressed in years. Payback period can be calculated in two ways depending on the nature of cashflow streams. If the stream is an annuity i.e. equal cashflow in each period, then the payback period can be calculated by dividing the initial outlay by the constant annual cashflow. Thus, if the initial investment of a project is S and cash inflow for every year is A, then the pay back period is calculated as $P = \frac{S}{A}$. On the other hand, when the cashflow stream is not an annuity but rather a mixed stream i.e. varies from period to period, the payback period is calculated by cumulating the cash inflows. The number of years after which the cumulative value of cash inflow equals or surpasses the original investment, is taken to be the appropriate payback period. The examples given below will illustrate these points.

   - Example 1: Let the initial investment of a project is Rs. 1,00,000 and it generates cah inflow of Rs. 20,000 every year. Therefore, the pay back period is 1,00,000/20,000 = 5 years.
   - Example 2: Let for the above project, the cash inflows are as follows: 1st year - Rs. 30,000, 2nd year - Rs. 25,000, 3rd, 4th & 5th year - Rs. 20,000 each. Therefore, the pay back period is between 4 and 5 years, as the cumulative value of cash inflow after 4 years is Rs. (30,000 + 25,000 + 20,000 + 20,000) = Rs. 95,000 and the cumulative value of cash inflow after 5 years is Rs. (30,000 + 25,000 + 20,000 + 20,000 + 20,000) = Rs. 1,15,000.

   The **accept-reject rule** for this method is as follows:

   - For any project, its payback period is compared to a pre-defined or minimum payback period. If the payback period of the project in consideration is less (more) than the pre-defined period, the project is accepted (rejected). While comparing two mutually exclusive projects, the criterion is to choose the one with a lower payback period.

   The advantages of this method are:

   - It is simple to calculate and easy to understand
   - It is superior to ARR method in the sense that it uses a cashflow analysis rather than accounting profit approach.

   The limitations of this method are:

   - It ignores all cash inflows after the payback period completely. This can often be misleading. Suppose there are two projects which have the same payback period, however, for one of the projects no cash inflows are generated after the payback period whereas the other generates cash inflows even beyond the payback period. In such a case the payback period method will leave the firm indeterminate, even though it is clear that the firm would prefer project 2.

- It does not take into consideration the entire life of the project, hence often highly profitable projects with longer payback periods get rejected in favor of projects which have a shorter payback period even though they are less profitable.
- It does not differentiate between projects in terms of the timing or magnitude of cashflows. It only considers the recovery period as a whole, as it does not discount future cashflows but treats all values at par. How this property of the payback period method turns out to be a drawback can be explained as follows. Consider two projects that have the same initial investment and the same payback period. However, one project (project 1) yields higher returns in the initial periods and lower returns in the remaining periods towards the end of the payback period, whereas it's the reverse case for the other project (project 2). In such a case, payback period does not give us the answer of which project to choose, even when it's clear that the first project should be chosen as it returns cash earlier than the first one.

Time adjusted methods

These methods consider the time value of money. The different methods in this category are as follows.

1. ***Net present value (NPV):***

   The NPV is calculated as:

$$NPV = \sum_{t=1}^{n} \frac{C_t}{(1+r)^t} - I_o$$

   In the bove expression,
   C_t → the net cash receipt at the end of year 't'
   I_o → the initial investment of the project
   r → the discount rate or the required minimum rate of return on investment
   n → duration of the project

   The **accept-reject rule** of this method is as follows:

   - A project is undertaken (rejected) if, NPV > 0 (< 0). The rationale behind this rule is that a project will be undertaken only if its benefits outweigh the cost i.e. the difference between inflows and outflows is positive and this difference is nothing but the NPV. When comparing between two mutually exclusive projects, a project with higher NPV is accepted as compared to the one with a lower NPV.

Example:

- Suppose for a project, I_o = Rs. 800,000; $r = 10\%$, $n = 3$ and $C_1 = C_2 = C_3$ = Rs. 400,000. The NPV is calculates as follows:

$$NPV = Rs.\left(\frac{4,00,000}{1.1} + \frac{4,00,000}{(1.1)^2} + \frac{4,00,000}{(1.1)^3} - 8,00,000\right) = Rs.\ 194,720.$$

  As the NPV is greater than zero, the project should be undertaken.

The advantages of this method are:

- It explicitly recognizes the time value of money and hence considers appropriate values of all costs and benefits accruing over the life of the project (equipment) by discounting them and making current and future values comparable.
- It considers costs and benefits of a project over its entire lifetime and hence the result we get is the one having incorporated all possible costs and benefits.
- The formula allows us to change the discount rate by changing the denominator. This feature is extremely important as the time value of money changes according to the span of the period and this change needs to be appropriately captured.
- By choosing a particular project among others on the basis of this criterion, we in a way choose the project which maximizes the wealth of all stakeholders.

The limitations of this method are:

- It is difficult to understand and calculate as often there might be benefits/costs which are non quantifiable.
- Reliability of its results rests heavily upon the discount rates chosen. However, there is no unanimity on the most appropriate discount rate that should be considered for calculations. It is a subjective concept and depends on the perceptions of the person performing the calculations.
- This method does not take into consideration the initial outlay of the project and its economic life. Between two projects it will always choose the one with higher NPV even if the one chosen involves higher initial outlay (which sometimes may be not feasible for the firm). Similarly in the case of economic life, even if a project has a higher economic life it might be chosen over the other if it has a higher NPV, whereas ideally the firm would prefer a project with lower economic life.

2. ***Internal rate of return (IRR):***

IRR is basically the discount rate at which the NPV of a project is zero. In other words, at this rate, the present value of all cash inflows summed together would be equal to the initial investment. For this reason, it is also called the break-even discount rate. Therefore, to calculate IRR (r), following equation is solved:

$$\sum_{t=1}^{n} \frac{C_t}{(1+r)^t} - I_o = 0$$

There is no closed form expression to calculate r from the above equation. Thus, the above equation is solved by trial and error procedure.

The **accept-reject rule** of this method is as follows:

- The decision to accept or reject a project on the basis of this criterion depends on the comparison of the IRR with a pre-defined cut off rate of return. The project will be accepted (rejected) if the IRR is greater (less than) than the cut off rate. When comparing between two mutually exclusive projects, this rule chooses the one with a higher IRR.

The advantages of this method are:

- It explicitly recognizes the time value of money and hence considers appropriate values of all costs and benefits accruing over the life of the project (equipment) by discounting them and making current and future values comparable.
- It considers costs and benefits of a project over its entire lifetime and hence the result we get is the one having incorporated all possible costs and benefits.
- By choosing a particular project among others on the basis of this criterion, we in a way choose the project which maximizes the wealth of all stakeholders as the IRR is compared to a cut off rate which is usually the opportunity cost of capital.
- It does not suffer with the limitation of subjectivity of discount factor, as IRR itself is a discount factor and is based only on the information internal to the firm i.e. internal cash flows. Thus unlike the NPV it does not suffer from arbitrariness of discount factor.

The limitations of this method are:

- It involves tedious and complex computations.
- There may be a case when the calculations lead to multiple rates. In that case it is difficult to judge which one is the correct rate.
- In case of mutually exclusive the one with higher IRR is chosen. However that might not always turn out to be the best in terms of profitability or maximization of shareholders' wealth.
- Under the IRR method it is assumed that all the intermediate cash flows are reinvested at the IRR (which is different for different projects). However, this might not be feasible for the firm i.e. firm cannot reinvest its cash flows at different rates.

3. ***Profitability Index (PI):***

This is a variant of NPV method. The PI value is calculated as:

$$PI = \frac{\text{Present value of all future cash inflows}}{\text{Initial investment}} = \frac{\sum_{t=1}^{n} \frac{C_t}{(1+r)^t}}{I_o}$$

In the above expression, the meanings of all the notations are same as those already given for the NPV method. According to this criterion a project is accepted (rejected) if PI exceeds (falls short of) unity. When comparing between two different projects this rule chooses the one with a higher value provided it is greater than unity. As this is a variant of NPV method, it has the same advantages and limitations as those of NPV.

4. ***Discounted pay back period method:***

This method is also based on the concept of payback period already defined. The difference in the two methods however rests on the fact that the discounted payback period is calculated taking into account, not the actual cashflows but their discounted value. Hence discounted payback period can be defined as the exact amount of time in which the discounted cashflows will add up to the initial outlay i.e. the time in which the project will cover its initial cost given its discounted cashflows. The method of calculation of discounted cashflows is the same as that of calculating normal payback period, except that now discounted cashflows are considered. All components in its calculation are same as normal payback period and the same holds for its accept-reject rule.

The advantages and limitations of this method are same as that of the payback period method except that it overcomes the drawback of ignoring time value of money, as it takes into account the discounted cashflows. Due to this feature it also has the advantages of other time adjusted methods.

1.7.3 Benefits of cost sharing with customers

As already discussed earlier[30], there is a significant advantage if the cost of implementing DSM measures is shared with the customers by the utilities. In general, if the cost is shared effectively through rebate, subsidy etc., the customers are encouraged for wider use of energy efficient equipmets. However, the benefits to the utilites and the customers of such subsidies need to be properly assessed before these are undertaken.

[30] in page 21 under the heading 'Electric Utilities'.

1.7.4 Financing distribution improvement and DSM programs

For successful DSM planning, one of the most essential steps is to arrange for resources to finance a DSM program. Generally, all over the world it has been noticed, that despite being technically and economically feasible, certain DSM programs do not get implemented due to lack of adequate finance. Such a situation often occurs on account of the uncertain nature of outcomes and inherent conflict with the objective of achieving increase in sales. Hence distribution utilities are usually reluctant to undertake DSM measures. Moreover, while costs associated with DSM project are usually not significant, due to poor cash situation, utilities find it difficult to arrange necessary funding. Hence, regulatory intervention to ensure adequate funds for distribution utilities for design, development and implementation of DSM programme is usually required.

Sources of financing for energy efficiency projects (including DSM) range from commercial banks to specialized energy efficiency funds to socially responsible investors. Financing through commercial banks, however, remains difficult in many cases as energy efficiency investments (will be referred to as DSM investments hereafter) often do not meet the standard investment criteria, such as collateral requirements. However, a growing number of specialized financing sources for energy efficiency are now available, as detailed below.

Following major financing sources are usually available to distribution utilities:

- Multilateral, bilateral and other international institutions/development agencies dedicated to promoting energy efficiency services. These also include dedicated lines of credit or special funds generated from the levy of additional charges to the end-users.
- Grants from governmental agencies.
- Self financing - recovery of costs through tariffs (DISCOM Mode).
- Private equity, venture capital funds and project finance debt from nationalized banks and other sources.
- ESCO financing.

The analysis of DSM projects worldwide by various DSM experts indicate that the multilateral, bilateral and other development agencies are usually the financiers of DSM programs undertaken for the developing countries. In the case of developed nations the financing is done by the utilities themselves (Self-financing) without the assistance of other agencies. Below, the different financing options are discussed in detail.

1. ***International Financial Institution and Development Agencies***
2. ***Grants from government/governmental agencies***

   There are several government agencies that give grants or create special funds for the purpose of providing finance for DSM programs. However, direct lending on the part of government (or in the form of grants or aid) has not been a prevalent practice in India so far and hence this option is not discussed in detail here.

3. ***Self financing or Recovery of Costs (DISCOM mode of financing)***

   Under the DISCOM Mode, the utility funds the DSM project either by utilizing its own funds (may be in the form of a special fund created by the utility for DSM financing) or though borrowings and contract out the certain aspects of the project works and implementation.

   Tariff Regulations, specified by the State Commissions for determining the annual revenue requirement (ARR) and tariff, do not generally have an exclusive provision under which the utilities can book the expenses incurred by it on DSM. Suitable provisions in the tariff Regulations to allow recovery of DSM related expenditure as a part of Annual Revenue Requirement is one of the simplest way to create necessary funding for the implementation of DSM programs. It would be appropriate that the State Commission may indicate a percentage of the ARR to be utilized for DSM programs. This percentage could be worked out on the basis of the indicated savings from the power purchase costs and peak clipping. In case of approval of the expenses under ARR, the utility is certain about recovering of the costs through consumer tariffs. In this case, the utility funds capital expenditure using same financing principle as used for other capital projects of the utility.

   Sometimes it may be possible to create Special Funds either within the utility or outside the utility which may be used by the utilities for design, development and implementation of demand side management program. Regulatory mechanism could be used for development of mechanism for creation of special funds. Such mechanism could involve levy or surcharge on existing consumption or incremental consumption or incremental demand, depending on the purpose of the fund.

   An example of such fund is 'Load Management Charge' fund created by various utilities in the State of Maharashtra. In May 2005, under Section 23 of the Electricity Act 2003, MERC directed all consumers to reduce their consumption to certain level. The Commission levied surcharge of Rs. 1/kWh for consumption above norm specified by the Commission. Similarly, the Commission directed rebate of Rs. 0.50 for reduction in consumption below norm set by the Commission. The Commission directed that the amount so collected by the utilities shall be used for promotion of energy efficiency, energy conservation and demand side management. The utilities in the State of Mumbai collected Rs. 70 crore during two months of May and June 2005.

   An example of fund created outside the utility is 'Urjankur Nidhi[31]' created by the Govern-

[31] The Non-Conventional Energy Department, Govt. of Maharashtra vide resolution dated 21-01-2006 has jointly promoted the Urjankur Nidhi Trust with Infrastructure Leasing & Financial Services (IL & FS) to promote non-conventional energy projects in Maharashtra. The objective of creating this fund is to develop and take equity in projects of Non-Conventional Energy. The trust has been registered under the Indian Trust Act, 1882. The fund is also registered with SEBI.

ment of Maharashtra by levy of cess of 4 paise on all units sold to commercial and industrial category consumers in the State of Maharashtra. State Energy Conservation Fund envisaged under Energy Conservation Act 2001 is another example of such fund.

4. ***Private equity, venture capital funds and project finance debt from nationalized banks and other sources***

   ESCO projects, manufacturing and licensing ventures, existing organizations and start-ups can all be financed with debt or equity. For a creditworthy company with significant assets and cash flow, designing a financing structure is a matter of choosing the lowest cost debt or equity options that meet the financing needs of the project. There are other mechanisms and structures available as well. For example, leasing or vendor financing are viable financing options for many energy efficiency projects and ventures. Similarly, letters of credit or bank guarantees can be arranged to facilitate financing. The details of different financing options under this categories are as follows:

   - *Debt:* Debt options include corporate or project loans under recourse or limited recourse structures, leasing arrangements, and full or limited guarantees. Debt financing can include options whereby loans convert to some amount of equity ownership if the project is successful, to increase the lender's rate of return.
   - *Recourse debt:* Financing with recourse is sometimes structured as corporate or balance sheet financing, whereby the debt holder is obligated to the primary sponsor of the project, and the loan must be reported on a company's balance sheet as a liability. In essence, the company stands behind the project or venture and the related debt, and financiers have recourse to the company's assets in the event of default. Recourse financing usually has a lower cost than project finance or limited-recourse debt because of its generally lower credit risk. In addition, warranties, guarantees and insurance can provide various forms of recourse to add to the creditworthiness of a transaction. Most energy efficiency (and other project finance type) projects require some degree of recourse to a creditworthy entity.
   - *Limited Recourse Debt or Project Finance:* Limited recourse financing is sometimes known as project finance. Under these transaction structures the project is financed largely based on its own merits, and payments are made by the project's cash flows. Financiers have recourse primarily to the project's cash flow and assets or additional collateral. Compared to recourse financing, structuring financing with limited-recourse is a time-intensive process. It involves a full clarification, mitigation, and allocation of all risks that could have a negative impact on the cash flows from the project or venture. The financing structure allocates risks among the parties in a transaction through contracts and financing agreements. Under these contracts different parties accept varying amounts of responsibility to repay the debt in the event that a project

fails and the loan is not repaid. The debt issue has different degrees of recourse to other parties to enforce the project's payment obligations if a financing contract is broken.

- *Secured debt:* Secured financing refers to when additional assets are pledged to the bank or financier as loan collateral. The assets can be cash, physical equipment or property, or sometimes a bank letter of credit. In the event of a default on the promise to repay the project debt when due, the bank has the right to seize and sell these assets and utilize the proceeds to repay the loan. Collateral liquidation is an expensive and time consuming process and the financier rarely collects close to the full collateral value, even on cash, after legal and other fees. Thus, collateral is never a substitute for a well conceived project with solid cash flows. Guarantees and other types of credit support can provide other assurance or security for debt repayment but are not collateral per se.
- *Leasing:* Leasing can be used to finance the sale of energy efficiency equipment and services. It is commonly used in vendor financing and ESCO projects and as part of utility programs. Lease financing can also be applied to energy efficiency manufacturing ventures. Leasing works best with simple equipment and large quantities of sales or installations. Large numbers of similar transactions facilitate a statistical approach to managing end-user credit risk. Lease financing is possible only in countries having fairly well developed capital markets and amenable laws.
- *Guarantee:* Guarantees can be provided by parent companies or third parties, and are essentially promises to pay a project's debt under certain conditions. Guarantees can be used to partially mitigate financial, performance (technological and operating) and political risk. These instruments can provide additional credit support for a basically sound transaction, thereby facilitating conventional financing at market rates. Guarantees can be made on part of a loan, debt service or to assure an investor's return on equity. Most commercial banks will issue or accept guarantees, which can be collateralized to provide additional credit support. However, guarantees are not usually considered to be collateral.
- *Equity:* Equity financing involves the ownership of a company or project, and can take a variety of forms. Equity can come from the project sponsor, or in the form of a private placement or preferred or common stock[32]. Equity usually provides longer term financing for a higher expected rate of return than debt. Usually a minimum of between

[32]There are two main differences between preferred staock and common stock. First, preferred stockholders have a greater claim to a company's assets and earnings. This is true during the good times when the company has excess cash and decides to distribute money in the form of dividends to its investors. In these instances when distributions are made, preferred stockholders must be paid before common stockholders. However, this claim is most important during times of insolvency when common stockholders are last in line for the company's assets. This means that when the company must liquidate and pay all creditors and bondholders, common stockholders will not receive any money until after the preferred shareholders are paid out. Second, the dividends of preferred stocks are different from and generally greater than those of common stock. When anybody buys a preferred stock, he/she will have an idea of when to expect a dividend because they are paid at regular intervals. This is not

20 percent and 30 percent equity in a project is required to obtain debt financing, depending on the company or customer's credit-worthiness. For larger projects in developing countries, according to the World Bank, the sponsor's equity stake is usually around 30 percent. Funders providing equity may provide more stable financing but also require significant control of the initiative.

- *Vendor financing:* Vendor financing occurs when a financier provides a vendor with capital to enable them to offer "point of sale" financing for their equipment. Vendor financing works well with high-volume sales of small products to customers in the residential and small commercial/industrial sectors. It is similar to leasing in that vendor financing lends itself to a statistical or portfolio risk management approach to end-user credit risk. Indeed, leasing is the most common form of vendor financing. Under a vendor finance scheme there are two types of agreements: one between the vendor and the financier; and the other between the vendor and the customer. The vendor/financier agreement defines the terms that can be offered to the customer such as rates, length of term and necessary documentation. A simplified and streamlined credit analysis process reduces transaction costs. The vendor/customer agreement defines the repayment terms for the loan. For energy-efficient equipment, these agreements can be structured such that the customer payments are lower than the value of the energy savings associated with the new equipment.
- *Export financing:* Many types of energy efficiency equipment and services are not currently available in developing countries. US vendors and buyers can take advantage of export credits and guarantees supplied by the Export Credit Agencies of the US Government, including the US Export-Import Bank, the Overseas Private Investment Corporation (OPIC)[33] and the US Trade and Development Agency (US TDA)[34], to sell or purchase imported equipment. Sources of trade finance for large, capital-intensive items include commercial bank export finance divisions and export credit agencies. For multiple sales of lower-priced items, companies should contact commercial banks with trade divisions, equipment distributors and agents. Export financing may be available at better terms than other types of debt for overseas projects due to the collateral value of the equipment being financed.

5. ***ESCO Financing (ESCO mode)***

An ESCO or **Energy Service Company** is a commercial company which provides a broad range of integrated and comprehensive energy service solutions including energy conserva-

necessarily the case for common stock, as the company's board of directors will decide whether or not to pay out a dividend. Because of this characteristic, preferred stock typically don't fluctuate as often as a company's common stock and can sometimes be classified as a fixed-income security. Adding to this fixed-income personality is the fact that the dividends are typically guaranteed, meaning that if the company does miss one, it will be required to pay it before any future dividends are paid on either stock (source: http://www.investopedia.com/ask/answers/182.asp).

[33] http://www.opic.gov/

[34] http://www.ustda.gov/

tion, as well as design, implementation and maintenance of energy saving projects. For any given project, an ESCO conducts an in-depth analysis of energy saving potential, designs the required energy efficiency solution and subsequently, installs and maintains the equipments to ensure energy saving during the payback period. The design is made in such a way that the savings in energy cost would usually be large enough to service the loan for implementing the energy efficiency measures and leave a surplus that is shared between the utility and the ESCO. Thus, the payment to the ESCOs is contingent upon the accrued actual savings and therefore, ESCOs are often called performance contractors. Some ESCOs may even finance projects and in that case, they recover their investment from the savings in energy cost. The basic ESCO model is shown in Fig. 1.7.

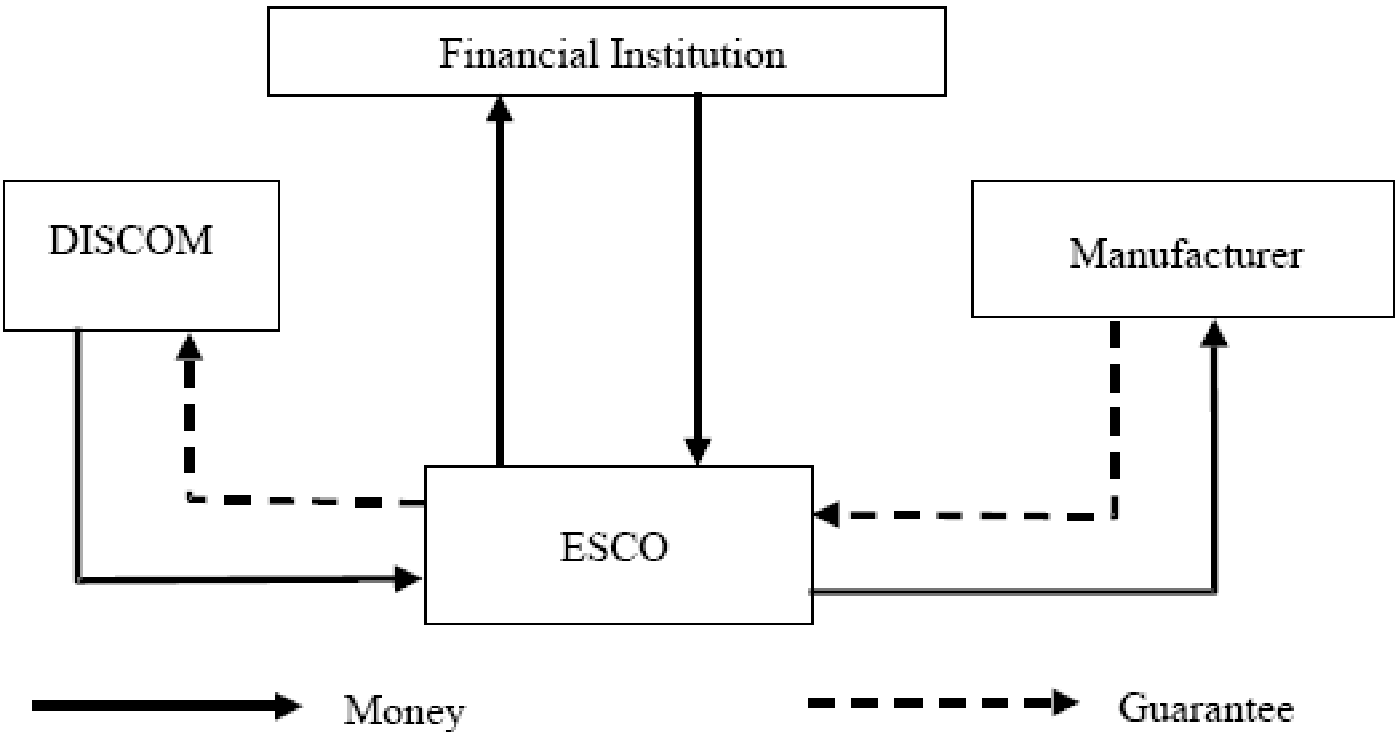

Figure 1.7: Basic ESCO model

ESCOs are usually differentiated on the basis of performance contracts from other firms that offer energy efficiency improvement or energy services, such as consulting firms and equipment contractors. Performance contract is directly linked to the amount of energy saved. In general, energy service includes energy audits, energy management, energy or equipment supply, and other services such as steam supply etc. ESCOs offer similar services as Energy Service Providing Companies (ESPCs). However, in contrast to them, they guarantee the savings and their remuneration is linked to the projects' performance. ESCOs may also provide or arrange financing. Different type of ESCO business models prevalent in the market are:

- **Full-Service ESCO:** The ESCO designs, finances and implements the project, verifies energy savings and shares an agreed percentage of the actual energy savings over a fixed period with the customer. However, the magnitudes of this saving is not guaranteed. This is also referred to as the **'Shared Savings'** approach. The ESCO takes on the risk of third party financing from a lender, putting the loan on its balance sheet.

  In this scenario, the ESCO is still carrying the cost of the project but without the additional cost of the guarantee. In financing EE projects, the cost of the capital for the ESCO is higher than the cost of capital to the Utility. Therefore the client (utility) is not carrying any risk, but then it is also not assured of any savings, although in practice such an outcome is unlikely. The likely outcome from a shared savings performance contract, should circumstances allow for this type of contract, is that the utility may accrue significantly greater financial rewards from the project than if a guaranteed savings contract had been used.

  If the energy end-user is sufficiently creditworthy, then guaranteed savings contracts can be used to repay financing, whereby the payments made to the ESCO are based on the measured energy savings. If limited recourse financing to the end-user is sought, shared savings or paid-from-savings contracts are used, with limited liability for the energy end-user. Utilities can also contract with ESCOs to deliver energy savings under their DSM programs. In this case, the ESCO undertakes projects at end-user facilities with financing from the utility. The ESCO is paid under a guaranteed savings arrangement.

- **End-Use Outsourcing:** The ESCO takes over operation and maintenance of the equipment and sells the output (e.g., steam, heating/cooling, lighting) to the customer at an agreed price. Costs for all equipment upgrades, repairs, etc. are borne by the ESCO, but ownership typically remains with the customer. This model is also sometimes referred to as Contract Energy Management.

- **ESCO with Third Party Financing:** The ESCO designs and implements the project but does not finance it, although it may arrange for or facilitate financing. The ESCO guarantees that the energy savings will be sufficient to cover debt service payments. This is also referred to as the **'Guaranteed Savings'** approach. The basic features of this approach are:

  (a) The utility takes on the third party financing from a lender, putting the loan on its balance sheet.

  (b) The ESCO guarantees that savings will be sufficient to cover the investment cost, and if they are not the ESCO pays the difference between the realized savings and project payments.

  (c) Excess savings can be shared between the utility and ESCO.

  In this scenario the utility takes on no risk even though they finance the project because the guarantee covers the financing cost, a known and quantifiable amount. However, guarantees add more risk onto the ESCO and more risk always trickles through as added cost to the project in the form of a higher percentage of the savings being taken by the ESCO. When a contract includes some form of guarantee, a contractor normally takes out insurance against that guarantee. Such insurance is generally expensive since insurance companies cannot adequately quantify these types of risks unless the contract is for a simple type of project with a long track record, like changing light bulbs, where there are few unknowns in the equation. The cost of the insurance policy is added, with associated mark-ups, to the cost of the contract. In summary, guarantees made by the ESCO may cause them to negotiate a higher, often significantly higher, percentage of the savings to ensure an adequate profit margin to cover all the risk they assume.

- **ESCO Variable Term Contract:** This is similar to the full-service ESCO, except that the contract term can vary based on actual savings. If actual savings are less than expected, the contract can be extended to allow the ESCO to recover its agreed payment. A variation is the 'First Out' model, where the ESCO takes all the energy savings benefits until it has received its agreed payment.
- **Equipment Supplier Credit:** The equipment supplier designs and commissions the project, verifying that the performance/energy savings matches expectations. Payment can either be made on a lump-sum basis after commissioning or over time (typically from the estimated energy savings). Ownership of the equipment is transferred to the customer immediately.
- **Technical Consultant (with performance-based payments):** The ESCO conducts an audit and assists with project implementation. The ESCO and customer agree on a performance based fee, which can include penalties for lower energy savings and bonuses for higher savings.

The benefits to the customers from ESCO model are:

- Technical and financial risks are shifted from customer to the ESCO.
- The payment to the ESCO are contingent, to varying degrees, upon the level of energy savings achieved.
- The customer may not be required to make an up-front capital investment (if the contract is structured as an operating lease or if the ESCO provides direct financing).
- If the utility required to borrow funds, the loans agreement can be structured such that the guaranteed savings stream will exceed the loan repayment obligations, producing a positive cash flow and resulting in immediate and real benefits from the project.
- Outcomes are guaranteed by ESCO.

1.7.5 Cost benefit and cost effectiveness analysis of a DSM project

An essential step of DSM planning process is the financial/economic evaluation/screening of DSM measures to select the most appropriate one. The basic purpose of conducting a financial or economic analysis of DSM programs is to be able to choose the most efficient and viable option after these programs have been screened on the basis of their technical potential and viability. Apart from being laid down as a step in the process of DSM planning, there are several logical reasons for conducting financial or economic analyses of the various DSM measures available.

The most important reason is that DSM programs do not just affect a single individual or a single section of the society, but the society at large. All sections of the society, be it consumers, electricity generators, or utilities, are affected in some or the other manner by DSM programs. Hence we need a comprehensive tool for the analysis of the costs and benefits to the society as a whole, which can facilitate the decision making process.

Furthermore, the implementation of DSM programs requires huge investments of resources of all kinds. Most of these resources have alternative uses, which implies that opportunity costs of DSM programs are really high. These combined with the actual investments amount to huge costs to be incurred on implementation of DSM programs. Hence we need to analyze each and every cost in detail along with the benefits so that we can check whether these high costs are justified by the benefits so generated i.e. whether the program is viable or not.

Another reason for using formal tools for such analyses is that often the costs and benefits associated with such programs are implicit or hidden (like the effects on environment). If these are ignored, we may not get the true picture of viability of programs. Hence, we need tools which facilitate the incorporation of such costs and benefits.

The two most common tools available for such decision making exercises are Cost Effectiveness Analysis (CEA) and Cost Benefit Analysis (CEA). CEA can be defined as an analysis of two or more alternatives in order to identify the alternative with the highest output to input ratio; that is, to achieve the maximum output or the result with the minimum input or costs. It is a comparative analysis of the costs and effectiveness of alternative interventions or services. The basic CEA uses standard techniques and methods associated with evaluating the effectiveness of any service, but it also adds the costs associated with the provision of these services into the mix. Thus, CEA is a technique used to choose the most efficient method for achieving a program or policy goal. The costs of alternatives are measured by their requisite estimated expenditures.

On the other hand, CBA can be defined as the use of economic analysis to quantify the gains and losses from a policy or program as well as their distribution across different groups in a society to ascertain the viability/feasibility of the program and to facilitate its comparison with other alternatives available. It is more of an economic analysis, but its procedure has its root from a financial process often referred to as 'capital budgeting'. It is an analysis technique employed to evaluate expenditure/investment decisions which involve current outlays and are likely to generate benefits over a period of time longer than a year. CBA is carried out by using different tools discussed in subsection 1.7.2 in page 79. However, it is to be noted that, decisions whether a particular DSM measure should be adopted or not should not merely be based upon comparisons of costs and benefits, but also on an analysis of to whom and in what manner these impacts occur. Therefore, different categories of perspectives need to be looked at depending upon the group of people/stakeholders affected as result of the DSM measure adopted as discussed below:

- *Consumer Perspective:* This looks at the interests of the consumers who are absent in any utility demand side management program/measure.
- *Program participant perspective:* This looks at the interests of the consumers who participate in a DSM program.
- *Utility perspective:* This looks at the interests of the utility owners.
- *Non participant perspective:* This takes into account the interests of the rate payers who do not participate in the program. This perspective is also referred to as "impact on rate level".
- *Average rate-payer perspective:* This is the perspective of the electricity rate payers taken as a whole (participants and non participants)
- *Societal perspective:* This looks at the interests of society at large.

The need for breaking up the analysis into several perspectives is that costs and benefits do not accrue to all stakeholders equally. Hence, no single perspective can capture the economic benefits to each subgroup in the society. Based on these different perspectives, different cost benefit tests have been proposed as means of choosing the best (most efficient) DSM measure. These are discussed below.

- *Participant test:* This test measures the costs and benefits of DSM for a participant consumer and evaluates and compares projects on the basis of the present value of the net benefits so derived (NPV Method). The intent of the test is to determine whether the participating customer is better off by participating in the program and to a lesser degree, by how much. The costs include the monetary value of increased power consumption (if it occurs), direct cost to participants to participate in DSM program and amounts claimed by the electricity company from the participants. The benefits include monetary value of reduced consumption of power (calculated by multiplying units saved by per unit tariff), avoided costs of equipment and maintenance, monetary incentives provided by the electricity company to participate in the program and tax benefits, if any.
- *Total resources cost test:* This test measures the total net benefit/costs in terms of the resources required for a DSM program and the point of view of both the utility and the consumers. The costs and the benefits are similar to those under the participant test except that the costs now also include the program implementation cost of the utility. This test

does not take into account the financial transfers between the electricity company and its consumers.

- *Rate impact test:* This test measures what happens to customer bills or rates due to changes in utility revenues and operating costs caused by the program, i.e. it measures the impact DSM programs will have on the utility and hence indicates the possible impact on rates. If the implementation of a DSM program leads to losses to the utility then they will be compensated by increasing the electricity rates. The benefits considered under this test include monetary values of reduced power consumption, increased metered power sales and costs charged to participant. Costs on the other hand comprise of the monetary values of increased power production, if applicable, reduced sales to consumers, financial incentives provided by the utility to its consumers and utility's program implementation costs.

- *Utility test:* This test evaluates DSM from the utility perspective. It measures the impact on utility revenue requirements. The benefits taken into account for this test include monetary values of reduced power production (avoided resource supply and demand costs) and costs charged to participants by electricity company. The costs include monetary values of increased power production, if any; financial incentives paid to participants and the utility's implementation costs.

- *Societal test:* This test is based upon the societal perspective. It measures the net benefits of a DSM program to the society at large and incorporates external factors also in its calculation. It therefore, presents a good picture of how important implementing DSM programs are for the society as a whole. The benefits taken into account include monetary values of reduced power production, participants' avoided costs and external benefits (positive externalities, as they may well be called). Similarly, costs include monetary values of increased power production, costs to participants, utility's implementation costs and external costs (negative externalities). However, it should be kept in mind that external costs and benefits are difficult to quantify and hence one has to be very careful in determining the appropriate values of these costs and benefits to arrive at accurate results for DSM program selection.

Other than the tests mentioned above, there are a couple of other tests that are directly based on outcomes of the DSM program, i.e. they are directly based on the energy that is saved from the DSM programs. The purpose of these tests is to evaluate programs on the basis of the cost of energy saved per unit as a result of the DSM program. These tests are the following:

- *Cost of demand reduction (utility):* To arrive at the cost, the following procedure is followed. The program cost in each year is discounted at the utility discount rate and summed up to obtain the total program cost. The demand savings in the terminal year of the program period are computed based on the number of net adoptions. The effect of transmission and distribution losses is considered to arrive at actual savings in the system demand. The program cost is divided by the system demand reduction to obtain the cost of saved demand (utility).

- *Cost of demand reduction (total resource):* This refers to all the costs incurred by consumers, utility and other program costs. In this case the gross participants are considered. To this, the program fixed cost is added . These yearly costs are then discounted at utility discount rare. The total cost of DSM program is divided by the demand savings to obtain the cost of saved demand (total resource). As in the above mentioned case, the program which generates a lower cost is considered to be superior.

- *Cost of saved energy (CSE):* The cost of saved energy is the levelised average cost of the DSM option per kWh saved. This is computed as follows:

$$CSE = \frac{\text{DSM option cost} \times \text{capital recovery factor}}{\text{Annual energy savings (KWH)}}$$

  If the annual maintenance cost is involved, it is added in the numerator to the annualized DSM program cost. In the above expression, the Capital Recovery Factor (CRF) is a factor which converts a present value into a stream of equal annual payments over a specified time, at a specified discount rate (interest).

With the help of these tests planners can choose the most cost efficient DSM measure to be adopted.

1.8 Best Practices in Communications and outreach and Relationship Building with Customers

For successful DSM implementation, active involvement of the customers is very necessary. For that purpose, the utilities should communicate the benefits of DSM measures to the customers effectively. This can be achieved by several ways.

1. ***Media:*** Media plays a vital role in customer education or awareness programs. There are different types of media, which can be used:

   - Newspaper
   - Radio
   - Television
   - Mobile phone

   Any of these means for communicating to the customers could be adopted. However, the message must suit to the type of media being used. The message should consider the social and economic class of the customer. The message could be from a celebrity, such as, film star, sportsman, politician, or any well known local person. In newspapers, paid advertisements (ads) can be given for propagating the benefits of DSM programs. However, The paid ads are very costly and so a judicious campaigning plan must be designed and implemented. It may be worthwhile to conduct feedback survey of the impact of the ads.

2. ***Communication through bills:*** The customers regularly receive the bills. These bills could be a good means of communicating benefits of the DSM. A properly designed campaign plan through the bills could very effectively convince the benefits of and need for DSM.

3. ***Communicating at billing collection centers:*** The customers regularly visit the billing collection centers (BCCs). The DISCOMs can put up pamphlets at the BCCs to advocate the benefits of DSM. In fact, these places can give live demonstrations of various electricity efficient products with a facility to measure the kwh consumption of different products. For example, live comparison of incandescent lamp, fluoroscent lamp, CFL. This would help the customer to have a first hand feel of efficient appliances. The set up must have volunteer(s) to attend to any query raised by the customer.

4. ***Communicating and Advertising at local events:*** The electricity service customers regularly visit the local events and place of amusements/ temples, etc. The places frequently visited or a place where a large gathering is expected may be utilized for DSM campaign. However, it must be ensured that the volunteers must be fully trained to address any query of the electricity customers. In fact, such occasions can also be utilized to resolve any billing and easily redressable complaint of the customers. These are the ways for developing a good relationship wherein the customer starts building a total trust in the DISCOM.

5. ***Buy-in of community or local leaders:*** DISCOMs can identify and target the community and local leaders for converting them DSM savvy. This would help the DISCOMs to take advantage of "follow the leader" principle. Human tendency is to follow or copy a leader or neighbor. In this regard, NGOs can also play a very vital role for educating the customers.

6. ***Target early adopters:*** The DISCOMs must identify individuals, institutions, and other organizations who want to be the leaders in the community/society. The DISCOM representative must visit such individuals and institutions and convince them about the DSM. Once they adopt the DSM, they would become the champions for your cause. DISCOMs may identify the champions from the following:

   - Government institutions
   - Educational Institutions (schools, colleges, and universities)
   - Housing builders

- Housing societies
- Industrial organizations
- Commercial organizations
- Nonprofit organizations

The DISCOMs must identify the champions and target their efforts to buy-in them for DSM. Once they have adopted, they will be champions for the DSM cause.

7. ***Pilot programs:*** These can be quite useful in making people aware of the DSM concept as a valuable and stable electricity resource for the future power demands of a region or a country.

1.9 DSM implementation issues

1.9.1 Role of distribution companies

The various roles, which a distribution utility can play for successful implementation of a DSM program are as follows:

- Assessment of technical potential
- Load research
- Market research
- Assessment of economic potential
- Preparation and design of DSM plan
- Preparation and design of DSM projects
- Project implementation
- Monitoring and reporting

All the above points have been discussed in subsection 1.2.5 in page 25.

1.9.2 Franchisee

The role of Franchise is a well-established concept in the corporate sectors. Under this concept, the owners (called the franchisers) sell the rights to their business logo and model to third parties (called franchisees). To invest in a franchise, the franchisee must first pay an initial fee for the rights to the business, training, and the equipment required by that particular franchise. Thereafter, the Franchisee offers products/services as per the prices decided by the Franchisor while maintaining the quality standards of the services (or products) of the Franchisor. In return, the franchisee will pay the franchise business owner an ongoing royalty payment (usually calculated as a percentage of the franchise operation's gross sales), either on a monthly or quarterly basis. Although the franchisee will not have as much control over the business as he or she would over their own, but may benefit from investing in an already-established brand.

The above concept is nowadys an accepted practice in power distribution business. The definiton of 'Franchise' in the context of power distribution business is as follows under Electricity Act (2203):

"Franchisee means a person authorised by a distribution Licensee to distribute electricity on its behalf in a particular area within his area of supply".

Therefore, in this scheme, Distribution Licensee and Franchisee would enter into a Franchisee arrangement under which the Franchisee will manage the electricity distribution function in the designated area within the licensed (Franchise) area of the distribution licensee. The main features of this agreement are:

- The Distribution Licensee will supply electricity to the Franchisee at a price specified in the agreement.
- The Franchisee will supply electricity to the consumers within the licensed area at a tariff (including reliability surcharges) set by the regulatory commission.
- The Franchisee will be required to improve the reliability of the system (fewer outages), improve the quality of power (reduced voltage & frequency fluctuations) and bring down the loss in the Franchise area.
- The Franchisee will manage the electricity distribution system of the Licensee in the allocated (licensed) area. They will undertake maintenance, upgradation and strengthening of the licensed area following the requirements of the Licensee.
- The Franchisee will handle all commercial activities relating to issue of new service connections, metering, meter reading, billing, collection, realizing bad debts, disconnection, reconnections, customer complaint handling etc. within the Franchise Area.
- All manpower to run the operations and commercial activities will be provided, managed and paid for by the Franchisee without any recourse to employment by the Distribution Licensee.
- The Franchisee will retain a portion of the revenue collection from consumers after deducting the amount payable/paid to the Distribution Licensee.

Presently, apart from the above well estblished roles, the Franchises are also required to undertake DSM activities within the licensed area. Towards this goal, the Franchisee will establish a DSM cell within its organisational set up and will take up the load research activity. Subsequently, Depending upon the major findings of the load research, the Franchisee will design DSM programme covering appropriate conservation and efficiency improvement measures for different categories of consumers. As an example, in recent times, Spanco Ltd. has enetered into an Distribution Frabchise agreement with Maharashtra State Electricity Distribution Co. Ltd (MSEDCL) for supplying power in Nagpur. In this agreement, among other committments, Spanco Ltd. will also be required to undertake the DSM measures in the licensed area[35].

1.9.3 Contractual issues and procedures

There are basically two types of performance contract procedures for DSM financing: a) shared savings and b) guaranteed savings. These two procedures are discussed in item no. 5 in page 90.

1.9.4 Linkages between equipment/appliances manufacturers and suppliers and energy service providers

For successful implementation of DSM, availability of appropriate equipments/appliances is a must. Therefore, the energy service providers (utilities) must maintain a close linkage with the manufacturers or suppliers of these equipments/appliances. In fact, only with consultation or meeting with the manufacturers/suppliers, an utility can decide on the feasibility of any particular equipment/appliance for achieving the DSM objectives. The details and the outcomes of these meetings are given in detail in point no. 6 in page 29.

1.10 DSM case studies

There are several induatries in India who have undertaken DSM measures for energy conservation. Some of these cases are described below.

1. **National Peroxide Limited, Kalyan (Maharashtra):** National Peroxide Limited (NPL)[36] is a pioneer and acknowledged market Leaders in the manufacture of Hydrogen Peroxide in India. The various DSM measures, among others, undertaken by the company is shown in Table 1.4 below.

   In Table 1.4 MLL stands for Mixed Light Lamp[37].

2. **LG Electronics India Pvt. Ltd., Greater Noida:** LG Electronics India Pvt. Ltd., a wholly owned subsidiary of LG Electronics, South Korea was established in January, 1997

[35] http://www.spancopower.com/services/power-distribution.aspx.
[36] http://www.naperol.com/.
[37] These are a combination of High Pressure Mercury Vapour & Incandescent Lamps. These offer better color rendition compared to HPMV Lamps & higher life compared to Incandescent Lamps. They offer instant ignition & available in 160W/250W ranges.

Table 1.4: Energy conservation measures undertaken by NPL

SL. No.	Energy conservation measures undertaken in the financial year 2009-10	Investment (Rs Lacs)	Annual Savings (Rs Lacs)
1	Replaced old P248 & Clarifier Water pumps with new Energy Efficient Pumps	1.5	2.16
2	Replaced 160 Watts MLL Lamp with 23 Watts CFL Lamps for plant lighting (150 Nos)	0.6	4.12
3	Installation of 200 KVAR 6.6 KV H.T Capacitor Banks on 2 MVA Transformer	9.1	0.74
4	Reducing transformer secondary voltage in the range of 2.5 to 3.0% & optimizing consumption	Nil	22.44
5	Installation of VFD units for 10 Ton boiler blower motor for energy efficient operations	1.5	0.85
	Total	12.7	30.75

after clearance from the Foreign Investment Promotion Board (FIPB). The various DSM measures, among others, undertaken by the company is shown in Table 1.5 below.

Table 1.5: Energy conservation measures undertaken by LG Electronics

SL. No.	Energy conservation measures undertaken in the financial year 2009-10	Investment (Rs Lacs)	Annual Savings (Rs Lacs)
1	Installation of Centralize Air Conditioner	100.0	14.57
2	Energy Efficient Lights installation	25.0	15.0
3	Energy Efficient Air conditioning for canteen	20.0	9.34
4	Power factor Improvement	3.0	31.8
5	Burner's Efficiency improvement	1.0	18.72
	Total	149.0	89.43

3. **IPCA Laboratories Ltd., Madhya Pradesh:** IPCA Laboratories Limited[38], is a leading pharmaceutical company of India having manufacturing locations at various places in India. It is engaged in the production of bulk drugs and formulations. The various DSM measures, among others, undertaken by the company is shown in Table 1.6 below.

4. **RUCHI Soya Industried Limited, Mangalore (Karnataka):** Ruchi Group of Industries is a well-known industrial group with its various manufacturing units located all over

[38]http://www.ipcalabs.com/.

Table 1.6: Energy conservation measures undertaken by IPCA

SL. No.	Energy conservation measures undertaken in the financial year 2009-10	Investment (Rs Lacs)	Annual Savings (Rs Lacs)
1	Replacement of "V" Belt with Flat Belt	4.8	0.8
2	Replacement of old inefficient motor with energy efficient motor	1.08	0.9
3	Installation of VFD	4.62	2.79
4	Replacement of old conventional gearbox with planetary gearbox	3.45	2.7
	Total	13.95	7.19

India. The various DSM measures, among others, undertaken by the company is shown in Table 1.7 below.

Table 1.7: Energy conservation measures undertaken by RUCHI Soya Ltd.

SL. No.	Energy conservation measures undertaken in the financial year 2009-10	Investment (Rs Lacs)	Annual Savings (Rs Lacs)
1	Replacement of Motors	1.68	3.96
2	Electrical saving through replacement of Motors in crystallizers	1.65	9.06
3	Replaced chilled water pumps motors	1.28	6.92
4	Replacement of boiler feed water pump	3.4	3.56
5	Installation of VFD in the air compressor	0.75	5.53
6	Installation of transparent sheet in packing section & ware house	6.06	3.52
7	Replacement of motor in ammonia compressor	1.9	5.93
8	Replacement of cooling tower blades	0.8	1.15
9	Utilization of heat of steam condensate for heating of oil cake in filter plant	1.51	4.72
10	Insulation of fatty acid storage tank	2.09	4.7
	Total	21.12	49.05

5. **Mindarika Pvt. Limited, Village Nawada, Fatehpur, Distt. Gurgaon (Haryana):** Mindarika Pvt. Ltd.[39] is indo-Japanese joint venture Company with Tokarika, Japan. It is a unit of Minda industries group. Mindarika product are used by most of the original equipment manufacturers for 4 wheelers in India like Maruti, Toyota (TKML) Honda (HSIL), Tata Motors, General Motors (GMIL), Ford India Ltd. M & M, Eicher Motors etc. The various DSM measures, among others, undertaken by the company is shown in Table 1.8 below.

[39] http://www.mindagroup.com/mindarika.html

Table 1.8: Energy conservation measures undertaken by Mindarika Ltd.

SL. No.	Energy conservation measures undertaken in the financial year 2009-10	Investment (Rs Lacs)	Annual Savings (Rs Lacs)
1	Replacement of 11 watt CFL by 5 watt CFL	0.05	0.31
2	Use of 18 watt tube light in place of 40 watt tube light on M/C‘S & office area	0.01	0.12
3	Instalation of soft starter in press M/C	0.06	0.28
4	Instalation of soft starter in molding M/C	0.35	1.62
5	Use of new electric based injection moulding machine in place of hydraulic machine	40.08	18.37
	Total	40.55	20.7

6. **Rashtriya Chemicals And Fertilizers LTD. Trombay unit, Mumbai:** Rashtriya Chemicals and Fertilizers Limited, Trombay, a Govt. of India Undertaking, is one of the largest integrated Fertilizer and Industrial chemicals complexes in the country. The various DSM measures, among others, undertaken by the company is shown in Table 1.9 below.

Table 1.9: Energy conservation measures undertaken by Rashtriya Chemical

SL. No.	Energy conservation measures undertaken in the financial year 2009-10	Investment (Rs Lacs)	Annual Savings (Rs Lacs)
1	Provision of capacitor banks on 11 KV system	35	90.01
2	Replacement of conventional 125 Watt HMPV light fittings with 70 Watt Metal halide light fittings	4.5	2.51
3	Replacement of 240 Nos of old A/Cs by new energy efficient A/cs	27.1	9.52
4	Installation of Capacitor Banks in Sulphuric Acid Plant	7	6.29
5	Provision of VFD for 2 No. of aerator motors in sewage treatment	4.35	6.24
6	Solar water heater for providing 6000 liter per day of hot water	9.88	6.83
	Total	87.83	121.4

7. **Manganese ore (India) Limited, Nagpur, Maharashtra:** Manganese ore (India) Limited (MOIL) is the largest Manganese ore producing company of India. MOIL is the first Public sector company to install wind farm of 4.8 MW and 15.2 MW for clean & green energy as well as for energy conservation. The various DSM measures, among others, undertaken by the company is shown in Table 1.10 below.

8. **BSNL, Telecom Bhavan, Thiruvananthapuram (Kerala):** BSNL is one of the largest Public Sector undertakings, fully owned by Central Government, engaged in providing World

Table 1.10: Energy conservation measures undertaken by MOIL

SL. No.	Energy conservation measures undertaken in the financial year 2009-10	Investment (Rs Lacs)	Annual Savings (Rs Lacs)
1	Installation of 212 HP screw air compressor with VFD panel in replcement of conventional reciporocating compressor with star delta starter	19	1.04
2	Installation of auxiliary fans for ventilationin in place of compressed air	3	2.225
3	Improvement in PF by using LT power capacitor	2	3.151
	Total	24	6.416

class telecommunication services. The various DSM measures, among others, undertaken by the company is shown in Table 1.11 below.

Table 1.11: Energy conservation measures undertaken by BSNL

SL. No.	Energy conservation measures undertaken in the financial year 2009-10	Investment (Rs Lacs)	Annual Savings (Rs Lacs)
1	Replacement of filament type indication lamps in Electrical control Panels by LED type indication panels	0.07	0.22
2	Replacement of 2x40 W Fluorescent fittings with 2x11 W CFL Fittings	0.25	0.34
3	Replacement of 2x40 W Fluorescent fittings with energy efficient 2x28 W T5 Fittings	0.24	0.06
4	Replacement of resistance type regulators of ceiling fans with energy efficient electronic regulators	0.02	0.03
5	Replacement of CRT Monitors of PCs with LCD Monitors	0.67	0.34
	Total	1.25	0.99

9. **Reliance energy limited (REL), Mumbai:** The various DSM measures undertaken by REL in its distribution system in Mumbai are as follows:

    - *CFL scheme:* The objective of the scheme was demand and energy saving during peak hours. Under the scheme, energy saving CFL worth Rs. 165 was provided at Rs. 63 with monthly instalment of Rs. 7 for 9 months. The scheme was implemented in two phases – pilot scheme and main scheme. 2.05 Lakh consumers participated in the programme and 6.17 Lakh CFLs were distributed. This resulted in energy saving of 16.85 MU per annum and demand saving during peak time of 10.79 MW.

- *Project on street lights:* Under this project, replacement of High Pressure Mercury Vapour (HPMV) with Medium Pressure Sodium Vapour (MPSV) was carried out. Estimated savings in Energy terms is 4.56 million kWh per year and in demand terms it is 1.1 MW.

10. **Department of Renewable Energy, Haryana (HAREDA):** In July 2003, the Government of Haryana designated the Department of Renewable Energy, Haryana as the Designated Agency to co-ordinate, regulate and enforce the provision of the EC Act in the State. The various DSM measures undertaken by HAREDA are as follows:

    - CFLs and T-5 tube lights in Govt. buildings have been made mandatory and use of conventional bulbs have been banned in govt. buildings. In the existing state government buildings, T5 fixtures and CFLs have been placed through government provided fund. So far 1,12,500 CFLs & 1,14,497 T-5 Tube lights have been replaced with an investment of Rs 5.03 crores resulting in annual saving of Rs 9.44crores in the electricity bills translating into an equivalent annual saving of 3.75 MW.
    - 702 villages made CFL villages with installation of 6,71,166 CFLs by power utilities and HAREDA.
    - Haryana is the first state in the country to implement EE street lighting in Hisar & HUDA Sectors, Panchkula through ESCO mode.
    - With effect from 15th August, 2008, use of CFLs and/or T-5 (28 watt) tube lights and/or Light Emitting Diode (LED) lamps has been made mandatory for all electricity consumers in industrial, commercial and institutional sectors having connected load of 30 kW or above.
    - To promote Solar Water Heating System (SWHS), rebate up to Rs.300/- per month for three years in electricity bills for domestic users has been implemented.
    - During 2008-09, SWHS of more than 2,00,000 litres capacity was installed resulting in a peak load shaving of 2 MW.
    - All Govt. Departments / Boards / Corporations have been instructed to purchase only star labelled products.
    - Use of ISI marked pump sets and accessories for new tube-well connections made mandatory.
    - Scheme on providing financial incentives on the purchase of ISI marked pump-sets @ Rs. 400/- per HP of pump with maximum ceiling of Rs. 5000/- per farmer has been introduced. Up to 2007-08, Rs.1.05 crore has been spent on upgrading 3308 pumps.
    - Awareness campaign has been launched through radio jingles, interactive radio programmes, T.V films, seminars and workshops, school education Programmes & Press advertisements.

Around the world also, many countries are paying quite serious attention to energy conservation measures. Some of these exxamples are described below. (http://en.wikipedia.org/wiki/Energy conservation)

1. **Japan**

   The Energy Conservation Center, Japan (ECCJ) promotes energy efficiency in every aspect of Japan. Public entities are implementing the efficient use of energy for industries and research. Within ECCJ, Asia Energy Efficiency and Conservation Collaboration Center (AEEC)[40] was established in April 2007 aiming for promotion of energy efficiency and conservation in Asian countries through international cooperation.

2. **Lebanon**

   In Lebanon, the Lebanese Center for Energy Conservation (LCEC)[41] has been promoting the development of efficient and rational uses of energy and the use of renewable energy at the consumer level since 2002. It was created as a project financed by the Global Environment Facility (GEF) and the Ministry of Energy & Water (MEW) under the management of the United Nations Development Programme (UNDP) and gradually established itself as an independent technical national center although it continues to be supported by the United Nations Development Programme (UNDP) as indicated in the Memorandum of Understanding (MoU) signed between MEW and UNDP on June 18, 2007.

3. **New Zealand**

   In New Zealand the Energy Efficiency and Conservation Authority (EECA)[42] is responsible for promoting energy efficiency and conservation. EECA was set up by the New Zealand Government in 1992 to encourage, support and promote energy efficiency, energy conservation, and the use of renewable sources of energy. In 2000 EECA became a Crown Entity, established under the Energy Efficiency and Conservation Act 2000. It is subject to the Crown Entities Act 2004. The passing of the Energy Efficiency and Conservation Act meant that for the first time, New Zealand had a legislative basis for promoting energy efficiency, energy conservation, and renewable energy.

4. **United Kingdom**

   In United Kingdom, responsibility for energy conservation fall between three Government departments although is led by the Department for Energy and Climate Change (DECC). The Department for Communities and Local Government (CLG) is still responsible for energy standards in buildings, and the Department for Environment, Food and Rural Affairs (Defra) retains a residual interest in energy insofar as it leads to emissions of CO2, the main

[40] http://www.asiaeec-col.eccj.or.jp/index.html
[41] http://en.wikipedia.org/wiki/The Lebanese Center for Energy Conservation
[42] http://en.wikipedia.org/wiki/Energy Efficiency and Conservation Authority

greenhouse gas. The Department for Transport retains many responsibilities for energy conservation in transport. At an operational level, there are two main non-departmental governmental bodies - the Energy Saving Trust, working mainly in the domestic sector with some interest in transport, and the Carbon Trust, working with industry and innovative energy technologies. In addition there are many independent NGOs working in the sector such as the Centre for Sustainable Energy in Bristol or the National Energy Foundation in Milton Keynes, and directly helping consumers make informed choices on energy efficiency.

5. **Iran**

   In Iran, energy efficiency initiatives are supervised by Iran Energy Efficiency organization (IEEO) (SABA)[43], which began its functions from March 1996.

6. **Australia**

   In Australia, several measures for demand side management are being undertaken for enhancing energy efficiency in the country[44].

7. **Sri Lanka**

   The Sri Lanka Sustainable Energy Authority (SLSEA)[45] was established on 01 October 2007, enacting the Sri Lanka Sustainable Energy Authority Act No. 35 of 2007 of the Parliament of the Democratic Socialist Republic of Sri Lanka. The SLSEA was established to realise the necessity of having an apex institution to drive Sri Lanka towards a new level of sustainability in energy generation and usage, through increasing indigenous energy and improving energy efficiency within the country.

8. **Canada**

   Canada, through its office of energy efficiency[46], active promotes adoption of DSM measures in the country. Recently, it has sanctioned 117 million dollars over a period of three years for encouraging wider adoption of DSM measures.

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