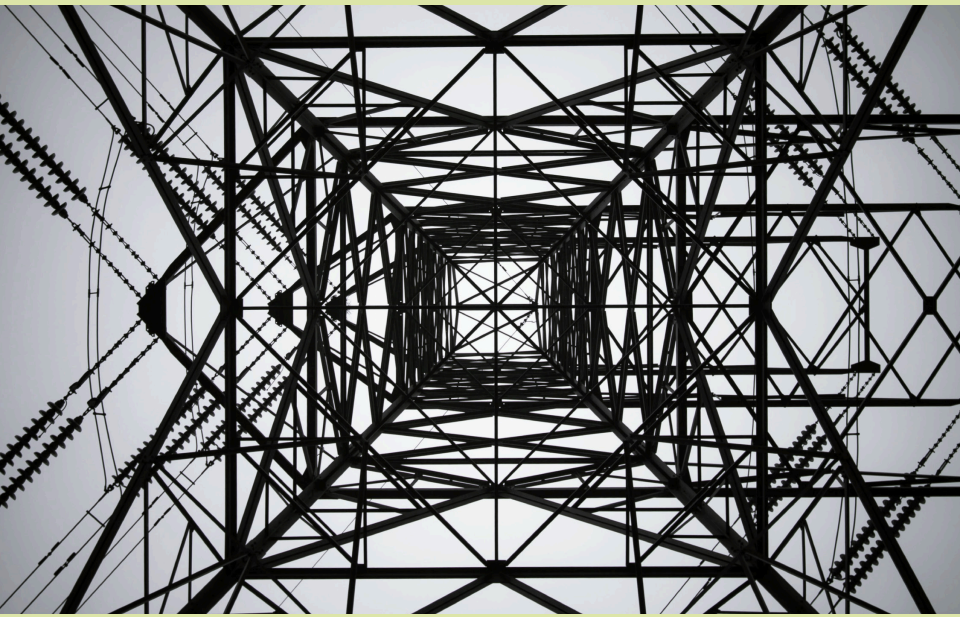
THE ECONOLER SERIES

DEMAND-SIDE MANAGEMENT

for Utilities in Emerging Economies



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Demand-Side Management

Introduction

After the first oil crisis of 1973, governments and electricity utilities realized the urgency of incorporating mechanisms that would enable them to reduce their dependence on external sources into their strategic vision in an increasingly competitive and unstable market. It is against such a backdrop that a new management approach of energy resources was developed, initially in North America, where experts felt that electricity-generating companies were in a strategically advantageous position to actively influence the issue of electricity demand. Born in the eighties, this concept is known as Demand-Side Management (DSM). It was developed based on a better understanding of elements that determine energy demand, their impact on equipment costs, as well as on the operation of electricity production systems.

DSM has often been considered one of the strategies capable of offering a complementary mode of action to electricity-generating companies[1] enabling them to effectively manage increasing demands for electricity. This strategy is aimed at introducing the following changes in four key elements:

a) Modify the load curve profile;

b) Reduce the network's technical and non-technical losses;

1. Governments can also undertake DSM activities; for instance by launching information and awareness programmes intended for energy users. Other steps such as the implementation of energy standards and building codes can also be directly introduced by the government. To alleviate the text in this document, we are systematically using the terms "electricity company" or "utility" to designate the organisations responsible for planning and implementing the programmes.

c) Influence and change the equipment-buying habits of customers so that they prefer to adopt efficient technologies;

d) Change consumer energy-using habits and behaviors.

Econoler has in-depth knowledge about DSM.This booklet introduces the concept and certain recommendations to be followed to put it into action.

Concept

DSM can be defined as the selection, planning and implementation of measures intended to have an influence on consumers to obtain desired changes in the load curve.[2] It is therefore easy to understand that the concept initially addresses electricity companies since they are directly affected.

The activities undertaken by a utility in the context of a DSM programme include:

- Load management;
- Establishing new applications and uses;
- The strategic conservation of energy;
- Increasing clientele;
- Positioning itself on the energy supply market.

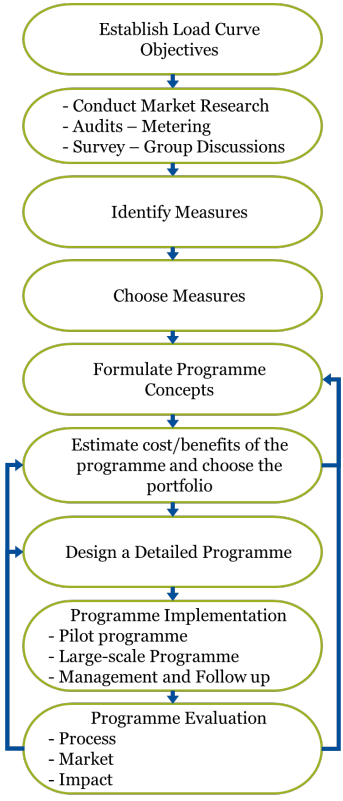
DSM only includes activities that require the deliberate intervention of electricity companies on the market to modify the load curve.According to this definition, when a consumer buys a more efficient refrigerator in response to a need to save energy or on the basis of a return-on-investment period, this cannot be considered as an integral part of DSM since the utility had nothing to do with the customer's decision. On the other hand, when a structured programme is implemented involving promotional components, information services provided to the customers and even financial support to encourage the consumers to purchase such refrigerators, this is indeed part of a DSM strategy.

2. The term "load" in this document represents the consumer "demand".

The distinction between a consumer's spontaneous action and an electricity company's deliberate scheme designed to affect the load and customer consumption is often hard to differentiate, but it is important and useful in evaluating the impact of DSM programmes. In fact, the spontaneous actions of some customers during programme implementation should be taken into account and considered later on during the evaluation of the DSM programme's effects.

The programme development process requires several steps defined below and illustrated in Figure 2-1.

Figure 2-1: Demand-Side Management Planning Procedures



1. Programme Planning

Programme planning includes:

- *Establishing Load Curve Modification Objectives:*
  The first component in the planning process is to establish clear and measurable objectives for load curve modification. The desired type of load curve modification will determine the type of programme that will be retained. The objectives will enable utilities to incorporate the DSM measures into the specific electricity needs of the target users.
- *Market Research:*
  Once the objectives are clearly defined, the planner must examine the various components of the electricity network including such issues as production, transportation, distribution and the end-use of energy in order to recognize any problem faced at each step of the process and the reasons for the load curve's current performance. The planning process must also include an analysis of consumption and demand forecasts. These phenomena must be well understood since the objective of a DSM programme is often to curb increases in consumption and demand. Research on the evolution of the demand must be supported by surveys and analyses to clearly understand the specific needs of each market and the different ways energy is used. All this information will foster a clear understanding of the sectors that present potential for the implementation of DSM programmes.
- *Evaluation and Selection of Measures:*
  Based on market research findings, the planner can determine the best way to adapt supply and demand by combining production increases with DSM programmes. All this should be in harmony, according to load curve modulation objectives, which will help to adjust the production capacity to an optimal demand profile. After the preliminary analysis, the planner intuitively determines the measures that could eventually be incorporated into the DSM programmes.

2. Programme Design, Analysis and Selection

The next step includes verifying the DSM measures and technologies applicable to predefined end-uses. These programmes will then be the object of rigorous selection procedures to determine the programmes that are most likely to meet the set objectives. A cost-benefit analysis and other tests will help select the programmes that would be the most beneficial for the participant, the electricity company, and the population.

3. Programme Implementation

The selected programmes are then ready to be launched. A specific structure will have to be developed for the implementation of the programmes within the electricity company and this may require the hiring of external players. A specific marketing strategy must also be developed for each of the programmes that have been selected.

4. Programme Evaluation

The implementation process, market response as well as the real impact of the programme on relevant parameters must then be evaluated. This impact must be compared to the impact forecasts established at the design stage. Changes may be incorporated into current programmes if the results of the evaluation suggest so.

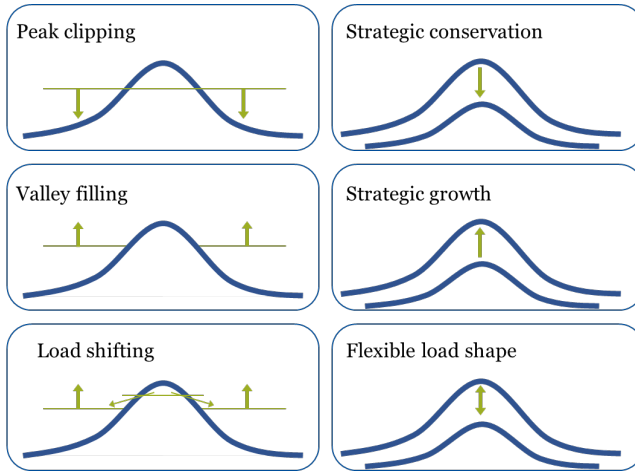
When a DSM programme is being planned by an electricity company, it is important that the target load curve objectives be established beforehand, which means that the utility should determine the effects that will be beneficial to the financial and operational status of the company. These load curve modification objectives include:

- Peak Clipping
- Valley filling
- Load shifting
- Strategic conservation

- Strategic growth
- Flexible load shape

These objectives are illustrated in Figure 2-2

Figure 2-2: Load Curve Modification Objectives



Peak clipping 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[3], but it also allows to reduce the operational costs of power stations and, to a certain extent,

3. Because it is difficult and expensive to store electricity, the creation of new power stations depends on the peak demand and consumption rate of electricity and not on the average yearly consumption rate.

the dependency on fossil fuels (such as natural gas, heating oil) for generating electricity.

Valley filling 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, is 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 of electricity 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. 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 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 in 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 and electrification in countries where hydroelectric resources are significant, or the energy matrix is clean.

Flexible load shape is a 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 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, as much as possible, in order to reduce operational costs and the costs of kWh production. In addition, valley filling has the advantage of increasing power sales, enabling the company 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 country- or utility-wise variations.

It is therefore apparent that DSM offers a wide variety of programmes either to increase or decrease the load and companies, whether they be public or private enterprises or rural cooperatives, can make use of them as per their specific needs.

DSM programmes can be classified under the following three categories:

1. *Energy conservation programmes* that promote the application of energy efficiency measures to, for example, equipment such as lighting, air conditioning and motors within different customer segments. These programmes are especially designed to reduce energy consumption and, indirectly, to reduce peak demand.
2. *Load management programmes* allow electricity companies to control, curtail or shift the load demand periodically on a daily or seasonal basis according to peak demand requirements or constraints. These programmes normally result in a decrease in peak demand and may or may not result in a decrease in energy consumption. In some cases the strategies and equipment used to control the peak load can lead to an increase in energy consumption.
3. *Increased Electricity Demand Programmes* may be used periodically on a daily or seasonal basis in order to fill the valleys when the network is fed by run-of-river power stations, for example. They are generally referred to as strategic power increase or surplus consumption measures.

Among these categories of programmes, several approaches can be recommended, for example:

1. *General information programmes*: To inform users about the generic options available for energy efficiency.
2. *Specific on-site information programmes*: To provide information on specific DSM measures that are appropriate for a particular company or residence.
3. *Financial assistance programmes*: To help the customers pay for the DSM measures. These programmes include low-interest loans, loan guarantees, discounts and shared-savings programmes.

4. *Direct installation programmes*: To provide comprehensive design, financial and installation services with respect to a series of energy efficiency measures.
5. *Alternative tariff programmes*: Include time-of-use tariffs, interruptible tariffs and load shifting tariffs. These programmes do not normally help to save energy but can be used as effective incentives to allow to shift some of the load to off-peak periods.
6. *Request for proposals programmes*: Programme through which an electricity company solicits proposals from customers and companies involved in the energy sector to promote energy savings in the region of the utility's operations.
7. *Market transformation programmes*: Their objective is to transform the market and promote a particular type of service or technology. These programmes encourage the widespread use of a given energy-efficient technology without the need for any continuous intervention by the electricity company.

Objectives and Importance of DSM

The objectives and importance of DSM may vary depending on the stakeholder, be it the electricity company, the government, or the population. The following paragraphs present the points of view that are generally shared by each of these stakeholders.

DSM in the Context of a Utility's Energy Planning Process

Technological, political, social and economic factors as well as the conditions pertaining to the production of electricity have brought about changes in the way power stations are operated and managed by electricity companies and in the way utilities envisage the future. Market deregulation and moves towards privatizing the energy markets have drastically changed these conditions.

Several electricity companies are facing several situations in terms of procuring sufficient funds to expand their power-generating facilities, dealing with fluctuating energy demands and dropping profit margins as well as regulated tariff structures (either high or low). In short, they are confronted with fierce competition when it comes to conquering and preserving their markets. Although DSM may not be the complete solution for all these difficulties, it provides the utility with innovative tools to overcome the odds in this changing environment.

For utilities that have to deal with an increasing demand for power, traditional load management methods (peak clipping, load shifting, valley filling) and energy conservation may help to delay the need for the construction of new facilities or the need for reducing their size. This aspect is particularly noteworthy in cases where facilities are intended to meet peak demand, since such investments are often not very cost effective because of the low utilization rate of installed equipment.

DSM should not only be considered as a component of an electricity company's energy planning process in the power sector. To optimize their activities in the sector, utilities must pay close attention to aspects related to production, transportation, and distribution, which involve the maintenance of production equipment as well as adapting transportation networks and distribution equipment. Although these elements are not directly linked to DSM, they play an important complementary role in achieving the objectives. It would indeed be incoherent to undertake DSM programmes without improving production, transportation, and distribution systems.

The major long-term objectives of a utility's DSM programme are to improve:

- Financial performance
- Customer relations

Some typical examples of the major objectives are: improving the gross margin of self-financing, increasing the profits and reducing the risk factors. Some electricity companies may face institutional constraints that may be a hindrance in achieving these objectives. These may include regulatory constraints, environmental concerns, and the utility's obligation to supply electricity to customers under acceptable (and often not very cost-effective) conditions and at a reasonable price. These constraints obviously vary according to the country and the nature of the electricity company, whether it is a public or private enterprise or a rural cooperative, etc. They may also depend upon the production, transportation, and distribution networks of the company as well as on the regulatory authorities.

In addition to these major long-term goals, complementary objectives are associated to the utility's global objectives:

The *operational objectives*, which are more explicit, guide the electricity company towards a definite action plan. Based on these objectives, DSM options are studied and evaluated. In cases where the utility is planning significant investments to meet an increased demand for power, a DSM option could be an opportunity to postpone these investments and reduce the financial needs in terms of fixed assets, on the medium- or short- term.

Operational objectives are established based on the particular features of the electricity company: its activities, financial reserves, its overall working environment and its competition.

These objectives are as follows:

- Improving the gross margin of self-financing
- Reducing dependence on fossil fuels
- Reducing or postponing the required investments for the construction of new power stations
- Maintaining power tariffs

- Increasing sales and revenues
- Providing the customer with the possibility of controlling, at least partially, the costs related to his electricity bill
- Satisfying regulatory constraints
- Increasing the operational flexibility of its system and its reliability
- Reducing the average production costs of kWh through the more effective management of power-generating stations
- Limiting the environmental impacts
- Striving to improve the image of the electricity company

For some electricity companies, the following objectives may be added:

- Restricting the problems related to voltage fluctuations and power outages
- Improving production facilities as well as transportation, and distribution infrastructures
- Reducing the number of unpaid bills

Load objectives are presented, among other things, as ways to meet some of the operational objectives, such as:

- Peak clipping
- Valley filling
- Load shifting
- Strategic conservation
- Strategic growth
- Flexible load shape

The Government's Point of View

If DSM is a promising innovation for electricity companies, it is also equally promising for the collective whole. For a government, the fundamental issue is knowing what

amount of investment can be allocated towards new energy production, transportation, and distribution means, as well as the required investments and the environmental costs associated with these activities.

The required minimization of these costs undoubtedly involves increasing power performance both in terms of supply and demand. This particular issue leads governments to explore the possibilities of using energy more rationally as a general rule and, more specifically, to become interested in DSM.

A government's DSM approach will generally involve two types of complementary actions.

- Saving electricity while maintaining the same degree of customer satisfaction, which may be achieved through the use of more energy-efficient equipment or through the rational use of existing equipment.
- Shifting a portion of load consumption to off-peak periods when energy is less expensive.

It is in such a context that, technically speaking, peak clipping, load shifting and energy conservation are objectives that governments support. It is also quite commonplace to find a government intervening in a utility's expansion policies. A government will also systematically support any programme launched by an electricity company to reduce peak load demand through load leveling, shifting or reducing electricity consumption (conservation) because these measures foster a decrease in production capacity needs and in the dependence on oil to produce additional power.

On the other hand, a government may not really be interested in supporting "valley filling" or "strategic Growth" since these measures do not have an impact on production capacities and they are only profitable for the electricity company. In addition, these measures result in an increase in power consumption, which may increase the government's costs if it provides subsidies for the power sold.

The difference between DSM applications by a utility and a programme's application by the government must be taken into consideration because of the misunderstandings that can occur between the two players and the possible negative impacts these differences can have on a DSM programme's efficiency.

Impacts on Consumers and Society

DSM is also beneficial for consumers since the costs related to their electricity consumption should normally decrease and their needs will continue to be met satisfactorily. Setting up DSM policies also helps the consumers – through the more efficient use of power – to be aware of and control their own electricity demand, which will eventually help to reduce their electricity bills.

As far as the industrial and business sectors are concerned, DSM programmes foster an overall growth in productivity, have a tendency to increase competitiveness between local companies and can even help them to anticipate future challenges associated with electricity costs.

Finally, DSM programmes are beneficial for the population, both at the local level and at the national level as well. Such programmes globally improve the environment, reduce the negative impacts linked to the construction and operations of power stations and generate a specific increase in employment rates when compared to the investments in other approaches intended to solve problems related to electricity demand increases.

Barriers to Setting Up DSM Programmes

The barriers to setting up DSM programmes are numerous and varied. Several studies by international financial institutions and international agencies specializing in the energy sector, such as the World Bank, take the following barriers into account:

Institutional Barriers

The biggest barrier, because it involves the decision-makers, is often due to a lack of understanding between government policy-makers and electricity company representatives concerning the fundamental mandate of these companies and the role they must play in the development and application of national power policies. As a fallout of such misunderstandings, electricity companies have often encouraged further power consumption whereas the government often strives to do the opposite by promoting a decrease in power consumption.

Moreover, the guiding principles of electricity companies are often a bone of contention between utility planners and political leaders who must take the external cost ramifications of power projects into account. As a result, whereas an electricity company could be tempted to exploit hydraulic resources to the maximum, the government must consider the socio-economic and environmental impacts of such projects.

Other examples such as the importance of close collaboration between the government and the industry in the launch of energy saving programmes show that it is fundamentally important to encourage collaboration and dialogue between the decision-makers and all concerned stakeholders in general when applying energy policies.

Moreover, it has been observed that governments are often unable to maintain follow-ups and continuity of DSM activities. This is often due, among other things, to the lack of proper guidelines and standards to ensure the distribution of quality energy efficient equipment (while the market is flooded by substandard items) and the absence of proper construction rules and regulations governing aspects such as the insulation and ventilation of buildings.

Barriers Associated with Tariffs and Subsidies

Both these factors are very important since energy tariffs and subsidies tend to change customer behaviour. However,

governments do not always pass on increases in actual power costs to the customer through a modification of current tariffs, so there is no incentive for the customer to monitor his consumption.

Electricity companies that are subsidized by the government and that sell power at abnormally cheap rates as well as tariff cross-subsidizing do not always create a healthy environment for energy savings since the end-users have no idea of the actual costs of power. Admittedly, any sudden increase in power tariffs could have an adverse effect on households and companies, which could also be counterproductive for the government. However the effects could be significantly attenuated if the measures were applied gradually over a period of time, which would help the consumers to adopt conservation measures through the implementation of DSM programmes. This would allow electricity companies to slow down the growth in demand and prevent increases in the government's actual power costs.

Market Barriers

Considering that, in several countries, a very large segment of the electricity consumed takes place in the non-residential sector, predominantly in inefficient public sector companies and in industries protected by the government and that the market structure in some countries is such that it does not essentially help to disseminate information on energy efficiency and its related technologies, the level of competition within these markets is weak and there is a lack of consumer information. These factors result in disincentives to invest in DSM programmes.

The lack of local manufacturing and distributing industries, in the area of energy-efficient equipment, and the lack of know-how in terms of implementing DSM projects among research institutes, local engineers and eco-energy companies are some of the major barriers for the implementation of market-oriented DSM projects.

Investment Barriers

For electricity companies, mustering financial resources or the availability of funds are often major limiting factors. These companies are sometimes weakened by a lack of financial resources. Some have debt problems while others suffer from structural problems; these syndromes are very common in developing countries. This type of situation does not encourage electricity companies to invest in improving performance or in DSM programmes.

Furthermore, such barriers do not encourage consumers to use energy-efficient equipment. Access to capital may be difficult because financial institutions are not yet fully convinced of the advantages of creating funds for energy conservation or because the financial products available are not adapted to this type of investment, which is generally low or medium in scale.

Moreover, the financial context is often less open to investments in the power saving sector in general and in DSM in particular.

Consumer Behaviour Barriers

These barriers are largely associated with consumer regulations or habits and represent the major forces of inertia with respect to the implementation of large-scale DSM projects. All over the world, it is generally difficult to change the customs and habits of a given population in regard to the way energy is used. Indeed, despite considerable increases in power tariffs, energy expenditures still only represent a relatively small proportion of the total expenditures of most companies and households. Therefore, there is hardly any motivation for them to adopt energy saving measures. In addition, in many contexts, such as rented office space, the investor is not always the one who benefits from the measures.

Although rare but still in use, some modes of power consumption may have a symbolic value. For example,

administrative offices or large companies that want to flaunt their social status or strength through an exaggerated use of energy like in office buildings where the lights are on at all hours of the day, etc. These bad examples may not favour the acceptance of DSM programmes.

Training Barriers

Organizing the right kind of training programmes for a utility's personnel to determine suitable tariff and demand structures is of the utmost importance. It is also important to change the perception of the personnel so that they consider any optimal energy efficiency programme as a strategy based on the principles of supply and demand (i.e. production and consumption) and not only on the production aspects, which is still often the case.

Demand-Side Management Example of Initiatives Supported by Econoler

Argentina, Analyse DSM Programme Designs

Econoler was mandated to analyse DSM project proposals presented by four electric utilities (EDENOR, EDESUR, EPEC of Córdoba, and EPE of Santa Fe), identify the barriers to project implementation, and evaluate the economic and financial results and incremental costs of each project.

Bahrein, DSM Planning

Econoler was mandated to plan a national DSM initiative for the Kingdom of Bahrain. The mandate included conducting a comprehensive review of the supply-demand equilibrium, establishing the energy consumption and demand levels for each energy usage (lighting, motors, HVAC, etc.), and identifying programmes in regard to their potential for load shape modulations and energy savings. The various programmes envisioned included: i) Awareness and information dissemination programmes on energy efficient technologies; and ii) demonstration projects and large-scale programmes aimed at transforming the market by providing incentives to clients to support the introduction of more efficient equipment. The main technology targeted by these programmes included lighting equipment, motors, variable speed drives, and off-peak cooling equipment. These programmes were complemented by measures aimed at the reduction of technical losses on the electricity transmission and distribution network as well as the introduction of new rate structures to send a more adequate price signal to clients. The introduction of new legislation either in the form of building codes or energy standards was also considered

as a means to set a minimum energy efficiency level for new constructions and the production and importation of equipment. Additional programmes to introduce labelling were recommended to educate customers on the importance of considering energy costs while purchasing appliances or other electricity consuming equipment.

Bangladesh, DSM Strategy Development Through the Use of Efficient Street Lighting and Agricultural Pumping

With the purpose of developing a DSM utility strategy for the Government of Bangladesh, Econoler designed and implemented of demonstrative pilot projects for street lights and water pumps in Tongi municipality (Pourashava), along with the development and delivery of an awareness and capacity building programme.

Econoler also helped introduce energy efficiency improvement programmes in cities, promoted best practices through demonstration pilot projects, delivered capacity building to municipal staff, officials and public service representatives, as well as awareness-raising among stakeholders about energy efficiency initiatives and other relevant issues. The implemented pilot projects achieved measured energy savings of 43% for street lighting and 23% for water pumping, thereby demonstrating the value of including such projects in a global national DSM strategy.

Burundi, Design of a DSM Programme to Reduce the Supply/Demand Gap

Econoler was mandated by the national utility (REGIDESO) to design a DSM programme aimed at reducing the supply/demand gap. The focus of the initiative was to: i) Conduct a survey of electricity use in the household and institutional sectors, which represent the majority of REGIDESO's subscribers; and ii) prepare tender documents for the acquisition of compact fluorescent lamps (CFLs) to replace

incandescent lamps in households and public buildings, which was going to be the first initiative of its kind in the country.

India, Madhya Pradesh, DSM Initiative Planning in Agricultural Pumping

The project consisted of performing planning studies for a DSM programme in Madhya Pradesh by helping farmers improve or replace inefficient pumps with more efficient units. This programme, run by the utility, was going to be tied to ongoing electricity service improvement projects targeting the rural network. As the pumping equipment was to be more efficient, the global water service was to be improved with a higher availability of the new upgraded equipment while maintaining the actual water flow and thus preserving water reserves.

Tanzania, Energy Rationalization and Demand Response Initiative Design

In the context of the energy rationalization and demand response consultancy for TANESCO, Econoler was mandated to assess Tanzania's energy situation and developed tailored DSM initiatives. The main objective of the assignment was to propose DSM actions that could be implemented immediately to help TANESCO address future demand growth and supply shortfalls. As part of the DSM programme development process, particular attention was paid to the rationalization of energy consumption in the industrial sector that accounted for approximately one third of total national electricity consumption.

About Econoler

Econoler is an international consulting firm with more than 40 years of experience in the design, implementation, evaluation and financing of energy efficiency and renewable energy programmes and projects. Econoler has carried out more than 5,000 assignments around the world in 160 industrialized, emerging, and developing countries, from all regions of the world. Our clients include national and local governments, public utilities, corporate sector as well as the leading UN agencies, multilateral and bilateral development banks and a host of other international organizations, foundations, and NGOs involved in fostering energy efficiency and sustainable energy.

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