CONSULTANT REPORT

ON INVESTMENTS
(TASK 5)

MOLDOVA ENERGY REGULATORY PARTNERSHIP

May 2015
This publication was produced for review by the United States Agency for International Development. It was prepared by George B. Schaeffer.

CONSULTANT REPORT

ON INVESTMENTS
(TASK 5)

MOLDOVA ENERGY REGULATORY PARTNERSHIP

Project Title:	Moldova Energy Regulatory Partnership
Sponsoring USAID Office:	Energy and Infrastructure Division of the Bureau for Europe and Eurasia
Cooperative Agreement #:	REE-A-00-07-00050-00
Recipient:	National Association of Regulatory Utility Commissioners (NARUC)
Date of Publication:	May 2015
Author:	George B. Schaeffer

National Association of Regulatory Utility Commissioners

This publication was made possible through support provided by the Energy and Infrastructure Division of the Bureau for Europe and Eurasia under the terms of its Cooperative Agreement with the National Association of Regulatory Utility Commissioners, No. # REE-A-00-07-00050-00. The opinions expressed herein are those of the author and do not necessarily reflect the views of the US Agency for International Development or National Association of Regulatory Utility Commissioners.

Contents

Executive Summary 4
Objective 5
Key Findings 7
Project Cycle 8
Integrated Resource Planning 10
- Introduction 10
- The Planning Process: Scope and Objectives 13
- Demand Forecasting 16
- Investigation of Supply-Side Options 18
- Preparation and Assessment of Supply Plans and DSM Plans 27
- Alternative Integrated Resource Plans: Construction and Assessment 31
- Implementation, Evaluation, Monitoring, and Iteration 36

Conclusion and Next Steps 38

Executive Summary

The approach taken for Task 5 will follow a different format. Based on discussions and material identified by ANRE, it became apparent that the approach towards investment planning and investments does not coincide with normal utility practice. To offer guidelines as to what normal practice is this report contains two distinct sections. The first is a short overview on the Project Cycle as it relates to large infrastructure investments. This is to provide background for the second section which is a detail description of an Integrated Resource Plan (IRP).

ANRE asked some specific questions concerning Investments. The Objective section specifically answers the ones that require a simple answer. To the ones that are much broader, the body of the Report deals with both Project Cycles and IRPs.

From an investment planning standpoint, it is critical to have a clear understanding of the Project cycles and their management which go through definite and describable phases. Each phase can be brought to some sense of closure as the next phase begins. Phases can be made to result in deliverables or accomplishments to provide the starting point for the next phase. The types of question being addressed by ANRE indicate that a full explanation of the Project Cycle is required. From observations and discussion, it appears that ANRE is far too involved in the operations of the utility and what is really lacking is an understanding of where the sector should be going.

The solution to the issue is the undertaking of an IRP or Least-cost Expansion Plan. An IRP is a standard to all major public services. As compared to the traditional planning process, least-cost planning broadens the participation by multiple parties and widens the range of the planning options that are assessed. Its integrative nature opens consideration of multiple planning objectives (such as social, environmental, and economic objectives) in evaluating demand-side and supply-side options. Economic rationales for least-cost planning are found in neoclassical and institutional economic thought. Multivariate decision analysis provides an analytical and decision-making framework for least-cost planning; it can be used to identify issues, objectives, preferences, and expected consequences of planning options. The balance of this report goes into the detail of the process by which an IRP is implemented and what the final content will be.

Utility integrated resource planning has been in effect in various parts of the United States for more than 25 years. While some utilities are regulated by the original IRP rules developed more than a decade ago, many states have updated their IRP rules to reflect current conditions and concerns in regional and national electricity markets. In states where this has occurred, IRPs filed by utilities tend to be more comprehensive and to exhibit more of the "best practices'. Utilities manage many projects, from high-volume and low-cost maintenance to capital-intensive, long-term development of generation, transmission and distribution infrastructure. Project life cycles can span 10 years or more in utility resource planning that have been described in this Report. Nonetheless, there are still many ways in which utilities can improve both their resource planning processes and the plans that are generated as a result of these processes. Engaged stakeholders and state public utilities commissions can provide oversight to this process, helping to promote resource choices that lead to positive outcomes for society as a whole.

At its completion, all stakeholders will have a common map to operate from for future investment decisions. It would be suggest that the IRP be completed by a neutral third party. There are several international energy firms that undertake the practice and several linear programming software packages

that can be utilized. From the Regulator's standpoint ANRE will have a complete understanding as to both what investments are needed, when and a basic estimate of how much. From this standpoint each year ANRE can sit down with the licensee and discussed what part of the IRP will be implemented, what changes need to be made and costs estimations of entire projects not just individual items. This would result in a considerable saving of clerical support from both sides – the Regulator and the utility.

Objective

Given the long term investment planning horizon for electricity supply, it is common to demand forecasts of 20-25 years and supply and system expansion based on such forecasts. Supply is particular important as in many cases the implementation of power plant from initial phase to final inspection could take upwards of a decade (for hydro) and at least 2-3 years for the most basic coal plants. Natural gas does have its advantages in speed to construct, but given the regional reliance on natural gas from the East makes diversification away from that source a high priority for Moldova.

The best way to develop this task is to first examine what specific questions were asked from ANRE. Some will require simple answers while others serve as the basis for the balance of the Report.

1. Expert opinion on the investment process of the Moldovan energy companies as well as the Agency's activities in this area.

The starting point of any utility invest programs is called an integrated resource management plan (IRP) or Least Cost Expansion Plan. The questions that ANRE are asking for and the requirements of planning an electricity sector do not coincide. As such one of the major priorities would be to undertake such an IRP exercise with all the stakeholders to plot a path for the sector to aspire towards. The body of this Report describes the undertaking of an IRP. It is the critical link for energy as Projects take years to implement. Given Moldova's independence on two sources – Ukraine (in political turmoil) and GazProm (a political tool), an IRP would be a great starting point to start the diversification process towards both cheaper and more secure sources.

The second aspect the author is highly critical of is that ANRE has to approve any investment valued at US$300 and has a useful life of more than 1 year. The TSO and DSO and soon to be independent suppliers are companies that work with US$ millions in assets, liabilities and revenue. The concentration of ANRE should be on supporting the long term reliability and quality of electricity (with its centerpiece being an IRP) and not on staff hours determining whether a US$ million operation can buy a laptop.

2. Since the Agency is obliged to examine and approve investment plans - what is the period for investment plans and programs for the distribution companies that needs to be approved?

It is not so much the period that matters, but agreement on the general direction of investment. The essential component of that would be the IRP. Once an agreement is reached on an IRP, then ANRE's role will be altered to be more in line with a strategic plan and whether such plans are being meet within a predetermined budget. At the very least the DSO should be submitting five year plans with two years in detail. This agrees with the Third Package. For the TSO the time period is 10 years with 2-3 years in detail.

It would also be suggested that the private sector model be followed. With the guidance of an IRP, the Board of Directors of the utility should determine the course of operations and investments. The Regulator should be informed of such an investment and give a predetermined "yes this investment can be included within the rates" if carried out, but it is the decision of the Board to invest or not. If the investment does not turn out so well then the Regular has the right not to include the investment within the rate, and it is up to the owners of the utility (even if it is the State) to determine the fate of the Board of Directors.

3. How to take into account investments by long-term investment programs?

See the section on IRP.

4. Challenges when approving investment after separation of supply activities from of electricity distribution. How to regulate the investment made by electricity suppliers?

Suppliers by their very nature will not have big investment. The large infrastructure will go to the DSO. Depending on the services contract with the DSO, the supplier's investment may be as small as an office, computers and a couple of service vehicles. After changing the situation of deciding on any investment of US$ 300 and a useful life beyond 1 year, it would seem to me a capital turnover of five years would be suitable as a guideline. For larger purchases, such as vehicles, a budget should be submitted for approval in advance (say every year) for large items. However, the supplier (as well as all the other licensee) should have the freedom to purchase small items without approval.

5. Investment of distribution companies:

- An example of the content of the investment program (1-2 year) of the American distribution utility

See the IRP section

- Criteria for assessing the need for or effectiveness of the investment program

See IRP Section

- The level of details of investment programs (how to determine what level of detail is the best - the generalized information or a detailed report for each item of each project);

See the IRP section

- Requirements for the regulatory agency's staff who reviews Invest program: who does it in the United States - only economists, engineers only, or neither one nor the other, or outsourced specialized independent companies. It would be useful to show a specific example.

If such an undertaking is internally completed, it would start with the planning department (which would include statisticians (demand estimation) and engineers who would provide the initial IRP. Management would then examine it and approve it. Finally, the Board of Directors would approve it and then it would be submitted for general approval to the Regulator.

If an IRP is completed externally, then an outside firm would complete the task and submit it to management.

- How to account for investments not covered by the original plans, but made by DSO or TSO due to reasons beyond their control (such as the destruction of equipment as a result of force majeure).

Such decision would be on a case by case basis. Under condition of force majeure the utility should have insurance to cover the loss and as such not effect on rates.

6. Are there special laws in the United States or other regulations governing the investment activities of energy companies? If so - how do we get a copy of such documents?

The complexity of this question goes way beyond an answer that can be provided within the Report. Any infrastructure project may deal at three levels within the US – the county, the State and Federal. Energy is not an exception as it applies to all investment. At the county level there are zoning issues and every county in the US has its own specific standard. At the State level would be environmental and safety issues as well as any special needs (such as roads, permitting and state related infrastructure needs). If interstate commerce is involved, the project would then also fall under the jurisdiction of Federal Energy Regulatory Commission (FERC).

There is no simple answer to this question.

As to whether to make the actual investment is undertaken or not, that decision would be left to the Board of Directors of the energy company, and of course would be based on an IRP.

7**. Amendments and additions to investment plans and programs**.

See attached with track changes.

Key Findings

There are two overriding findings concerning investment and ANRE relationship towards it within the licensees they regulate. The first is the sector needs a long term plan which normally comes in the form of an IRP or Least Cost Expansion Plan. Moldova needs a way forward from an energy perspective. They are caught in a very difficult situation with respect to their sources. In fact at present it can be said that their sources of energy are exercising monopolistic powers on Moldova. Given that Moldova is disadvantaged because it has no natural fossil fuels and its power sector was designed under the Former Soviet Union, the population is being forced to pay very high prices relative to others in a similar position with fossil fuel reserves. The solution to this problem is to develop a long term plan to take advantage of the resources that Moldova has within the country and to examine the accessibility of resources from bordering countries.

Given that Moldova is working very hard to meet the standard of the Energy Community rules and regulations, its acceptance will open a wide variety of opportunities for it to engage in energy trade. To prepare itself for that opportunity, the Moldova energy sector needs to develop a long term investment plan (IRP). Such a plan will prioritize investments in trade, generation, transmission and distribution to maximize the economic benefit of investment made.

As to the second key finding, ANRE is at present examining every investment of US$ 300 or more that has a long term life of greater than a year. This microeconomic approach is expensive, time consuming and misses the broad point that ANRE's role is the manager of the sector. As such they focus their

attention on the direction of the sector and key investments that will benefit the economy as a whole. The decisions on such small investments should be made by the owner of the assets. ANRE's role should be the examination of large projects (as provided by the IRP) and approval of them on the whole instead of individual components. The responsibility of such management should be left to the owner/manager of the utility and it's Board of Directors.

Project Cycle

Project management is the process and activity of planning, organizing, motivating, and controlling resources, procedures and protocols to achieve specific goals in scientific or daily problems. A project is a temporary endeavor designed to produce a unique product, service or result with a defined beginning and end (usually time-constrained, and often constrained by funding or deliverables) undertaken to meet unique goals and objectives, typically to bring about beneficial change or added value. The temporary nature of projects stands in contrast with ongoing business which is repetitive, permanent, or semi-permanent functional activities to produce products or services. In practice, the management of these two systems is often quite different, and as such requires the development of distinct technical skills and management strategies.

The primary challenge of the project life cycle and its management is to achieve the entire project cycles within the binding constrains of performing them and objectives while honoring the preconceived constraints. The primary constraints are scope, time, quality and budget. The secondary — and more ambitious — challenge is to optimize the allocation of necessary inputs to provide a least cost solution.

The Project Life Cycle refers to a series of activities which are necessary to fulfill project goals or objectives. Projects vary in size and complexity, but, no matter how large or small, all projects can be mapped to the following life cycle structure[1]. Figure 1 outlines the basic concept of a project life cycle over time and the following list the basic components of the life cycle.

- Starting the project
- Organizing and preparing
- Carrying out project work
- Closing the project

Starting the project is where the opportunity has been identified, impact evaluated, alternatives reviewed, and a solution defined. Within this phase is where the project objectives are defined and the conceptual aspects of the project agreed upon with the various stakeholders. At this stage a prefeasibility study may be undertaken as a preliminary step in trying to evaluate whether significant resources should be dedicated toward developing it as a full scale project.

Figure 1. The Project Life Cycle

[1] Different variation of the number of steps to be included exists. The version used for this brief overview can be found at https://www.uakron.edu/pmo/plc/

Source: University of Akron, Project Management Office (https://www.uakron.edu/pmo/plc/)

During this early period only a few people are involved as this could be considered the idea stage. Various options will be examined and out of those options one with the most promise will be identified for detailed examination under the next phase.

Organizing and Planning is the undoubtedly the most critical component of a successful project. The stage one has a couple of ideas with some preliminary thoughts and section of the most promising. At this stage more people become involved and a feasibility study is undertaken that will both confirm the correct direction to take, but plan out ht e details the chosen direction. The Planning Phase consists of those processes performed to establish the total scope of the effort, define and refine objectives, and develop the course of action required to attain those objectives. In addition, the project is broken down into manageable areas of work and planned in terms of time, cost and resources. This is a continuous process and will extend throughout the execution phase of the project.

The first step of the Planning phase is the creation of a detailed Project Plan which the project manager will refer throughout the project to monitor and control time, cost and quality. The project manager will then create the following plans:

- Resource Plan: to identify the staffing, equipment and materials needed
- Financial Plan: to quantify the financial expenditure required
- Quality Plan: to set quality targets and specify Quality Control methods
- Risk Plan: to identify risks and plan actions needed to minimize them
- Acceptance Plan: to specify criteria for accepting deliverables

Finally, a Phase Review is carried out to assess the deliverables produced to date and approve the start of the Project Execution phase.

The next step is to carry out the work. In the Execution Phase, the deliverables are physically built and presented to the customer for acceptance. While each deliverable is being constructed, a group of management processes are undertaken to monitor and control the deliverables being created by the project. During Project Execution the project team produces the deliverables while the project manager monitors and controls the project delivery by undertaking:

- **Time Management:** tracking and recording time spent on tasks against the Project Plan
- **Cost Management:** identifying and recording costs against the project budget
- **Quality Management:** reviewing the quality of the deliverables and management processes
- **Change Management:** reviewing and implementing requests for changes to the project
- **Risk Management:** assessing the level of project risk and taking action to minimize it
- **Issue Management:** identifying and resolving project issues
- **Acceptance Management:** identifying the completion of deliverables and gaining the customers acceptance
- **Communications Management:** keeping stakeholders informed of project progress, risks and issues

Once the customer has accepted the deliverables and a Phase Review has been carried out to determine whether the project objectives have been achieved, the project is ready for closure.

The final step is closing the project and consists of those processes deemed necessary and performed to finalize all activities to formally complete the project and any contractual obligations. This phase includes close-out, testing, handover and demobilization.

This short overview is provided as a precursor to the more detail review on what goes into developing utility investments plans and what is expect of them. Bearing in mind that utility project planning is a dynamic process; an ever changing situation with many factors influencing it. For example, what would be considered a small larger agricultural community could literally change overnight if a large corporation decided either to move its headquarters there or set up a major manufacturing center. Not only would the utility to have to cope with the facility itself, there would be secondary repercussion as more people moved into the area to fill the jobs, secondary services to service the population and even secondary and tertiary types of business that would support the main manufacturing concern.

Integrated Resource Planning

Introduction

Integrated Resource Planning (IRP) or Least Cost Expansion Plans can be thought of as a process of planning to meet users' needs for electricity services in a way that satisfies multiple objectives for resource use. Broad objectives can include:

- Conform to national, regional, and local development objectives.
- Ensure that all households and businesses have access to all their electrical needs.
- Maintain reliability of supply.
- Minimize the short term or long term economic cost of delivering electricity services.
- Minimize the environmental impacts of electricity supply, delivery and use.
- Enhance energy security by minimizing the use of external resources.
- Minimize foreign exchange costs.

Each country, or other planning region, establishes its own objectives to guide planning for electricity services. Objectives such as those listed above are often among those selected to guide IRP. Such objectives as the above conflict with one another to varying degrees. Therefore, preparing, deciding upon, and implementing a preferred resource plan require both a series of objective *analyses* and the use of *processes* by which the values and judgments of stakeholders are applied in developing plans.

Developed Countries

In many developed countries, IRP has been pursued by privately owned integrated utilities under regulatory oversight, or by governmentally owned utilities. IRP approaches were originally applied to *vertically integrated* power systems. Integrated resource plans could therefore govern the selection of power plants as well as investment in other aspects of electricity supply and in demand-side efficiency measures as well.

A number of developed countries privatized electricity generation and reduced the amount of price regulation in the late 1990s, a process known as electric industry restructuring or as power sector reform. As a result, the selection, construction, and operation, of generation facilities were left largely to private investors responding to their perceptions of the markets for power output.

Of course, each generating facility must still comply with government regulations that apply to all power facilities. But restructuring or power reform often leaves the *selection of* and *investment in* generating facilities to the unregulated market. When generation investment, and with it pricing, is no longer subject to governmental or regulatory direction, IRP must be adapted to the changed market structure. If competitive generation markets are introduced at the retail level, so that energy users purchase power supply services directly from the market, then IRP must be reinvented. It must move to the jurisdictional level, where national or state/province level IRP processes can develop benchmark plans. National benchmark IRPs can help in monitoring the performance of the electricity sector on critical policy variables like costs to consumers and environmental protection. Such national or state IRP processes can inform policy development to structure and regulate the competitive electric generation market.

However, if competitive generation markets operate only at the wholesale level, while electricity users must still purchase power at retail from distribution utilities, then IRP can still be applied at the utility system level in much the same manner as it is when there is a vertically integrated utility system. IRP can still function as it designs investments in:

- transmission and distribution systems;
- end-use efficiency options; and
- mix of power available at wholesale which best satisfies IRP objectives.

With or without electric industry restructuring, IRP processes are useful for very large electric systems with extensive economic, environmental and social impacts. They provide the general blueprint needed to meet an essential component of dairy life and work, electricity. That blueprint provides the path forward to insuring that electricity is not the constraint with the development of an area and its resources.

Developing Countries

Many developing countries confront issues concerning the basic needs for reliable electricity supply and the provision of electric service to all households. Many are experiencing rapid growth in the demand for power as incomes improve. Just as in more developed countries, there is a need to minimize generation costs while meeting development and environmental objectives. IRP can help countries with varying market structures, whether it functions as a blueprint for a governmentally owned utility system or as a benchmark utilized in the process of regulating the private power market. Developing countries need to stay abreast of new technologies for generation and transmission as well as for electricity end-use, and to consider all available technologies, including end-use efficiency and electricity generation using local renewable resources, on a consistent basis. IRP can assist in developing responses to the restricted availability of capital for electricity supply investments as well as the growing private-sector involvement in financing and operating generation facilities.

Summary

IRP is built on principles of comprehensive and holistic analysis. Traditional methods of electric resource planning focused on supply-side projects only, i.e., construction of generation, transmission, and distribution facilities. Demand-side options, which can increase the productivity with which electricity is used by consumers, were not considered. Too often, even the assessment of supply-side options was limited to a few major technologies, and cost-benefit analysis of the alternatives was rudimentary. By contrast, IRP considers a full range of feasible supply-side and demand-side options and assesses them against a common set of planning objectives and criteria.

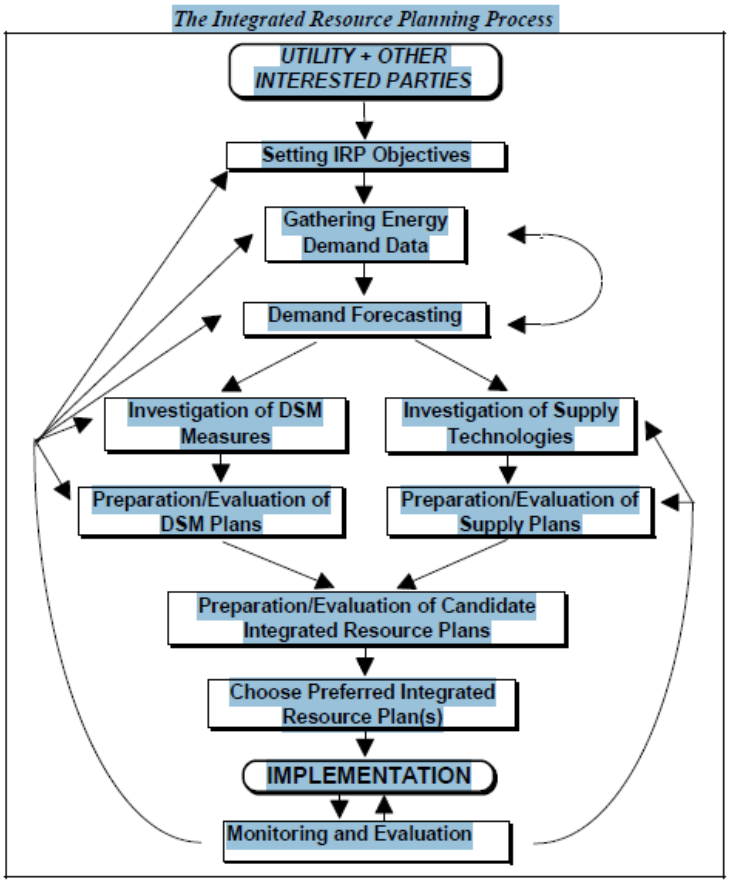
In summary, IRP provides an opportunity for electric system planners to address complex issues in a structured, inclusive, and transparent manner. At the same time, it provides a chance for interested parties both inside and outside the planning region to review, understand, and provide input to planning decisions.

The remainder of this discussion sets out the elements of integrated resource planning for electricity. The steps in this process generally are to:

- establish objectives;
- survey energy use patterns and develop demand forecasts;
- investigate electricity supply options;
- investigate demand-side management measures;
- prepare and evaluate supply plans;
- prepare and evaluate demand-side management plans;
- integrate supply- and demand-side plans into candidate integrated resource plans;
- select the preferred plan; and
- during implementation of the plan, monitor, evaluate, and iterate (plan revision and
- modification).

Figure 2 below depicts the various elements involved in integrated resource planning for electric systems as well as the major linkages amongst elements.

Figure 2. Integrated Resource Planning



Source: US Agency for International Development: Global Center for Environment, Office of Energy, Environment, and Technology. *Best Practices Guide: Integrated Resource Planning For Electricity.* (Washington, DC).

The Planning Process: Scope and Objectives

The Scope of Planning

The policies of national and sub-national governments frame the structure of ownership, operation, and regulation of electric facilities and systems. Policy also establishes the rights and responsibilities of all sectors of society as they relate to electric system planning and operation.

The operation of the electric system necessarily affects a wide range of legitimate societal interests. In structuring the IRP process itself, it is desirable to include not only members from various departments of a utility system (for example, engineering, finance, law, and customer service), but also representatives of (other) government agencies (ministries or departments of economic planning, environmental protection, and energy), energy consuming sectors, community groups, etc. Incorporating

the views of a broad spectrum of those that will be affected by planning decisions can foster consensus and avoid polarization as those plans are implemented.

The logical geographic boundaries for power system planning may or may not coincide with the National boundaries. The existing power system may be operated on a national basis, for example. In such cases there may be a neat fit between national plans, policies, or regulations and the boundaries for ongoing application of more detailed planning processes for the power sector. In other cases, however, there are reasons for a planning boundary that does not correspond to the nation. Moldova is just such a case, where it was part of the All Union System of Power Supply during the Soviet period.

With Moldova, the demand for power is on one side of a national boundary, and resources on the other. Such situations create a case for cross national planning. Political and practical difficulties currently limit cross-national power planning. However, it may be to the mutual benefit of nations to establish IRP that crosses national boundaries. Establishment of a regional working group or a regional electric power pool might provide a foundation for developing more through-going regional IRP over time.

Whatever the geographic level at which planning for power systems is applied, there will usually be planning issues that cross the boundary at the very least, questions of transmission interconnections and the creation of power grids that interconnect power systems that may once have been islands. In principle the IRP methods described here can be used at the inter-utility system level. The degree to which inter-system IRP is applied, for example, in transmission planning, will depend on whether the parties involved can expand the boundaries for integrated planning, at least for purposes of considering inter-system project alternatives.

Similarly, IRP can be applied to a localized problem within a power system. For example, there may be a local region within a utility service area that is capacity-constrained. Local IRP can be focused in the particular area to determine the mix of feasible transmission, distribution, and load-management options, and develop a preferred plan to address the localized problem.

In describing electric IRP in this guide, it simply refers to the utility system to indicate the geographic boundaries of the planning process, whatever they might be.

Setting Objectives

Explicit objectives for the planning process are formulated in qualitative terms. They generally do not quantify the level of outputs or service to be provided. However, criteria by which the achievement of each objective may be measured must be established. National policy and planning affect the objectives addressed in planning. Country-level economic development and environmental protection policies, supplemented by provincial/state level policies in federated countries, influence the structuring of IRP. In particular, national development objectives and management strategies for energy resources should be reflected as objectives in electric resource planning processes.

The stakeholder concerns that inform the planning process are a critical source of planning objectives, possibly more specific in character than those derived from government policy. Specific planning objectives may be preliminary and subject to modification as initial informational and assessment activities convey a clearer picture of current and expected conditions to stakeholders. Several objectives are established at this stage of the planning process. The table below presents possible objectives that

utility planners and others might choose to guide the formulation and evaluation of integrated resource plans.

Once planning objectives have been agreed on, measures must be ascribed to each objective.

Cost objectives lend themselves well to quantitative measures of performance, while social objectives may require a qualitative approach to measurement. Measurement of environmental performance may entail a mix of quantitative measures (for example, estimates of air pollutant emissions) and qualitative measures (for example, aesthetic impacts).

Table 1. Objectives for Integrated Resource Planning

Possible Objectives for Integrated Resource Planning

Objective	Nature of the Objective
Reliable electric service	Serving consumers with minimal disruptions in electric service
Electrification	Providing electric service to those without convenient access to electricity is a common objective in developing countries
Minimize environmental impacts	Reducing the impacts of electricity generation (and energy use in general) is a goal that has received increasing attention in recent years. Environmental impacts on the global, regional, and local scales can be considered
Energy security	Reducing the vulnerability of electricity generation (and the energy sector in general) to disruptions in supply caused by events outside the country
Use of local resources	Using more local resources to provide electricity services — including both domestic fuels and domestically manufactured technologies — is of interest in many countries. This objective may overlap with energy security objectives
Diversify supply	Diversification may entail using several types of generation facilities, different types of fuels and resources, or using fuels from different suppliers
Increase efficiency	Increasing the efficiency of electricity generation, transmission, distribution and use may be an objective in and of itself
Minimize costs	Cost minimization is key impetus for pursuing IRP, and a key objective in planning. The costs to be minimized can be costs to the utility, costs to society as a whole (which may include environmental costs), costs to customers, capital costs, foreign exchange costs, or other costs
Provide social benefits	Providing the social benefits of electrification to more people (for example, refrigeration and light for rural health clinics and schools, or light, radio, and television for domestic use). Conversely, social harms, as from relocation of households impacted by power project development, are to be prevented or minimized
Provide local employment	Resource choices have different effects upon local employment. IRP objectives can include increasing local employment related to the electricity sector, and increasing employment in the economy at large
Acquire technology and expertise	A utility (or country) may wish to use certain types of supply project development in order to acquire expertise in building and using the technologies involved
Retain flexibility	Developing plans that are flexible enough to be modified when costs, political situations, economic outlook, or other conditions change

Source: US Agency for International Development: Global Center for Environment, Office of Energy, Environment, and Technology. *Best Practices Guide: Integrated Resource Planning For Electricity.* (Washington, DC).

Demand Forecasting

Demand forecasts estimate the amount of electricity needed in the geographic area served by a power system. Forecasts may project the amount of energy (Watt-hours) and power (Watts) that will be needed over the course of a day, a week, or a year. In the context of IRP, forecasts typically look at energy and power requirements from five to 30 years into the future. A demand forecast is basic to analyzing how much new generation capacity may be needed, which generation resources are applicable, how transmission and distribution systems should be expanded, and in which customer groups or geographic areas these requirements will be concentrated.

Data Needs for Demand Forecasting

Demand forecasts require data describing how electricity and alternative fuels are currently used in the utility systems service area. Some of the types of information needed for forecasting are:

- Sales records: Records of electricity sales for as many historical years as are available. Sales records by geographical area and by customer class (for example, household, commercial and industrial classes) are needed, along with the number of customers by class and by area.
- Demand records: Data on power demand that chart the MW requirements on the utility over days, weeks, months, and years are needed to determine the relationship between electricity sales and the amount of generation capacity required. Disaggregated data are useful. The shape of the load curve (the variation of peak loads over time, or the load profile.) helps to determine what types of generating capacity are needed.
- Economic and demographic data: Forecasting uses historical data on economic performance, and population or the number of households.
- Economic and demographic projections: A utility company may make its own economic and demographic projections for its service territory, or these projections may be obtained from an economic planning ministry or from some other entity.
- Energy end-use data: Types of end-use data include the number/fraction of households using specific electric appliances, the number/fraction of commercial, institutional, or industrial consumers using different types of electric equipment, and the amount of electricity used per customer per end use. These data are referred to as penetration or saturation data (for example, the percentage of households with electric lighting) and energy intensity data (for example, the kWh of electricity used per household per year). Ideally, historical data of these types would be available for each customer class and each major end use. In practice, even a single year's worth of such data may be hard to obtain. In some cases, partial data on appliance ownership or use, most frequently for the household sector, can be found in national census documents. In some developing countries, government agencies or nongovernmental organizations have studied energy end-use, or have been participated in data collection activities funded by bilateral or multilateral aid. These studies are rarely as complete as needed. New end-use surveys are often needed to obtain the data required for end-use forecasts.

Types of Forecasting Models

Methods used to forecast demand include trending, econometric analysis, end-use simulation, and combinations thereof. *Trend forecasting* assumes that past rates of change in electricity use, or in electricity use per customer, will continue into the future. A growth rate calculated from historical data (sales or peak demand data) may be applied to estimate future consumption and demand. Separate

trending forecasts can be compiled for each customer class or geographic division. Trending requires only access to basic sales and peak statistics, and the use of simple statistical methods. Trending forecasts assume that the future will be like the past, which often turns out to be untrue. Changes in technology, structural shifts in the economy or in demography, and changes in regulations are difficult to capture with a trending forecast. Trending is most useful for short-term forecasting (one to two years), for which the assumption that the future will be like the past is more robust.

Econometric forecasting assumes that past relationships between electricity use or peak demand and various economic or demographic variables continue to hold into the future, but econometric forecasts are generally more detailed than trending forecasts. In econometrics, the first step is to look for statistically significant historical relationships between economic variables and electricity sales or peak demand. Variables used to develop econometric relationships may include household income, electricity prices (by consumer group), prices for other household necessities, employment (by sector and sub-sector), labor productivity, tourism, industrial or agricultural output (measured in physical quantities or monetary terms), commercial-sector output (by sub-sector), use of other fuels, and the prices of other fuels.

Regression procedures (linear, non linear and auto stochastic) can be used to test how well changes in one or more driving variables (such as those above) predict the value of the quantity to be forecast. In addition to testing the statistical significance of these relationships, econometric tools allow calculation of the mathematical relationships among parameters. Once statistically significant non correlated historical relationships between economic or demographic variables that affect electricity use or demand are identified and specified, projections for the driving variables must be developed. Such projections can often be obtained from ministries of economics or finance, or sources such as national banks. These projections are used to drive the econometric forecasts of electricity use or peak demand. As the factors that influence household electricity use are generally different from those that affect commercial, institutional, or industrial electricity needs, econometric forecasts, at least of electric energy use (as opposed to peak demand), are typically done separately for each major customer group, then aggregated to estimate system-wide sales.

End-use forecasting differs from trending and econometric forecasting in that it builds up estimates of electricity needs starting with an analysis of what electricity is used for. An end-use model of household electricity use might include separate estimates of electricity used for lighting, water heating, space heating, air conditioning, fans, cooking, entertainment, and other appliances. Using the example of air conditioning, one can specify a relationship between end use variables:

> Electric energy use for air conditioning = number of households * fraction of households with air conditioners * amount of cooling required per household * energy intensity (kWh per unit cooling delivered) of average air conditioner model in use.
> In this example, one can forecast energy usage by projecting each of the four parameters on which air conditioning electricity usage depends. End-use forecasts can be prepared using spreadsheet software, or using customized forecasting software packages, of which several are available.

End-use approaches have several advantages. They can be quite detailed, providing more information for planners. They can provide integrated forecasts of both energy and peak power demands. The assumptions used in forecasting are usually easy to follow, check, and revise as new data become available. End-use forecasts provide an excellent framework for estimating the impacts of energy-

efficiency options and demand-side management by making changes to parameters used in the baseline forecast. In the example used above, for instance, the analyst can change the assumed energy intensity of air conditioners to reflect introduction of more efficient units. On the other hand, end-use forecasts are data-intensive. Surveys of different types of buildings are usually needed to collect good data on energy end-uses.

Since the future is inherently uncertain, most forecasters prepare a base case and several alternative forecasts of electricity use and peak demand. The base case might be the forecaster's best estimate of how the parameters that influence electricity use will evolve over time, while alternative forecasts might include projections that assume high or low economic growth, higher or lower fuel prices, higher or lower population growth, or other combinations of key parameters. Alternative scenarios give planners an idea of the sensitivity of forecast results to changes in the assumed value of key parameters. *Forecast scenarios* can be used to assess whether a candidate IRP includes sufficient flexibility that it can be cost-effectively modified even if demand is higher (or lower) than anticipated.

Investigation of Supply-Side Options

An electricity supply system consists of power generating technologies, transmission and distribution (T&D) technologies, fuel supply systems, and environmental controls and waste disposal processes. A review of supply options begins with identification of all applicable options and related infrastructure, review of the attributes of the options, and selection of promising options for further study and analysis. There are hundreds of different supply options and configurations of options that could be used in a power supply system.

Options for Generating Electricity

The many types and sizes of power plants can be broadly grouped into central-station, local, or dispersed applications. In countries where electrification is a priority, it may be necessary to choose among these applications, or make different choices for different areas within the country. Central power stations are often large generators designed to feed electricity into a central power grid serving an extensive region. The generating capacity of central power stations can range from tens to thousands of megawatts. The following table provides a sampling of types of generators suitable for use in central power stations.

Table 2. Large Scale Supply Options

Generation Options for Central Power Stations

Gaseous and Liquid Fuels (natural gas, oil products)
- Steam Cycle
- Combustion Turbines
- Combined-Cycle
- Repowering and Refurbishment of Existing Power Plants
- Large Internal Combustion Engines (Diesels)
- Fuel Cells (large arrays — still under development)

Solid Fuels (coal, biomass)
- Steam Cycle (many boiler configurations available)
- Gasification/Combined Cycle
- Nuclear Generators

Renewable Fuels
- Larger Hydroelectric (including pumped-storage)
- Wind "Farms" (arrays of many turbines)
- Large-array Solar Photovoltaic and Solar Thermal
- Geothermal
- Hybrids

Source: US Agency for International Development: Global Center for Environment, Office of Energy, Environment, and Technology. *Best Practices Guide: Integrated Resource Planning For Electricity.* (Washington, DC).

Local power plants are designed primarily to meet electricity needs of an isolated electric grid in a particular locale (a larger village or town, for example) or for a large institutional or industrial facility. They tend to range in size from tens of kilowatts to tens of megawatts. In some cases combinations of technologies may be most appropriate. The following table lists some of the types of generators that can be used in local applications.

Table 3. Small Scale Supply Options

Generation Options for Local Power Generation
Gaseous and Liquid Fuels (natural gas, oil products)
Combustion Turbines
Combined-Cycle (small units)
Internal Combustion Engines (Diesels)
Fuel Cells (still under development)
Solid Fuels (coal, biomass)
Small Steam Cycle
Gasification/Internal Combustion Engines
Biogas/Internal Combustion Engines
Renewable and Other Fuels
Small and Medium Hydroelectric (including pumped storage)
Wind "Farms" (one to several turbines)
Solar PV and Solar Thermal, Small and Medium-sized arrays

Source: US Agency for International Development: Global Center for Environment, Office of Energy, Environment, and Technology. *Best Practices Guide: Integrated Resource Planning For Electricity.* (Washington, DC).

Dispersed generation provides power to residences (or small groups of residences) and businesses. Where great distances separate potential electricity users and/or the existing electricity grid is far away, dispersed generation can be a cost-effective alternative to grid extension. The following table describes some of the technologies suitable for dispersed generation.

Table 4. Generation Options for Dispersed Generation

Generation Options for Dispersed Generation
Gaseous and Liquid Fuels (natural gas, oil products)
Very Small Combustion Turbines
Internal Combustion Engines (Diesels, gasoline generators)
Small Fuel Cells (still under development)
Solid Fuels (coal, biomass)
Gasification/Internal Combustion Engines
Biogas/Internal Combustion Engines
Renewable and Other Fuels
Mini and Micro-Hydroelectric
Wind Power (turbines in a range of sizes, with battery storage)
Solar PV, Small arrays (in a range of sizes, with battery storage)

Source: US Agency for International Development: Global Center for Environment, Office of Energy, Environment, and Technology. *Best Practices Guide: Integrated Resource Planning For Electricity.* (Washington, DC).

The types of generating plants that are added to electricity grids must be matched to the varying loads encountered during each day, week, or year. Electric systems must consider needs for baseload, intermediate load, and peaking capacity. These types of capacity can be characterized as follows;

- Baseload capacity is designed to operate for most hours of the year, perhaps 50 to 80 or more percent of the time (50-80+% .capacity factor.). Coal-fired steam-cycle power plants, nuclear plants, geothermal, wind, solar and hydroelectric plants are examples of baseload generation capacity.

- Baseload plants may have high capital costs, but typically their fuel costs are low. The output of baseload-type plants cannot be rapidly decreased or increased to follow load, i.e. adjusted to changes in the amount of power needed. (Sometimes hydro plants follow load, in which case they are not baseload units.)

- Intermediate-load plants provide power during periods when demand is higher than minimal levels, such as during the day and evening (capacity factors about 15-50%). Technologies for intermediate-load plants include oil or gas-fired steam cycle plants, combined-cycle plants, some hydroelectric plants, and internal-combustion-engine generators.

- Peak-load plants provide power when demand is highest, and may operate only a few percent of the hours in the year. Types of peak-load power plants include combustion turbines (sometimes also used as intermediate load plants), internal combustion engine plants, and pumped-storage hydroelectric facilities. Different types of power plants require different fuels or resources. It is necessary to consider what fuels and resources are available from domestic sources or imports, and the fuel delivery infrastructure (such as gas pipelines, liquefied natural gas terminals, coal mines, coal transport trains, and oil distribution networks). Depending on the fuel used, fuel treatment (coal cleaning or gas processing, for example) may also be necessary.

Transmission, Distribution and Supplier Infrastructure

The Transmission System Operator (TSO), Distribution System Operator (DSO) and suppliers form an essential part of an overall electricity plan. Combined this infrastructure delivers electricity from power plants to consumers. Transmission lines carry power from power plants to the main electric grid, and along its major branches. Power from transmission lines is stepped down, or reduced in voltage, for distribution to electricity users. There may be several sets of transformers to step down transmission voltage to the voltage level used by consumers. The distribution system carries power from transmission lines via substations and transformers, delivering electricity to its final points of use. The supplier meters, bills and performs the necessary consumer functions. Numerous technical options for all three must be optimized, planned and costs estimated to find an efficient solution.

Emissions Treatment and Waste Disposal

Generation options often produce pollutant emissions or wastes. Obvious examples include emissions of the air pollutants nitrogen and sulfur oxides (NOx and SOx) from coal, oil, and gas-fired power plants, and the ashes from coal combustion. The quantity of emissions and wastes per unit of electrical

output varies by type of generating technology and with the fuel used, as do emissions control and waste disposal costs. Emissions of carbon dioxide (CO2), which as a greenhouse gas contributes to climate change, can be reduced by choosing low- or no-carbon generating options and fuels.

Attributes of Supply Options

A major part of the process of reviewing the supply options is the collection of the quantitative and qualitative information needed to sift among alternatives. Table 5 below describes the most important types of information required for each generation option. Resources for reviewing supply options are available from international agencies (Energy Information Agency (EIA), the World Bank and International Energy Agency), trade organizations or institutes, private sources, and non-governmental organizations.

Preliminary Assessment of Options

Once assembled, data on supply options must be evaluated to select attractive options to include candidate supply plans. This evaluation and preliminary selection can be done in several ways, including preparation of a matrix to rank each option according to its score (for example, cost per MW, fuel cost per kWh, or carbon emissions per kWh) on key attributes. Often, particularly for larger power plants, advanced review of supply options involves identifying candidate sites where the power plants or dams could be located. Quantitative and qualitative considerations enter into the options evaluation. The goal is to screen out options that are clearly inappropriate based on cost, resource, technical, or other grounds. Options passing preliminary screening are assessed more fully at a later stage.

Table 5. Supply Options for Dispersed Generation

Attributes of Supply Options

Attribute	Information About the Attribute
Plant capacity	In what sizes is the supply option available from vendors (or via local construction)?
Maximum and optimal capacity factors	For what fraction of the year is the full capacity of a generation option likely to be available to generate electricity?
Fuel type	What quantities and qualities of fuel are required by a generation option?
Efficiency	What is the efficiency of the supply-side technology? For a generation technology, efficiency is the net amount of electricity produced per unit of fuel input. For T&D technologies, efficiency is expressed in terms of the percentage of power or energy lost during transmission or distribution.
Fuel costs	How much do the fuels used for power generation cost? How much are they expected to cost over the planning period time horizon?
Reliability	How reliable is the technology under consideration? What has been its operating history, either domestically or in other countries?
Capital and operating costs	How much does it cost to acquire, operate, and maintain the technology (in addition to fuel costs)?
Lifetime	How long will the supply-side technology be operable?
Decommissioning costs	What is the expected net value of the plant at the end of its useful life, including the costs of decommissioning? Decommissioning should be considered for all options, even dams that may last longer than other options.
Foreign exchange requirements	What fraction of the capital, operating, and maintenance costs of the power plant will be spent in-country, and what fraction must be spent on imported goods?
Environmental impacts	What quantities of air pollutants, liquid wastes, and solid wastes are produced by a generation option per unit of electricity produced? How much land is required for the option? Is cooling water is needed? For a hydroelectric facility, how much area will be submerged when a dam is complete, and how many households and farmers affected? What are the environmental impacts of plant construction and decommissioning?

Source: US Agency for International Development: Global Center for Environment, Office of Energy, Environment, and Technology. *Best Practices Guide: Integrated Resource Planning For Electricity.* (Washington, DC).

For example, screening calculations may be in order to establish whether a supply option is ruled out on economic grounds. Some of the types of cost calculations often used in economic screening include:

- Life-cycle costs of generating options can be computed to compare very different generating options. Capital, operating, fuel, waste treatment, and decommissioning costs (or salvage value) enter into calculation of overall plant net present value (NPV) and NPV per kW or kWh. Sensitivity analysis can be used to evaluate the impact of changes in key parameters (such as discount rate and capacity factors) on plant economics. (Life cycle cost analysis can also be used in screening demand-side options, as discussed below.)

- Leveled busbar cost. This analysis estimates the life-cycle cost (revenue requirement) of power from a supply option at the busbar, the point at which electricity leaves the plant. Busbar revenue requirements, calculated in cost per kWh, may be used as indicators of overall costs when sifting among supply options.

- Leveled annual cost versus capacity factor. Calculation of the variation of annual costs (including capital, fuel, and O&M costs) at a range of capacity factors provides an indicator for how plant economics will change depending on how the plant is used.

- Simplified production cost analysis is another method of estimating the cost of power from a supply option.

Investigation of Demand-Side Options

Demand-side management, or DSM, refers to programs or projects undertaken to manage the demand for electricity: reducing electric energy use, changing the timing of electricity use (and thereby the profile of peak power demand), or both. By reducing the demand for electric energy and power, DSM options can reduce the use of existing electric supply facilities (or, equivalently, serve more users with given facilities), and defer the addition of new capacity.

Review of DSM options begins with identification of all applicable options and their cost and performance characteristics. The more promising DSM options are selected for further study and incorporation in draft DSM programs and plans.

DSM Options

The list of potential DSM options for utility systems is longer than the list of supply options.

DSM options can be roughly divided into five categories, as follows:

1. Information and/or Incentives to Encourage Efficiency in Electricity Use

   One class of options is to provide information to electricity consumers on how to use energy wisely and efficiently, and to provide pricing structures that help spur customers to change the amount and timing of energy use. Although there is uncertainty in the estimates of electricity or peak power savings from all types of DSM measures, the savings from information/price incentive measures are perhaps hardest to quantify.

2. Higher-efficiency Technologies

   Another class of options is energy efficiency measures. These are technologies that reduce energy use (usually with some reduction in peak loads) by substituting more efficient appliances and equipment for less-efficient units or systems. Energy efficiency measures are available for virtually every end-use application. A small sample of generic measures, organized by sector (customer group), is presented in the table 5.

3. Fuel-Switching Technologies

   In electric IRP, the most common types of fuel-switching options are those that save electricity and reduce electric peak loads by substituting another fuel for electricity. Fuel switching to electricity is also considered. Illustrative fuel choice alternatives:

- Use of natural gas or solar energy (instead of electricity) to provide space heat, water heat, or industrial process heat; Use of natural gas or solar-thermal absorption chillers or natural gas engine-driven chillers (instead of electricity) for air conditioning or refrigeration; and
- Use of electric appliances for cooking, instead of wood stoves or coal stoves.

Table 6. Energy Efficiency Options

Selected End-Use Electric Energy Efficiency Measures

Residential Sector

- Higher-efficiency appliances (air conditioners, refrigerators, stoves, water heaters, electronic devices)
- Devices that save hot water (efficient washing machines, plumbing fixtures)
- Compact fluorescent lamps
- Automatic lighting controls
- Building envelope improvements (insulation, window improvements) to reduce cooling, heating, and sometimes lighting needs.

Commercial/Institutional Sectors

- Higher-efficiency air conditioning, refrigeration equipment
- High-efficiency fluorescent bulbs, lamp ballasts, and lighting fixtures
- Lighting, cooling, space heating, and water heating controls
- High-efficiency office equipment
- Building envelope improvements
- High-efficiency electric motors, drives, and controls

Industrial Sector

- Process improvements
- High-efficiency electric motors, drives, and controls
- Applicable commercial/institutional sector measures

Other Sectors

- High-efficiency cooling and refrigeration equipment for the agricultural sector
- High-efficiency electric motors, drives, and controls for mining and transport applications
- High-efficiency lighting products for street lighting

Source: US Agency for International Development: Global Center for Environment, Office of Energy, Environment, and Technology. *Best Practices Guide: Integrated Resource Planning For Electricity.* (Washington, DC).

4. Load Management

Load management measures reduce peak demand by shifting power use from times of high power demand (for example, during the day or early evening) to times of lower demand (during the night). Examples include:

- Water heater controllers for household applications. These can be simple timers that turn off appliances during peak times, or electronic controls (load control.) activated by the utility system operator. With centrally activated load control systems, different groups of end-use equipment can be cycled off for a few minutes during each peak load hour.

- Ice-storage systems for air conditioning. Ice is made at night by refrigeration, and stored until air conditioning is needed (for example, in an office building or hospital) during the day. The ice is then melted in a heat exchanger and used to cool the building.

- Special interruptible rates. Large volume electricity users may be offered price discounts in exchange for allowing the utility to disconnect all or a portion of their electrical equipment when the utility system is short of generating capacity.

Attributes of DSM Options

It is necessary to collect data on DSM options so that they can be compared with each other and with supply-side options. Attributes of DSM options that need to be considered are described in table 7.

Table 7. Energy Efficiency Options

Attributes of DSM Options

Attribute	Information about the Attribute
Applicability	To what sectors and end-uses can the DSM measure be applied? What is the size of the market for which the measure is applicable?
Fuel type	For fuel-switching measures, what fuel is used?
Reliability and lifetime	How has the measure performed in previous applications? What is its typical lifetime?
Efficiency	How much energy and power does the measure save, relative to standard equipment?
Capital and operating costs	What does it cost to own, operate, and maintain the technology?
Environmental impacts	What are the impacts of the technology, relative to standard equipment?
Foreign exchange requirements and local input	What fraction of the materials and technology for the DSM measure can be provided locally?

Source: US Agency for International Development: Global Center for Environment, Office of Energy, Environment, and Technology. *Best Practices Guide: Integrated Resource Planning For Electricity*. (Washington, DC).

Preliminary Assessment of DSM Options

Once information on the key characteristics of DSM options has been assembled, the list of options is narrowed to those to be included in candidate DSM plans. As with the preliminary assessment of supply options as was discussed earlier, narrowing the list of DSM options involves applying quantitative and qualitative screening criteria.

One measure often used in preliminary screening is the overall lifetime cost of a DSM measure per unit of energy saved (for example, in cents per kWh of electricity saved), which is then compared to the

overall cost to generate and deliver the electricity that would otherwise be required. Information about the cost of saved energy from specific DSM measures can be combined with estimates of the amount of total energy that could be saved by implementing each measure to construct a cost of saved energy curve.

The example shows how much electricity might be saved beginning with the lowest-cost measure. Improved energy-efficiency in industrial processes, which has a negative cost because the efficiency measures actually cost less to install and operate than standard measures. The measures - efficient office machines, efficient air conditioning, efficient electric motors and drives, efficient non-residential lighting, and efficient residential lighting are arranged in order of increasing cost. If the objective is to minimize the total cost of energy services, one would plan to implement DSM measures until their cost of saved energy reached the cost of supplying and delivering electricity.

Preparation and Assessment of Supply Plans and DSM Plans

Once data on the possible supply-side and DSM options have been assembled, and a list of the most attractive options in each category has been decided upon, the next step in the planning cycle is to compile the options into candidate supply and DSM plans that help to meet forecasted electricity demand.

Supply Plans

A *supply plan* is one that meets the electricity needs indicated in the demand forecast in a practical manner using supply-side resources. Many different candidate supply plans can be assembled from a list of candidate supply resources. Reducing the list of supply plans to a manageable few is undertaken by linear programming software tools. Some of the elements that must be considered in preparing and evaluating supply plans are:

Location of power plant or other supply resources: What sites are suitable for hosting power plants? Access to fuels or resources, access to transmission facilities, population density, and political and environmental considerations all play a role in determining where facilities can be sited. This issue is especially critical for medium and large hydroelectric facilities.

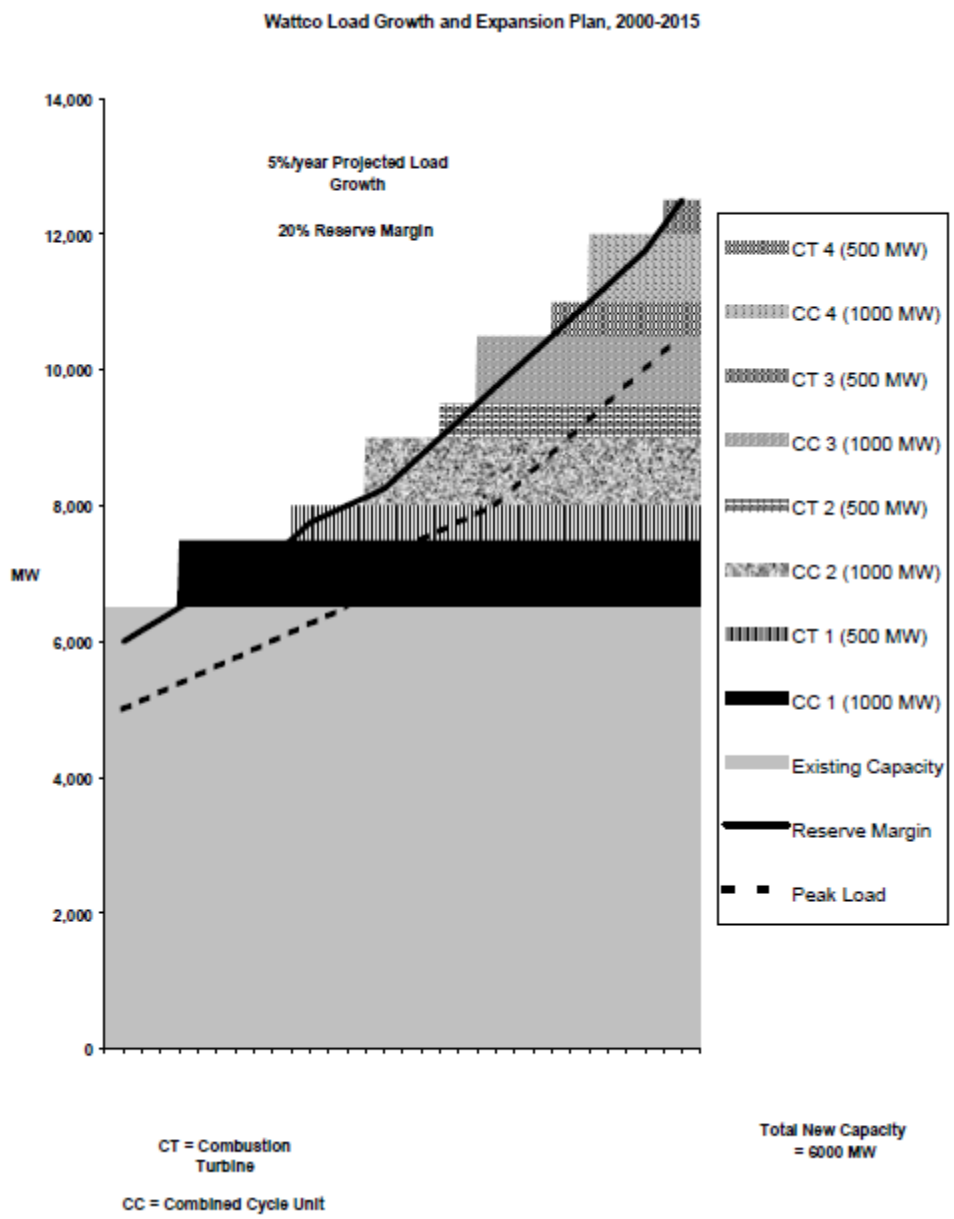
Timing relative to need: When will electricity supply resources be needed? For power plants that require a long lead time to construct, planning must start well in advance of when power will be needed. This is a critical issue for large baseload power plants, as well as, again, large hydroelectric facilities.

Costs and financing: How much money will be needed? How do financing needs compare with the availability of capital? Are the facilities included in a plan suitable for private, as well as public, financing?

System integrity and reliability: A supply plan should meet forecasted peak power demand with sufficient capacity to spare for emergencies.

A simplified preliminary supply plan for an imaginary electric utility is contained in Figure 2. It consists of existing resources, and new resources added to meet load. The new resources are a mix of combustion turbines (CTs) and combined cycle units (CCs). Unless a natural resource such as a river is close and can be built without environmental damage, CCs are often the economical choice for serving loads. CTs are usually the least-cost choice for meeting peak demand (and providing a reserve margin).

Figure 2. Energy Efficiency Options



Source: US Agency for International Development: Global Center for Environment, Office of Energy, Environment, and Technology. *Best Practices Guide: Integrated Resource Planning For Electricity.* (Washington, DC).

The figure is simplified to show how new resources may be planned to meet forecasted demand. In an actual system, some existing resources may be retired, other resources than CTs and CCs may be planned, and the size of the capacity additions will vary from the largish generic capacity additions shown. In developing candidate supply plans, many alternative resource configurations are prepared and assessed using linear program software.

Assessing Supply Plans

Each candidate plan must be assessed using such criteria as cost (capital cost, total cost and rate of return on investment), technical reliability (often measured as loss-of-load probability or reserve margin), environmental impacts (air pollutants, solid waste created, land area lost), and other quantitative and qualitative criteria. Standard evaluation approaches and software tools are available to aid in the evaluation of candidate plans. Systems planning software tools are used to determine whether the grid configuration included in a supply plan will be adequate to meet energy and power demand, and to simulate the way that the power plants in a supply system are dispatched.

DSM Plans

Once DSM measures have been screened roughly to identify the most attractive options, candidate measures are bundled into prototypical DSM programs that could be implemented to secure the reliability, cost, environmental, and other benefits of the DSM technologies. The delivery of programs requires administration, advertising and marketing, and monitoring and evaluation of results, the anticipated costs for which must be included in screening candidate programs.

Prototypical DSM programs (and, ultimately, those actually delivered) combine one or more

DSM measures with a set of services or inducements to encourage energy users to adopt the program measures. Programs may include information, technical assistance, and certification of vendors, financing, or other services. Program inducements may be include rate designs, monetary incentives and rebates to consumers or suppliers, subsidized financing, or other incentives. DSM programs may be organized around a specific set of technologies, such as technologies for lighting. Alternatively, programs may offer a suite of products and services aimed at decreasing energy use (or reducing peak loads) among a segment of energy users such as household, commercial/institutional, agricultural, or industrial customers.

Assembling candidate DSM plans from candidate DSM programs (and assembling programs from candidate measures) involves weighing a number of considerations. Some of these are similar to the criteria for evaluating supply plans, but some are unique to DSM.

- Technology availability: Are the technologies to be promoted commercially available in the country? If not, what would need to be done to increase their availability?
- Program effectiveness: Common technical measures of DSM program and plan effectiveness are the annual and cumulative energy savings, and annual peak power savings, that can be expected from implementing the programs.
- The timing and persistence of savings: How long will the savings achieved under the program last? When will savings be available, and how does the timing of savings correspond to the timing of electricity needs?
- Financing: Are sufficient funds available to finance the DSM programs at an appropriate level? Can financing be obtained from the same sources as financing for supply resources?
- Social and institutional issues: What are the impacts of candidate programs and plans on customers, the suppliers and installers of appliances and equipment, and others? Will particular DSM programs result in greater local employment than others?
- Environmental issues: What are the environmental impacts of alternative plans?

Assessing DSM Plans

Assessment criteria for DSM plans overlap those for supply plans, and include energy and peak power savings, costs, practicality and applicability, net environmental impacts, and other criteria as described above. The basic measure of the cost-effectiveness of a DSM program or plan is how its costs compare with those of the supply-side resources that it displaces. If its total cost exceeds the total cost of the supply-side resources displaced, a DSM measure is prospective cost-effective. In addition to this total cost perspective, DSM cost-effectiveness may be assessed from the subsidiary perspectives of the utility (the utility cost perspective) and those of participating and non-participating customers.

The most accurate way to calculate the avoided cost of the energy saved via a DSM plan is to compare the costs of energy from integrated resource plans that 1) include, and 2) exclude the

DSM programs to be evaluated. In practice, estimates of avoided costs are often based on the costs of a supply-side plan, and streams of avoided energy and capacity costs by year are used to evaluate the benefits of DSM savings.

Assumptions as to how markets will react to DSM offerings must be made. The experience of earlier DSM programs and initiatives can provide guidance as to the market impacts to expect from particular programs. Until the utility system or other program administrator gains first-hand experience with DSM, informed judgment must be used to establish the initial estimates of program impacts to use in developing the IRP.

Alternative Integrated Resource Plans: Construction and Assessment

The culminating steps in IRP assemble candidate supply- and demand-side plans into a set of

Candidate integrated resource plans, evaluate these IRPs, and select a preferred IRP for the coming years. Table 8 provides a representative guide to the criterion for selection. Candidate IRPs combine plans for supply- and demand-side resources into a *resource portfolio* that meets forecasted electricity requirements. There are two strategies for constructing candidate IRPs from supply-side and DSM plans.

IRPs can be constructed incorporating the energy and peak power savings from a DSM plan into a supply-side plan, then reducing the amount (or delaying the dates of plant construction) of generating capacity added in the supply-side plan so that the electricity supply meets forecasted demand less DSM savings.

Alternatively, software tools are available that can generate and evaluate many different supply/demand combinations.

With either strategy, candidate IRPs must be reviewed carefully to ensure that the candidate plans are fully practical. Deciding among the candidate IRPs is then a matter of setting the evaluation criteria to be applied, evaluating and ranking the candidate plans according to the criteria, and then using the results of the evaluation to decide on one or more preferred plans to adopt for implementation.

Table 8. Energy Efficiency Options

Sample Criteria for Assessment of Integrated Resource Plans

Financial Criteria

- Overall plan cost (including capital, fuel, and other costs, usually expressed in "present value" terms)
- Plan capital cost
- Plan fuel costs
- Plan foreign exchange cost
- Interest coverage ratio
- Return on equity
- Utility net income
- Internal generation of funds

Performance Criteria

- Customers served
- Loss of load probability
- Reserve margin
- Efficiency of energy use (on supply- and/or demand-side)

"Energy Security" Criteria

- Diversity of supply (fraction of each fuel used)
- Use of domestic resources
- Use of renewable resources

Environmental Criteria

- Amount of carbon dioxide produced over the life of the plan
- Amounts of other air pollutants (acid gases, particulate matter, hydrocarbons) produced over the life of the plan
- Amount of land used for energy facilities
- Liquid waste production
- Solid waste production (accounting for differences between hazardous and non-hazardous wastes)
- Plan impact on wildlife, biodiversity

Other Criteria

- Aesthetic issues (impact of plan on recreation, tourism)
- Employment impacts of plan
- Impacts of plan on other economic sectors (both positive and negative impacts)
- Political acceptability/feasibility of plan
- Social implications of plan (including impacts on local and indigenous populations)
- Cultural impacts of plans (impacts on culturally important resources)

Source: US Agency for International Development: Global Center for Environment, Office of Energy, Environment, and Technology. *Best Practices Guide: Integrated Resource Planning For Electricity.* (Washington, DC).

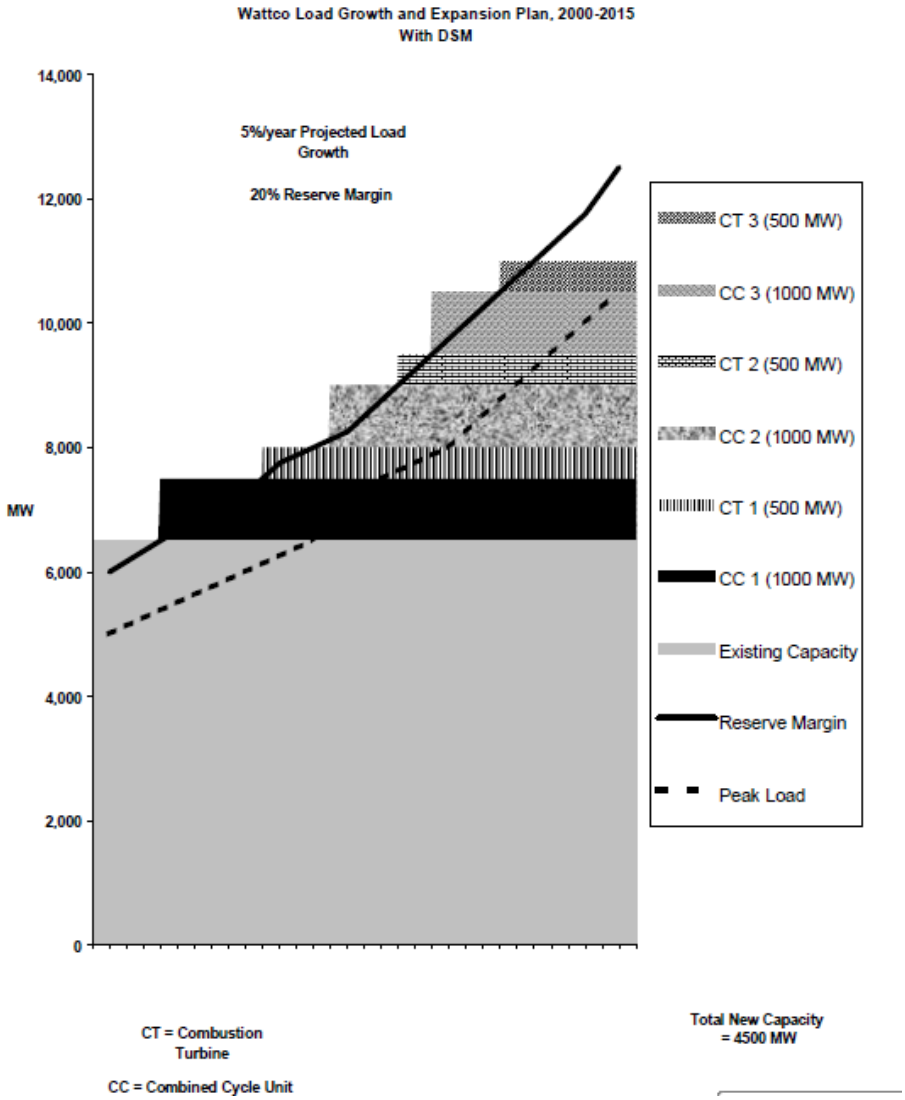
Assessment and Selection

Selecting a preferred IRP from a wide range of choices is a complex process, and should be decided systematically if the result of the planning process is to be credible. There are several software packages that can be used for deciding which plan or plans are most desirable. Most of the programs are based on multivariate linear program technology. Whatever tool or technique is used to aid in deciding among plans, it is ultimately the people involved in the planning process who will decide which plan is to be adopted and implemented. The initial ground rules for the planning process as a whole will have identified the locus of ultimate responsibility for arriving at a decision on the preferred IRP. One of the

critical process principles of IRP is to conduct the decision process in a transparent, clear, and complete manner, so that others may review the decisions made along the way.

IRPs are a mix of supply-side and demand-side resources. While the supply-side resources generally dominate, DSM resources can significantly reduce required supply-side additions over a planning period. This is illustrated in the simplified supply plan for an imaginary electric utility that is contained in figure 3. Because of DSM, the amount of new generating capacity that is required is reduced 25%, from 6000 MW to 4500 MW, due to the reduction in forecasted load. The load reduction results from summing the impacts of the DSM programs in the plan, though the mix of programs is not shown in the figure.

Figure 3. DSM Effects on Projected Load



Source: US Agency for International Development: Global Center for Environment, Office of Energy, Environment, and Technology. Best Practices Guide: Integrated Resource Planning For Electricity. (Washington, DC).

Resource Plan Report

When a final IRP has been completed, it is usually described in a fair amount of detail. An outline for an IRP report is contained in Table 9. Technical appendices may include supporting studies that were done to develop particular kinds of inputs needed for the IRP, as well as detailed input assumptions and model outputs.

Table 9. Outline for IRP Report

IRP Report — Typical Contents

Introduction
Goals and objectives of the planning process; responsibilities of the entity organizing the process; participants in the process.

Summary
Components of preferred resource plan; its costs and impacts; near-term implementation actions to be taken.

Electricity Requirements
Historic usage patterns; methods used to forecast future electricity requirements; key exogenous assumptions; forecasts of energy requirements and demand by usage group (household, commercial, industrial, irrigation, others); forecast scenarios for resource planning.

Supply-side Resources
Existing electricity supply and T&D system; characteristics of feasible supply additions; assessment and screening of options; candidate plans to meet demand forecast scenarios.

Demand-side Resources
Identification of DSM measures by usage group; use of avoided costs to screen options; development of candidate DSM programs and plans.

External Costs and Benefits
Identification of environmental and other externalities to be considered; methods for measuring external impacts of alternative options (physical impacts and, where used, monetized impacts).

Development of Candidate Plans
Approach used to integrate supply and demand options; range of candidate plans considered; criteria used to select short list of candidate plans with different mixes of supply and demand options; sensitivity analysis of results of major plans under alternative assumptions.

Selection of Preferred Plan
Differences among key plans: generation options; T&D upgrades; costs of plans; financial feasibility; environmental impacts (air, water, land); socio-economic impacts; other differences; criteria and process used to select preferred plan.

Preferred and Contingency Plans
Preferred plan (DSM elements; supply elements; detailed costs, benefits, and other impacts; adaptability and resilience of plan in face of risks); contingency plans.

Implementation and Monitoring
Near-term action plan; DSM plan; procedures for interim and full updates to the selected IRP.

Appendices
Supporting studies and data

Source: US Agency for International Development: Global Center for Environment, Office of Energy, Environment, and Technology. *Best Practices Guide: Integrated Resource Planning For Electricity.* (Washington, DC).

Implementation, Evaluation, Monitoring, and Iteration

The adoption of an IRP is a decisional milestone in the planning process, but not its end.
Implementation of the IRP still lies ahead. The IRP serves as a benchmark against which actual utility system performance is measured. More profoundly, the IRP should be a living document, to be revised as conditions change and as new information becomes available. During implementation of the last adopted IRP, ongoing evaluation of the effectiveness of the resource plan is useful. Implementation of the supply-side components of an IRP involves execution of contracts for the purchase of power or the construction of utility-owned facilities.
Often competitive requests for proposals are used to implement the several supply-side elements of an IRP. During the process of soliciting and evaluating bids to provide supply-side resources, the utility may gain information about the cost and availability of options in the preferred plan varies significantly from the assumptions in the preferred plan. This may require revisiting and revising the plan.

Once resources added pursuant to a procurement process are in service, their performance may be better or worse than had been expected. Monitoring the performance of the electric system, and in particular the new elements added in implementing a resource plan, provides critical information for the next iteration of the resource planning process. In the case of performance at lower levels than expected, if a common type of power plant or other plant is involved, performance in a specific utility system can be compared with data on performance in other jurisdictions to help determine whether the problem is localized or is common to the technology.

In the case of DSM programs and plans, the utility or other program administrator typically will monitor the number and types of customers participating in programs, the electric energy and peak savings experienced, and the costs of implementing the programs. Monitoring data facilitate subsequent evaluation of the effectiveness of the DSM programs, and the comparison of program impacts with original estimates. DSM Program evaluation assesses the impacts of programs on energy consumption, the process by which they being delivered and their effectiveness in causing market development.

Process evaluation aims to assess the implementation of programs. This includes management, marketing, field delivery of programs, quality control procedures, and the response of target groups, such as customers and dealers, to the program. Process evaluations provide critical feedback as to both tactical issues of program delivery and strategic issues of program design. They inform program sponsors, managers, and stakeholder parties both about mid-stream corrections that may be feasible and desirable, and about how to build on the lessons of the program in promoting replication.

Process evaluations employ several methods. These include in-depth surveys with program managers, site visits, survey techniques, focus groups, and documents review. Process evaluations must be thoroughly coordinated with impact evaluations. Though their methods are mostly distinct, there are some cases in which survey instruments are administered to participants and non-participants to serve both impact and process evaluation needs.

Assessing the performance of DSM programs is relatively more difficult than evaluation of the performance of supply-side resources and programs. One cannot directly observe the impact from DSM in the way that one can measure the production and costs of production from a supply resource. Rather, one must infer results through impact evaluation activities.

A variety of impact evaluation methods have been developed, applied, and refined. The major methods used in impact evaluation are indicated in the table. Several of these have been gathered together into an International Performance Measurement & Verification Protocol (IPMVP.) in which several countries participate.

Table 10. DSM Impact Evaluation

Major DSM Impact Evaluation Methods

Approach	Characteristics of Approach
Site inspection	Inspection of a larger facilities or a sample of smaller ones to verify installation of DSM measures. Does not directly measure energy consumption. Does not address "free rider" issue.
End use metering	Measures specific circuits in larger facilities or a sample of smaller ones to quantify energy consumption. Does not measure energy savings measurement applies to period before and after installation of DSM measures. Does not address "free rider issue."
Analysis of billed consumption	If billed consumption data are available, statistical analysis of consumption before and after DSM measure installation can estimate impact from DSM. If a comparison group of "non-participants" is included, can begin to address "free rider" issue and estimate net impact of DSM.
Surveys of customers	Surveys of customers, both "participants" and non-participants, can be used to strengthen conclusions drawn from any of above approaches.
Market transformation	Examines broader market trends such as the mix of equipment sold and installed in order to infer the sustainability of DSM impacts after specific DSM programs have been concluded.

Source: US Agency for International Development: Global Center for Environment, Office of Energy, Environment, and Technology. *Best Practices Guide: Integrated Resource Planning For Electricity.* (Washington, DC).

Since planning is a continuous process, the development of IRPs is repeated periodically. Major planning cycles may vary from two to five years. Interim updates may be scheduled, or midcourse corrections may make as necessary to respond to changing conditions. Flexibility is important. When a development occurs that was not adequately foreseen or considered, it is important to revisit the plan, rather than rigidly abiding by it, or, in the alternative, bypassing it.

When done properly, IRP provides a structure and an opportunity for utility systems and stakeholders to learn and to develop plans in a co-operative atmosphere. Although the IRP ultimately adopted is considered the blueprint for utility activities, conditions do change.

Changes in an IRP over time are inevitable, necessary, and desirable, when made in a transparent and well-documented fashion.

Conclusion and Next Steps

The major conclusion is ANRE needs to step back from the micromanagement of investment activities and develop a broader approach to investment. Electricity infrastructure requires long term planning with many considerations. Moldova, given its external constraints with suppliers, needs to develop a way to diversity out of the situation they are currently being forced to face. In addition, the sector is working hard to comply with Energy Community mandates that will allow they access to other sources of power that will certainly be cheaper and more reliable than the sources they have used in the past. The first step to such a process is to uncover your opportunities and determine which ones are economically and technically feasible in the short, intermediate and long term. An IRP will provide that direction.

In terms of next steps the recommendation is to contact donor organizations and banks active within Moldova who could finance the IRP study. The request would have to come from the Ministry of Economy. As an example through the World Bank grant money is available to undertake such studies. Direct country requests can also be made, but the limitation would be the country donating the money would want a consulting firm from their own country to perform the Study. Once financing is confirm the stakeholders in energy (which includes gas) should agree to undertake the tasks for all of them will be required to provide highly technical data as inputs to the Study. In this situation ANRE should be the coordinator as the overall manager of the sector.

The IRP itself can serve as a basis to both develop the sector and diversify. Diversification is critical as the major flash point of the sector is price. Diversification would open up opportunities to import from anywhere in Europe as long as the transmission infrastructure is in place to draw it within the grid. Given the public's sensitivity towards electricity prices a high priority should be given towards contracting for the IRP and getting a plan for more economic terms for energy.

Prior to the implementation of an IRP, the ANRE investment department needs to expand its investment planning horizon to at least the requirements of the Energy Communities Second and Third Package. For transmission the time period is 10 years and for distribution it is 5 years. Although asking for detail within the coming year is acceptable, ANRE needs to have a sense of what the participants will be doing in the longer term. Electricity is a business where Projects can sometimes take years to develop, plan and implement. ANRE, as the regulator, needs to be aware of what the licensee have planned for long term growth and maintenance of the grid.

For questions regarding this publication, please contact Erin Hammel (ehammel@naruc.org) or Jargalan Jambaldorj (jjargalan@naruc.org).

National Association of Regulatory Utility Commissioners (NARUC)
1101 Vermont Ave, NW, Suite 200
Washington, DC 20005 USA
Tel: +1-202-898-2210
Fax: +1-202-898-2213
www.naruc.org