INTEGRATED RESOURCE PLANNING (IRP)[1]

Amulya K.N. Reddy and Gladys Sumithra

(International Energy Initiative, 25/5 Borebank Road,
Benson Town, Bangalore -- 560 046, India)[2]

> *I keep six honest serving men*
> *(They taught me all I knew);*
> *Their names are What and Why and When*
> *And How and Where and Who*
> *-- Kipling*

1. WHAT is IRP?

IRP is an approach to energy planning. It is based on the view that what human beings want -- as individuals and as societies -- is not energy *per se* but the services that energy provides. Development requires, therefore, an increasing level of energy services to satisfy basic needs more fully, to improve the quality of life, to increase production and to advance development. Thus, the level of energy services must be taken as the measure of development, rather than the magnitude of energy consumption and supply.

The level of energy services can be improved by increasing energy consumption -- this requires an increase of energy supplies and/or by increasing the efficiency with which end-use devices utilize energy -- this requires efficiency improvements[3]. Further, an increase of energy supplies can be

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[1] Based on the presentations made at the Workshops on (1) *Integrated Resource Planning* organized by the *Working Group on Energy Strategies and Technologies* of the *China Council for International Cooperation on Environment and Development*, the International Energy Initiative and Institute for Techno-Economic and Energy System Analysis (ITEESA), Tsinghua University, at Beijing, China, on May 8-16, 1995, and (2) *Privatization and Regulation in the Power Sector* organized by the International Energy Initiative at Hotel Imperial, Singapore, on June 21-23, 1995.

[2] Tel/Fax: +91-80-554 8426, E-mail: amulya@iei.uunet.in

[3] When energy is used efficiently, the expansion of energy supplies to increase the level of energy services can be partly, if not completely, avoided. Hence, the adage: a kilowatt hour saved is a kilowatt hour generated, which is not strictly accurate because the energy saved is at the consumption end of the transmission-distribution system whereas the energy generated is at the generation end, and in between are all the T & D losses. In fact, therefore, a kilowatt hour saved is equivalent to 1.29 kilowatt hour generated at 22.5% T & D losses.

achieved either by centralized generation (from conventional sources) or from decentralized generation from non-conventional sources. The additional constraint that the sources should be environmentally sound leads to the restriction that the centralized sources should be "clean" (clean coal, natural gas, hydro) and that the decentralized sources should be renewable (biomass biogas and producer gas), wind, small hydel and solar).

Such an abundance of possibilities implies that a central task is to arrive at a mix of sources to increase energy services that satisfies an objective. *Integrated Resource Planning is an energy planning approach to identify the mix* of "clean" centralized, decentralized renewables and efficiency improvements that will meet the demand for increasing energy services for instance at least cost or least environmental impact.

2. **WHY is IRP essential?**

The electricity systems of most developing countries are trapped in several crises if by the word crisis is meant *a situation that does not permit continuation of old patterns of behaviour*. In particular, there are four crises: the capital crisis, the performance crisis, the access crisis and the environmental crisis.

The *performance* crisis is characterized by the serious deterioration in the technical and financial performance of the electricity utilities. The *access or equity* crisis arises because the electricity system was (and is) expanded in the name of the people but a significant fraction of the population does not benefit directly from electricity because it has no access to it. The *environmental* crisis is based on the fact that almost every conventional electricity generation project -- whether coal-based, oil-based, nuclear or hydro -- has major environmental impacts due to which they are often under public attack on environmental grounds.

The essence of the capital crisis of the electricity systems is that their financial requirements are several times more than what can be provided by its traditional supplier of capital, namely, the governments.

In quantitative terms, the investment I, required in any particular year t for expansion of installed capacity, can be estimated with the following formula[4]:

$$I(t) = E(t-1) \times \mathbf{a} \times g(GDP) \times UCOP = E(t-1) \times g(CAP) \times UCOP$$

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[4] Amulya K.N. Reddy, "Problems arising from Current Approach to Electricity Planning", Workshop on *Integrated Electricity Planning*, International Energy Initiative, 24 February, 1993, Bangalore.

where E(t-1) is the installed capacity (in MW) at the beginning of the base year, g(GDP), the growth rate of the GDP, g(CAP) the growth rate of installed electrical capacity, a = g(CAP)/g(GDP), the ratio of the growth rates of installed electrical capacity and GDP, and UCOP, the unit cost of installed capacity in US $/MW.

If E(t-1) the installed capacity (in MW) at the start of the base year, as well as **a** and UCOP, are taken as *given,* one is left with I, the investment required for expansion of installed capacity and with g(GDP), the growth rate of the GDP. If it is not acceptable to lower the economic growth rate below a certain minimum value of g(GDP), then a certain minimum investment I has to be ensured to sustain this growth rate.

In theory, there are five sources for this investment, I: funding from the central government[5]; from the Indian electricity sector (consisting mainly of the utilities, but also including the corporations concerned with electricity generation and electrical plant manufacturer if they exist in the country), from the national private sector; from the multilateral banks such as the World Bank and the Asian Development Bank; and from the foreign private sector.

The typical situation is that the government has reached its limit as far as funding was concerned. Funding possibilities from the electricity sector are almost zero because it has virtually no surpluses to make available for investment. The national capital market does not have adequate spare funds to make a significant contribution from the Indian private sector. The World Bank highlighted in 1989 an "unbridgeable gap" between capital demand and supply at the level of the whole developing world. The Bank stated that the requests from the electricity systems of developing countries added up to $100 billion per year in response to which only about $20 billion was available from the World Bank and other multilateral sources, leaving a gap of about $80 billion. In other words, there is no hope of getting funding from the multilateral banks such as the World Bank and the Asian Development Bank. In this capital crisis, Option #1 -- the soft option preferred by governments -- is *the mendicant's approach* of begging for funds from the foreign private sector to fill the gap between the annual investment required and the maximum funding that could be provided by the central government.

The hard option #2 arises from taking as given both E(t-1), the installed capacity (in MW) at the start of the base year, as well as **a** and UCOP. If, in addition, there is a decision to tighten one's belt and manage within one's means, then I gets fixed at what can be raised internally, and one

[5] Central *and* state governments in a federal set-up.

has to accept whatever economic growth rate comes out of the analysis. The problem is that this growth rate may turn out to be unacceptably low, say 2 per cent, i.e., less than the population growth rate -- in which case this option based on *the reduced-growth-rate approach* is unacceptable.

The Integrated Resource Planning approach is Option #3. It takes both E(t-1) as well as a minimum growth rate g(GDP) as given, and explores the possibility of lowering the annual investment required by decreasing the product (**a** x UCOP).

Decrease of the product (a x UCOP) can be achieved by decreasing **a**, the ratio of the growth rates of installed capacity and GDP and/or by decreasing UCOP, the unit cost of installed capacity in Rs crore/MW. The factor **a** which is conventionally taken between 1.5 to 2.0 can be reduced to much lower values through efficiency improvements[6], i.e., through getting a greater GDP bang for a lower energy buck. [China has reduced its energy intensity from around 1.4 in 1978 to around 0.8 in 1993.] UCOP can also be lowered by reducing the cost of conventional generation through efficiency improvements and the cost of transmission by reducing T & D losses and/or by generating at the consumption sites through non-conventional decentralized technologies (for example by co-generating electricity in bagasse boilers in sugar factories, or by decentralized electricity generation in villages from biogas- or producer-gas). Thus, apart from the improvement of end-use efficiencies, the efficient production and transmission of conventional energy and the harnessing of non-conventional decentralized sources of energy can also reduce the financial requirements of the power sector.

At the same time, the exploitation of decentralized renewables and efficiency improvements are crucial ways of reducing negative environmental impacts. It is this concern for achieving environmental soundness that has been one of the main motivations for *Integrated Resource Planning*.

Thus, Integrated Resource Planning is a powerful tool for tackling the capital and environmental crises.

3. **WHO should do IRP?**

Thus far, IRP is mainly pursued in USA -- but not in Europe and Japan -- where regulatory commissions have made IRP mandatory in 40 out of 50 states. Also, in the USA, IRP is pursued only for electricity; it is not discussed for oil product prices.

In the USA, IRP is done primarily by the utilities, but there is nothing that restricts the central or provincial governments of a developing country (through the finance and energy ministries) from carrying out such exercises. There are, however, concerns over IRP being done by governments. Since in the USA, IRP is often done under the mandate of the regulatory commissions, there is a view in some quarters that IRP necessarily means a *command and control* economy.

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[6] The term "efficiency improvements" is used here in the general sense to include using less energy for a given energy service in the same type of device, but also inter-fuel substitution and structural changes in GDP.

But, this not be the case at all. If the governments carry out IRP exercises and have a reasonable idea of what would be a rational mix of "clean" centralized, decentralized renewables and efficiency improvements to meet the demand for increasing energy services, such an idea can then become the basis of prescribing the rules of the game for the market and ensuring that there is a level playing field for candidate technologies to find a place in the mix. Government intervention is involved but not necessarily with counter-productive incentives or price controls as a pre-requisite for IRP implementation.

In addition, the mix suggests the directions for research and development support. The bias in research and development against some of the most promising renewable technologies and efficiency improvements that characterized the past need not be perpetuated. The government therefore has to play an enabling role for the market to be fully effective since prices alone cannot get it right. This means that the market for energy technologies and IRP must complement each other.

4. **WHERE should IRP be done?**

It has been suggested that apart from utilities, the governments of developing countries -- of not only market but also centrally planned economies -- would benefit from IRP exercises at the central, provincial and city levels. In fact, the most important challenges are to devise policy so that the plans of utilities and governments are harmonized. In fact, IRP can be done at the firm or farm level and in this case too governmental policy formulation can attempt to bring about win-win situations so that what is in the interests of the firm or farm is also in the interests of the government, or at least that what is in the interests of the government is also in the interests of the firm or farm.

5. **HOW should IRP be done?**

A step-wise approach to IRP would consist of

(1) defining the objectives of the entity doing the IRP, for instance, in the case of a national government, the objective may be sustainable development consisting of (a) economic efficiency, (b) satisfaction of basic human needs starting from the needs of the neediest by widening access to energy services and increasing their level, (c) strengthening of self-reliance and the empowerment of settlements, and (d) harmony with the environment;

(2) constructing demand scenarios incorporating the objectives defined in the above step;

(3) listing of all the options of providing the energy services making sure that the options are not restricted only to centralized supply options but also include saving options as well as decentralized supply options;

(4) costing all the options on a common basis, ensuring that environmental costs (pollution controls, emission fees, etc.) are included in the costing, i.e., externalities are internalized[7];

(5) estimating the potential contribution of each of these options of saving and generation to a supply mix;

(6) ranking the options according to increasing cost;

(7) and counting the cheapest option of the first element of the supply mix, then the next more expensive option, ... , and so on until the energy requirements are met, in which case the resulting cost-supply staircase yields a *least-cost mix* that is the basis of the IRP.

In fact, the DEFENDUS methodology provides a simple method of estimating energy demand and designing energy supply so that the planner has complete control over the entire computation. The planner can evolve a method that can be tailor-made for the particular case under consideration. The use of spreadsheet packages enhances the power of the planners because they can make alterations without being dependent on the source-codes of the programmers. Auditing of the computation is easy because the progress of the calculation can be checked manually with a calculator. Also, the steps followed are "transparent" enough to be easily understood and amenable to easy modification by another planner. And those who wish to replicate computations can use the first computation as a model and/or "default case" and therefore avoid "re-inventing the wheel".

Though the methodology was initially developed for electricity, it has been shown to be amenable for use for other energy sources/carriers. It is also possible to go from scenarios for a single source/carrier to scenarios for a number of sources/carriers, i.e., from source/carrier planning to energy planning. The methodology also permits an estimate of the environmental impacts and the macroeconomic implications of the DEFENDUS scenarios.

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[7] In much of the IRP that is done today, these environmental costs are excluded.

6. **WHEN should IRP be done?**

To avoid "closing the stable after the horse is stolen", IRP should obviously be carried out as part of energy planning before the energy investments are made and the policies to guide or induce such investments are formulated. In any case, such a prior exercise before the implementation of energy plans will quantify the problems of demand and supply and provide bench-marks for expenditures from the total cost of the least-cost IRP. It will also screen technologies of saving and generation to highlight ones that are outside the least-cost range.

7. **IRP and Demand-Side Management (DSM)**

In view of the emphasis being devoted to DSM for developing countries by many industrialized countries and non-governmental organizations in those countries, it is important to clarify some differences in the scope and thrust of IRP with respect to DSM.

Firstly, whereas a least-cost plan from an IRP exercise invariably includes cost-effective DSM measures, all DSM measures need not necessarily be a part of the outcome of IRP. Often, DSM programmes do not compare the costs of DSM measures with generation options; thus, they argue for them irrespective of their *relative* cost-effectiveness.

Secondly, IRP assumes an attitude of humility: "We do not know which technologies of saving and generation will be part of the least-cost mix; let us discover these technologies which form part of the mix!". In contrast, DSM strikes a more confident note: "We know which DSM measures are cost-effective; let us implement them!"

The distinction is partly because in IRP the cost comparison is with other constituent of the mix including generation options. DSM programmes tend to compare costs with a particular generation option.

Finally, IRP involves both *supply*-side management (SSM) and *demand*-side management (DSM), but not a blind addition of these two crucial approaches. An essential characteristic of IRP is an *integration* of SSM and DSM by satisfying an objective such as least cost.

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