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INTEGRATED ELECTRICTY PLANNING: SOME PERSONAL REFLECTIONS

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1. What is IEP?

IEP is an electricity planning approach to identify a mix of centralised sources, decentralised/renewable sources and DSM measures (including efficiency improvements) that will meet the demand for increasing energy services at least cost (or least environmental impact). IEP is a special case of the more general integrated resource planning (IRP), which can be used for resources such as oil, water, land, etc.

2. *Seven step methodology of IEP* (Figure 1)

- Define the objectives of the entity doing the IEP. In the case of a national government, the objective may be sustainable development defined as a process of growth of energy services.
- Construct demand scenarios incorporating the objectives defined in the above step;
- List all the options of providing the energy services making sure that the options are not restricted only to centralised supply but also include saving as well as decentralised supply options;
- Cost all the options on a common basis, ensuring that environmental costs (pollution controls, emission fees, etc.) are included in the costing, i.e., that externalities are internalised;
- Estimate the potential contribution of each of these options of saving and generation to a supply mix;
- Rank the options according to increasing cost (Figure 2);
- Count the cheapest option as the first element of the supply mix, then the next more expensive option, and so on until the energy requirement is met, in which case the resulting cost-supply staircase (Figure 3) yields a least-cost mix as an output of the IEP process.

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1. IISc work on IEP

The IEP programme was developed (along with Dr Gladys Sumithra, Dr P Balachandra and Ms Antonette D'Sa) between 1987 and 1991 at the Department of Industrial Management (as the Department of Management Studies was then known). This programme had to be pioneering and independent because at that time it did not have foreign or indigenous models to emulate.

After several years of hard work on the end-uses of electricity in industry and homes, etc., the group evolved the DEFENDUS **(DE**velopment-**F**ocused **END-U**se-oriented **S**ervice-directed) methodology for estimating the demand and supply of energy in an energy system. This methodology provided a simple spreadsheet method of computing energy demand and supply in which the analyst has complete control over the entire procedure.

The DEFENDUS approach to energy planning was used initially for electricity in the state of Karnataka. The work was published *in extensio* in 1991 in the Indian policy journal, ***Economic and Political Weekly***[2]. A popular version of the work was presented at Pune on as the PARISAR Annual Lecture of 1990 which was eventually widely disseminated in booklet form[3]. It was also shown that the DEFENDUS approach could be used for other energy sources/carriers and other geographical regions[4].

2. An Example of an IEP Exercise

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[2] Amulya K N Reddy, Gladys D Sumithra, P.Balachandra and Antonette D=Sa, " A Development -Focused End-Use-Oriented Electricity Scenario For Karnataka. Part 1 **Economic and Political Weekly,** Vol XXVI, Nos 14 & 15, April 6 1991 pp 891-910 Part II **Economic and Political Weekly** April 13 1991, pp 983-1002.

[3] Amulya K N Reddy, Development, Energy And Environment - A Case Study Of Electricity Planning In Karnataka. **Parisar Annual Lecture** 1990. Published by: S.J.Patwardhan, Secretary, Parisar, Yamuna, I.C.S.Colony, Ganeshkhind Road, Pune 411 007.

[4] Amulya K N Reddy, Gladys D Sumithra, P.Balachandra and Antonette D=Sa, Integrated Energy Planning: Part 1. The Defendus Methodology, **Energy for Sustainable Development**, Volume II, No.3, September 1995.- pp-15-26.

Amulya K N Reddy, Gladys D Sumithra, P.Balachandra and Antonette D=Sa, Integrated Energy Planning: Part Ii. Examples Of Defendus Scenarios **Energy for Sustainable Development**, Volume II, No.4, November 1995. pp- 12-26.

The first least-cost electricity scenario for Karnataka published over a decade ago in 1991 described the main outputs that result from an IEP exercise.

Rigorous comparative costing was done for 15 centralised, decentralised and saving technologies. The cost-supply curve (Figure 4) shows the least-cost mix of technologies required to meet the energy requirement for Karnataka (as perceived in 1986 on the basis of government policies prevailing then). It was found that efficient motors were the cheapest technology, and therefore, they became the step in the IEP staircase, i.e., the first element of the mix. The next step consisted of improvement of irrigation pumpsets, followed by small hydel, compact fluorescent lamps, cogeneration from bagasse fuel in sugar factories, biogas, producer gas and then natural gas.

In contrast to the least-cost mix, the official approach started with nuclear, coal and hydel. It turned out that the least-cost supply scheme was only about ***one-third*** of the cost of the conventional centralised supply scheme corresponding to what may be called "high-cost planning". The area between the maximum-cost and least-cost curves (Figure 4) represents the waste of public funds that would result from adopting, not the least-cost mix, but an arbitrary mix that has obviously been arrived at by considerations other than cost minimisation. The global environmental impacts, measured for example by the CO_2 emissions, are less for the IEP scenario compared to the high-cost scenario. The IEP supply scheme can also achieve energy goals quicker. Thus, IEP scenarios that include efficiency improvements and decentralised sources are ***cheaper, quicker and more environmentally benign.***

The IEP scenario has other advantages, for example, it is a massive employment-generating programme. And the development focus of the IEP scenario would correspond to a dramatic improvement in the quality of life.

3. Advocacy for IEP

Apart from the papers that were published, advocacy for the DEFENDUS approach was vigorously pursued through (1) presentations, (2) workshops, and (3) least-cost electricity planning exercises in various states of India and in certain Asian countries.

A number of presentations of the work were made at a various centres in India and abroad -- Bangalore, Mysore, Berkeley, Washington, DC, Montreal, Princeton, Bangkok and Stockholm. These presentations received a warm reception.

As many as 12 workshops were held between 1993 and 1996 exposing over 375 participants, mostly from electricity boards, to the concepts and methodology of IEP through lectures and/or hands-on spreadsheet-based computer training. For instance, IEI supplied 314 pages of course materials and software consisting of floppies with 17 spreadsheets to the training course at Tsinghua University, Beijing

Least-cost electricity-planning exercises were carried out for Karnataka, West Bengal, Kerala, Andhra Pradesh and Tamil Nadu states of India.

4. Potential Beneficiaries of IEP

IEP offers benefits to government, electricity utilities, electricity regulatory commissions and connected consumers.

5. Was IEP a failure?

With all the pioneering and indigenously developed work and the substantial potential benefits to government, utilities, regulatory commissions and connected consumers, one would have expected these bodies to enthusiastically accept and implement the least-cost plans. In fact, IEP has been completely ignored at the state and central levels. It was not even put on the agenda of energy ministries and discussed. It appeared that years of work "had gone down the drain". If the work were fundamental in nature, and therefore without any thought of application in mind, the neglect of IEP would not matter. However, in advocacy work intended to change policy and to lead to implementation, the neglect appeared to be a serious shortcoming.

For many years, this total neglect of our IEP work was construed as a major failure that had to be accepted gracefully with an attitude of "we have done our duty". In recent years, however, the search for an explanation for the "failure" of IEP has attracted interest. It soon became clear that there are factors external to the country as well as internal factors within the country that have not been favourable to IEP.

With the rise of liberalisation, privatisation and globalisation (LPG), the ***external environment*** became unfavourable for IEP and even hostile to it. IEP was considered to be part of central planning. With liberalisation, IEP has been side-lined. Leave-it-to-the-market became the mantra. IMF-led institutions jettisoned IEP and put their emphasis on power sector reforms – unbundling, privatisation, etc.

The ***internal environment*** was also not conducive. No agency/department of the government was charged with least-cost planning. There was no integrating body assessing the demands of the various supply agencies and allocating appropriate roles to them. Instead, different supply agencies bargained for budget shares in a situation where some agencies were much more powerful than others. Each electricity source was a different empire and under a different department/ministry. These autonomous empires tried to expand at each other's expense. The powerful empires (for example, the atomic energy establishment) grabbed a larger share of the resource allocation.

The exercise was not an optimisation process at all. It was a bargaining process in a resource market involving various demand-making departments and a few resource-supplying departments. The main result of this process was that resource constraints are introduced post-optimisation. The final distribution is therefore not an optimum solution. With all the cards stacked against IEP, it should be no surprise that IEP has not flourished.

6. Barriers to IEP

Institutional Barriers: There is no institutional vehicle for IEP. Decision-makers assume responsibility only for supply-side management but not for demand-side management.

Dominance of old centralised supply-biased paradigm: Decision-making is based on a centralised supply-biased paradigm that by and large sidelines decentralised sources and demand-side management (DSM). The “any-power-is-better-than-no-power” syndrome aggravates this bias.

Information Barriers: Unfortunately, IEP is information-intensive and knowledge-intensive; agencies that can benefit from IEP, for example, energy ministries, rarely have the requisite information and knowledge or can obtain it by outsourcing.

Market Barriers: A major barrier arises from open/hidden subsidies to conventional energy sources particularly fossil fuels. As a result, the playing field for the contending options is not level. Electricity prices do not reflect costs. And, market prices do not reflect environmental costs and damage; in fact, they mask the environmental advantages of the new and cleaner energy options. There is also first-cost sensitivity (where decisions are based on initial, rather than life cycle, costs). Finally, indifference to energy costs leads to limited attention to alternative energy options.

7. Necessary and sufficient conditions for IEP implementation

- There must be commitment at the highest central/state government level to integrated electricity (least-cost) planning in which supply and saving options are treated on equal terms.
- This commitment must be demonstrated by the establishment/designation of an integrating agency with executive powers to decide on contributions from various supply and saving options.
- The integrating agency must have in-house capacity to carry out IEP or be willing to out-source it to academic institutions and/or NGOs.

It is clear that none of the above conditions obtained for the IEP exercises that were carried out in India. There was no commitment at the highest levels of the central and state governments to integrated electricity (least-cost) planning. There was no integrating agency with executive powers to decide on contributions from supply and saving options. The agencies that may have had interest in IEP did not have in-house capacity to carry out exercises and were not willing to out-source it to academic institutions and/or NGOs. No wonder the DEFENDUS exercises were ignored. They were not a failure; they were premature and ahead of the times.

However smart a proposal, if it depends upon integrated action from several ministries/departments, it will not be implemented unless there is an integrating agency. Way back in the early 1980s, there was an attractive proposal to tackle the oil crisis, which in fact was a diesel crisis. Replacing kerosene lamps with electrical lighting would allow the removal of subsidies on kerosene, which would allow an increase in diesel prices. This, in turn, would tilt the modal choice for freight transport in favour of railways, thus reducing the demand for diesel for trucks. But, this proposal depends on co-ordinated action by electricity boards, road transport authorities, railways and petroleum ministries. This co-ordination could not be achieved without an over-riding executive

authority. In the absence of such an authority, the attractive proposal remained on paper.

8. Partial implementation of cost-supply staircase

There is a “silver lining to the IEP cloud. This is the “good news” that many steps of the cost-supply staircase have been implemented. Out of 7 technologies in the least-cost energy mix, four technologies have been implemented in Karnataka -- small hydel, compact fluorescent lamps and surplus electricity from bagasse combustion in sugar factories. That is four steps in the seven-step least-cost energy staircase have been climbed.

The Defendus scenario for Karnataka cannot take all the credit for this extent of implementation, but the advocacy efforts have had considerable influence. The question arises as what has enabled some technologies to spread while others have not taken off. It appears that technologies that are economically viable can be disseminated through the market with in some cases the help of some enabling policies of the government. In contrast, the technologies that require significant intervention and innovative policies from the government cannot take off without (1) commitment at the highest central/state government level to integrated electricity (least-cost) planning and (2) an integrating agency with executive powers to define and ensure the implementation of the least-cost mix. In that sense, the partial success of the IEP reveals what can and what cannot be achieved without government will and support.

9. Bangalore Metropolis and its services

It appears that the lessons from the experience of IEP have much wider applicability than electricity planning. In fact, any challenge that requires an integrated and holistic approach can benefit from the lessons from the IEP experience.

Consider Bangalore Metropolis. Its smooth functioning depends on the sustained provision and maintenance of at least 26 services managed by at least 29 agencies (Table 1). Every service is associated with a stress that provokes a response and the stress-response relationship invariably displays a "Hooke's Law" behaviour (Figure 5). With increasing stress, the response changes reversibly only up to an "elastic limit"; beyond that, the system breaks down catastrophically and irreversibly. The challenge therefore is to identify for the various services parameters for (a) the stress, (b) the response and (c) the indicators that yield information on how far the service is from break down (and

the inelastic limit). A crude first attempt list of stress and response parameters for Bangalore's services is given in Table 1. The table also includes a few indicators to reveal how far the service is from breakdown, i.e., they are an early warning system. An integrating decision-making agency such as a Bangalore Task Force must monitor these indicators and assume/be delegated executive authority to take integrated action when the indicators approach breakdown.

10. Integration of Services

Services interact and therefore this interaction must be taken into account and used. Take the case of roads (Figure 6A). There is the constant problem of one agency, BMP, repairing and surfacing the roads, and other agencies, such as BWSSB and BSNL, digging them up very soon afterwards. Decades have passed and the concerned agencies have not been able to co-ordinate. Quite clearly, the relevant services – roads, sewerage and telephones – interact with each other and must co-ordinate their actions. In another example (Figure 6B), if the agency that approves house plans, insists as in Israel, that solar water heaters must be installed, then the power requirement of each housing unit should be reduced by a couple of kilowatts. Imagine the saving of electricity over thousands of apartments. It has been estimated that solar water heaters in Bangalore can save as much power as a Kaiga-type nuclear power station.

All this means that in a matrix of services there should be terms to express the interaction between services. Much patient work has to be done to develop the interaction coefficients.

11. Routine and Emergency Operation for Services (Figure 7)

When a service is well within its "elastic" limit, it can be operated in the normal/routine manner via the relevant ministry and department/agency. When, however, the indicator for the service approaches some danger level (defined in advance by the integrating body and monitored by citizen's groups and NGOs), normal/routine procedures will not work (Figure 7). In Bangalore (defined in advance by the monitoring agency today, this appears to be the situation with roads and traffic. Control over these services has to be assumed by or transferred to an integrating body such as a Task Force; otherwise the situation will become even worse. This transfer is particularly important when two or more services interact. When there is a disaster situation in a city (due to floods, cyclone or earthquake), the indicators for most (or all) services cross danger levels. In such a situation, the government has to decentralise governance of the city to an integrating body (for example, a Task Force). But,

this implies that the ministries must surrender their control over the city agencies to the Task Force at least for the period of the emergency. The disaster cannot be tackled effectively unless this change of governance is achieved.

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Table 1: Bangalore's Services, Agencies responsible, Stress and Response Factors

	SERVICE	AGENCY/DEPARTMENT	STRESS	RESPONSE	*INDICATOR*
1	City planning	BMRDA, BDA, KSB	Land-use changes	Deviation from plan	Deviation/max deviation
2	Communication – Land lines	BSNL	Usage	Malfunctioning	Malfunctioning lines/ Total lines
3	Communication – Cell phones	AIRTEL, HUTCH,etc	Usage	Signal	Signal/Acceptable Signal
4	Communication – Radio	DOORAVANI			Actual/Normal
5	Communication – TV	DOORDARSHAN, NDTV, etc			Actual/Normal
6	Cooking Fuel	OIL COMPANIES	Demand	Supply	Supply/Demand
7	Drains	BWSSB	Flow	Capacity	Flow/Capacity
8	Electricity	BESCOM, KPTCL	Demand	Supply	Supply/Demand
9	Fire	FIRE SERVICES	Demand	Supply	Supply/Demand
10	Food grains	CIVIL SUPPLES, PS	Demand	Supply	Supply/Demand
11	Health Care	DMS, PS	Demand	Affordable Services	Affordable Services/Dema
12	Housing	BMP, KSB	Demand	Affordable Supply	Affordable Supply/ Demand
13	Lakes	LDA	Inflow into lakes	Water quality	Water quality/ Tolerable quality
14	Law and Order	BCP	Population	Violations	
15	Milk	BDMS, MD, PS	Demand	Supply	Supply/Demand
16	Railways	SR	Demand	Supply	Supply/Demand
17	Roads	BMP	Traffic Density	Condition	
18	Sewerage	BWSSB	Flow	Capacity	Flow/Capacity
19	Traffic – Bicycles	BCP	Flow	Capacity	Flow/Capacity
20	Traffic - Two-wheelers	RTO	Flow	Capacity	Flow/Capacity
21	Traffic - Three-wheelers	RTO	Flow	Capacity	Flow/Capacity
22	Traffic – Cars	RTO	Flow	Capacity	Flow/Capacity
23	Traffic – Buses	KSRTC, BMTC	Flow	Capacity	Flow/Capacity
24	Traffic - Trucks	RTO	Flow	Capacity	Flow/Capacity
25	Waste	BMP	Quantity	Capacity	Quantity/Capacity
26	Water	BWSSB	Demand	Supply	Supply/Demand