INTERNATIONAL ENERGY INITIATIVE
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Bangalore

List of project reports and papers

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Abstracts

1. Promotion of cogeneration in sugar factories **– "Feasibility Study of the Potential for High Efficiency Cogeneration in the Sugar Industry – A Case Study of Three Sugar Factories"**, IEI, June 1993

   Although India, with about 500 sugar factories, has been the world's largest sugar-producer, cogeneration of electricity using high-pressure boilers had not been a common practice. However, the estimated 250 million tonnes of sugarcane processed annually in India could provide about 3,500 MW. A study was conducted on the benefits and costs of high-pressure cogeneration in three sugar factories in Karnataka. The study demonstrated the possibilities of cogeneration in these cases, along with the costs and benefits of installing high-pressure boilers, based on the parameters indicated.

2. **"Replication of Rural Energy and Water Supply Utilities (REWSUs) – Proposal for an Implementation Package",** Amulya K.N.Reddy, V.Balu, Gladys Sumithra[1], P.Rajabapaiah, and Antonette D'Sa, August 1993.

   This was a detailed implementation package for the large-scale replication of village-based biogas-diesel fuelled electricity generation and water supply plants similar to that in Pura (Kunigal taluk, Tumkur district, Karnataka). It included a description of the costs and benefits of a single village-based scheme, the criteria of selection of other villages where such schemes could be implemented and the costs of implementation -- construction, training of personnel, and initial operation of such systems in villages.

3. **"Part I: The Pura village case study"**, P.Rajabapaiah, H.I.Somashekhar[2] and Amulya K.N.Reddy; "**Part II: Economic viability of a Pura-type Rural Energy and Water Supply Utility (REWSU)"**, Amulya K.N.Reddy, Gladys Sumithra and Antonette D'Sa; "**Part III: Replication of Pura-type REWSUs"**, Amulya K.N.Reddy, V.Balu, Gladys Sumithra, and Antonette D'Sa, 1994

   In order to address the questions and comments raised during several discussions of the above implementation package, a detailed scrutiny was made of the previous calculations and proposal. The result of the updated analyses was this paper in three parts, including the detailed costing of a biogas-based electricity and water supply system and replication of such systems in the proposed project.

[1] Mr V.Balu, IAS, and Dr Gladys Sumithra from the Karnataka State Government's Planning department, were on deputation with IEI during the periods August 1992 -July 1996 and February 1993-November 1996, respectively.

[2] Mr P.Rajabapaiah and Mr H.I.Somashekhar were from the Centre for the Application of Science and Technology to Rural Areas (ASTRA), later Centre for Sustainable Technologies (CST), Bangalore.

4. **"Technology Menu for efficient energy use: Motor Drive Systems"**, National Productivity Council (India) and the Center for Energy and Environmental Studies of Princeton University (USA), sponsored by IEI (Bangalore) and TIFAC (New Delhi), 1994

   A joint study in 1992 by India's National Productivity Council and Princeton's Center for Energy and Environmental Studies, on the scope of energy efficiency measures in Indian industry, showed that about a third of the total energy consumption can be saved through non-capital-intensive efficiency improvement measures, with payback periods of less than three years. The study also generated a Technology Menu for Efficient Energy Use with information on specific end-use devices such as electric motors, pumps, fans, compressors and variable speed drives.

   In 1994, IEI took up the second phase of the Technology Project in association with the Technology Information, Forecasting and Assessment Council (TIFAC) of the Ministry of Science and Technology, Government of India. This second phase aimed to use the Technology Menu document to apprise individual entrepreneurs of the energy-saving potential of efficient technologies and to get their feedback regarding the limitations and constraints in using these menus in their factories.

5. **"Analysis of mulberry cultivation for silk-worm farming and gasification"**, Antonette D'Sa and Amulya K.N. Reddy, June 1995

   Biomass from crop waste, converted into gaseous fuel, can be used in dual-fuel mode to run engines for power generation. The electricity so generated can be used for pumping water for irrigating the fields on which crops yielding such biomass are grown. However, such a mutually contributing scheme would not necessarily yield enough revenue for the system (from only the payment for irrigation) unless the crop grown has a suitably high commercial value, in addition to yielding adequate biomass for the gasification process. Mulberry could be considered a suitable crop for the system, as the price of its leaves (fed to silkworms) is linked to the price of silkworm cocoons for the silk industry. An analysis was therefore made of the costs and benefits of a biomass-gasification-electricity-irrigation-mulberry-silkworm scheme, with each parameter treated as a variable in turn. It showed the range of prices at which the costs could be reimbursed from the returns to the silkworm rearing farms.

6. **"Enron and Other Similar Deals vs the New Energy Paradigm"**, Amulya K.N.Reddy and Antonette D'Sa, *Economic and Political Weekly*, 17th June 1995, Vol.XXX, No.24, pp.1441-1448

   It was emphasised here that genuine solutions must address all the crises of the electricity sector – capital, performance, equity/access and environmental degradation. The Enron-type deals are therefore defective because, by their high

costs passed on to the purchasers, assured high plant load factors instead of the existing cheaper options, imported (in preference to local) equipment, among other factors, they worsen the technical and financial performance of the associated state utility. The emphasis should therefore shift to the new energy paradigm, considering the provision of more energy services rather than higher consumption.

7. "**Integrated Energy Planning: Part I. The DEFENDUS Methodology"**, Amulya K.N.Reddy, Antonette D'Sa, Gladys D. Sumithra and P.Balachandra[3]**,** *Energy for Sustainable Development*, Vol.II, No.3, September 1995, pp.15-26 and **"Integrated Energy Planning: Part II. Examples of DEFENDUS Scenarios"**, Amulya K.N.Reddy, Antonette D'Sa, Gladys D. Sumithra and P.Balachandra, *Energy for Sustainable Development*, Vol.II, No.4, November 1995, pp.12-26

This two-part paper deals with a method of resource planning in which the future requirement of a resource is estimated on the basis of the magnitude of services expected by consumers and the technology level, while a mix of sources is identified to bridge the demand-supply gap in a cost-effective manner.

The first part describes the methodology proper – including the conceptual framework, the reasons for developing a simple worksheet-based method, and the actual computational procedure. Starting with the prevailing energy system, development-focused end-use-oriented service-directed (DEFENDUS) scenarios for future demand are constructed, paying deliberate attention to equity (in the extent to which services are spread among potential consumers) and the efficiency with which services are obtained. The investment and operating costs/unit and, if required, environmental costs of energy supplied/saved are then estimated, to obtain a least-cost ranking. Whereas with most pre-programmed packages, the planner must accept the format already provided, this approach enables one to validate every step of the procedure and incorporate modifications as required.

Part II demonstrates the adaptability of the method described in Part I to different regions and fuels (coal, petroleum products, and biomass).

8. **"Analysis of Electricity Consumption of Irrigation Pumpsets in the State of Maharashtra"**, Girish Sant and Shantanu Dixit, Prayas, Pune (funded by the International Energy Initiative, Bangalore), December 1995.

IEI invited energy analysts from Prayas (Pune, Maharashtra) to undertake a study of the water-energy nexus in their state, with a focus on analysing the electricity use by pumpsets for irrigation. The study indicated that the then subsidy pattern benefited only a fraction of the farmers in the state, who could, even without it, afford to pay a more reasonable tariff. Tariff restructuring and end-use efficiency improvements, even if undertaken by the State Electricity

[3] Dr Balachandra is from the Management Studies Department, Indian Institute of Science, Bangalore.

Board, would yield substantial benefits in terms of resource conservation, energy saving and cost recovery for energy use.

9. "**Census of irrigation wells and pumpsets in selected *taluks* of Karnataka & estimation of electrical usage of pumpsets in Karnataka**" (report prepared by Gladys Sumithra), July 1996

   The number of electrified irrigation pumpsets in Karnataka state had been shown to be increasing rapidly. In addition, since several sectors were not metered, the total electricity use attributed to irrigation appeared to be an allocation based on the reported number of pumpsets and a specified consumption per pumpset. IEI had metered a sample of irrigation pumpsets in the state; this study attempts to examine issues of electricity use by irrigation pumpsets, on the basis of the IEI sample.

10. "**Exercises for Integrated Resource Planning for Kerala - End-use Analysis: Technical Report I – Electricity**", Integrated Rural Technology Centre (IRTC), Mundur (Palakkad, Kerala) and International Energy Initiative (IEI), Bangalore, 1996.

    A sample survey was conducted to obtain information on energy (in particular, electricity) use in the residential, commercial, agricultural and industrial sectors of the state of Kerala. The residential sample consisted of 6,787 households, 346 agricultural units, 1,162 commercial establishments, and 123 low-tension (small-scale) industrial establishments. Based on the survey, an analysis was made of the various end-uses in each user-category, providing a rarely found demand-side picture. (Apart from the high-tension category, all the electricity-using categories have been assessed). The demand-side analysis was juxtaposed with an overview of the supply-side resources of the state.

11. **Report on Karnataka Household Survey of Electrical End-uses (1994-95)**, IEI, 1997.

    An IEI-sponsored household survey was conducted by a group of engineering students in four districts of Karnataka; the sample included 1,165 households. The objective was to study the pattern of electricity use service-wise so as to estimate the scope for efficiency improvement, and to ascertain whether or not there were significant differences between consumers on the basis of regional and rural/urban location. The analysis of the information received, conducted at IEI, included engineering estimates and statistical regression, based on the electricity bills and appliance stock. The report presents the questionnaire and detailed tables on the analyses of regional and state-level service-wise electricity use.

12. **"Karnataka's Power Sector – Some Revelations"**, Amulya K.N.Reddy and Gladys Sumithra, *Economic and Political Weekly*, 22nd March 1997, Vol.XXXII No.12, pp.585-600

    This article presents a detailed analysis of Karnataka's power sector – the present situation, the trends in electricity demand and supply, the Electricity Board's financial problems, and the important technical and policy milestones resulting in the current situation. Among the main problems is the fact that 58% of the total available electricity is not metered at the consumer level and agricultural use is over-stated to compensate for distribution losses such as theft. The agricultural subsidy is not reimbursed to the Electricity Board and this loss adds to the huge outflow for debt repayment, leading to a debt trap.

    A way forward is suggested through the cumulative effects of several demand- and supply-side measures, such as time-of-the-day metering, improved-efficiency devices (particularly those that reduce peak demand), reducing T&D losses particularly theft, better capacity utilisation, co-generation at sugar and other industrial plants and tapping decentralised renewable sources of energy.

13. Study on **Karnataka's system load (from the Load Dispatch Cell of the Karnataka Electricity Board)**, Antonette D'Sa and K.V.Narasimha Murthy, 1997

    The Load Dispatch Cell (LDC) of Karnataka's state distribution and transmission utility, the Karnataka Electricity Board (now the Karnataka Power Transmission Corporation Limited) has been co-ordinating between the existing generating stations to meet the state's demand. The electrical load (MW) actually met by the system is recorded at every hour at the LDC. The ledgers with the handwritten records were used to feed the required numbers into worksheets and thereby obtain daily, monthly, seasonal and annual load curves for the years 1993-94, '94-95, '95-96, and '96-97. The load curves so obtained were used to estimate the average (± standard deviation) base, intermediate and peak loads met at different times of the day and the year. As information on the hourly load met was not otherwise available, this effort provided IEI with a valuable basis for further analysis of the system.

14. Preliminary study of **Karnataka's electricity generation capacity and its ability to meet the required demand**, Antonette D'Sa and K.V.Narasimha Murthy, 1997

    Information on the potential of each of the state's generation plants and the capacity of the hydro-reservoirs was obtained from the Karnataka Power Corporation Limited (KPCL), the state's main generation utility. Juxtaposing the potential so computed with the estimated base, intermediate, and peak loads (computed on the basis of the analysis described above), a generation model was drawn up. Through this model, an attempt was made to select the most appropriate options from among the given stations (subject to the limitations

imposed particularly in the case of hydroelectric plants), at different times of the day and seasons of the year.

15. **"DEFENDUS Electricity Planning for Andhra Pradesh"**, Antonette D'Sa, November 1997

IEI had been conducting workshops on least cost electricity planning (using the DEFENDUS model) for personnel from several State Electricity Boards (SEBs). The workshops led four SEBs to appoint small teams of engineers to interact further with IEI for the purpose of preparing least-cost plans for their states. However, apart from the state of West Bengal, IEI had eventually to step in to draw up the demand and supply estimates, based on data from the SEBs.

This plan, in accordance with the Defendus methodology, includes estimates of electricity demand – in business-as-usual, development-focused and improved-efficiency scenarios, till the year 2006-07 (coinciding with the horizon of the Xth Five-Year Plan of the country). It also suggests practical ways of meeting this demand (through projects already invested in and suggested conservation programmes), depending on costs per unit. The report was sent to the APSEB.

16. **"DEFENDUS planning applied to fertilizer use for corn-growing in Brazil"**, Mariana de Oliveira Pedreira[4] and Antonette D'Sa, December 1997

The integrated resource planning methods, already proven to be applicable to various energy carriers, were used in this case for optimising fertilizer use. The resource demand to be met was the requirement of nitrogenous fertilizer for corn (maize) growing in Brazil. Estimates of future fertilizer demand were constructed on the basis of corn production in different demographic and agricultural scenarios. Analogous to the options for meeting energy needs (where the choices include additional energy through conventional and/or non-conventional sources, and/or efficiency improvement in the use of energy), the options considered for fertilizer application were increased production and/or imports of manufactured fertilizers, increased organic manure and/or more efficient methods of applying fertilizer in the fields. Based on estimates of the cost per unit of each option, least-cost supply schedules of options were drawn to meet the demand in each scenario.

17. **"DEFENDUS Electricity Planning for West Bengal"**, WBSEB (N.N.Ghosh and S.K.Mukherjee) and IEI (Antonette D'Sa), January 1998

Detailed demand scenarios for the five main electricity distribution agencies (public and private) in the state were drawn up to estimate the aggregate demand till 2006-07. These estimates were compared with the Central Electricity

[4] Ms de O. Pedreira was a Graduate student at the University of São Paulo, Brazil and this work was used towards her Master's degree.

Authority's Annual Electricity Plans. The costs of the available generation/conservation/increased capacity utilisation options to bridge the state demand-supply gap were then estimated, to derive a least-cost-supply staircase. The likelihood of surplus capacity in this state if all the proposed were actually implemented, was also considered. The report was discussed and accepted in principle by the Chairman and other Members of the Board of WBSEB.

18. **Rewsu Project – "Phase-I Implementation of Rural Energy and Water Supply Utilities (REWSUs): Final Report to the Rockefeller Foundation"**, A.R.Shivakumar, Sudhir Chella Rajan[5] and Amulya K.N.Reddy, July 1998

A rural energy and water supply utility (REWSU) had been operated since 1987 in the village of Pura in Karnataka. It had been designed at the Indian Institute of Science (Bangalore) and had received operational support from the Karnataka State Council for Science and Technology (KSCST). The hardware of the REWSU included a biogas plant connected to a dual-fuel diesel engine and alternator, a control panel, a water pump in a borewell and distribution networks of electricity and water to individual households, while the "software" consisted of an implementing agency that would construct the plant and provide training and later supervision and technical support, a village committee for the management of the plant operation, and operator/s for the actual running of the plant.

Following detailed analysis of the Pura case, IEI obtained funding from the Rockefeller Foundation to establish nine REWSUs in Karnataka for Phase I of an implementation programme. The main objective of this Phase was to explore the feasibility of replicating REWSUs through independent implementing agencies, although with external finance and training/technical support; it was envisaged that the experience gained during Phase I would provide the necessary inputs to design a larger-scale replication programme.

A report was prepared on the status of the project in 1998, including general observations on and guidelines for implementation.

19. **"Least-cost Electricity Planning for Karnataka"**, Antonette D'Sa, July 1998

Least-cost electricity scenarios had earlier been created for Karnataka for 1991-2000, with 1986-87 as the base-year. The new version started with 1994-95 as the base-year and extended to 2006-07. However, more than mere updating, there were modifications in terms of: a detailed analysis of the energy services in the domestic sector (through the earlier mentioned household survey), disaggregation of high-tension industrial supply by industry (through additional unit-level data obtained from the State Electricity Board), the possibility of increasing the capacity utilisation of industrial captive plants as a supply option, and construction of several least-cost supply schedules (distinguishing between

[5] Dr Rajan had been with IEI (Bangalore) from January 1995 till December 1998.

projects already under construction and those due to be commenced). The report was given to the heads of the Planning and Energy departments of the State.

A summary of the method employed and results obtained from the least-cost electricity planning exercise for Karnataka was prepared for the purpose of distribution (including the Planning and Energy departments of the state). A PowerPoint® presentation on the conclusions reached was also prepared for display.

20. **"Least-cost Planning Exercise for Kerala State Electricity Board"**, Antonette D'Sa and K.V. Narasimha Murthy, December 1998

As in the case of the other least-cost electricity planning exercises, demand scenarios and least-cost electricity plans were constructed for the state of Kerala. This state was different from the others in that it had its own long-term power sector plans with which these least-cost estimates could be compared. As in the case of Karnataka, a summary report and PowerPoint® presentation were also prepared.

21. **"Report on Efficient Lighting for the Residential sector**", Antonette D'Sa, 1999

This study of the lighting devices in use in the residential sector deals with incandescent bulbs, fluorescent tube lights and the various compact fluorescent lamps. It considered in detail, the differences between the types of devices (including ballasts), the differences in performance characteristics (e.g., the effects of voltage and frequency), visual comfort afforded (e.g., colour rendering, flicker, etc.), and adaptability to use.

An analysis was made of the costs and benefits (both electrical and financial) -- to consumers, to the utilities and to society -- from the replacement of the existing incandescent bulbs with others of higher efficacy (comparable light at lower energy use). The barriers to acceptance by households and instruments to overcome these barriers were also considered. Inability to pay the higher purchase prices of more efficient bulbs (fluorescent tubes and compact fluorescent lamps) as well as subsidised tariffs (that lower the monetary value of electricity saving) hindered the domestic sector from investing in improved devices. Hence, financing schemes in which the costs of the replacements are shared by all those who gained seemed appropriate.

There are also several Annexures with technical specifications, and examples of programmes from other parts of the world.

22. **"Power Sector Liberalisation: An Overview"**, Antonette D'Sa, K.V.Narasimha Murthy and Amulya K.N. Reddy**,** *Economic and Political Weekly*, Vol.XXXIV, No.23, 5th-11th June, 1999, pp.1427-1434

The Indian power sector was opened to private participation in 1991; even so, generation has commenced at very few private plants. Independent power producers (IPPs) claim that their progress has been hindered by problems such as litigation, financial arrangements, and obtaining clearances and fuel supply agreements, while the state utilities have been burdened by power purchase agreements (PPAs) that favour the IPPs with such payment clauses as base-load take-off, "deemed generation" irrespective of actual utilisation, high capital costs, and high returns on them.

23. Report of the **"Study on the Feasibility of Implementation of the Least-cost Electricity Plan for West Bengal"** by WBSEB (N.N.Ghosh) and IEI (Antonette D'Sa), August 1999

The least-cost estimates worked out jointly by IEI and the West Bengal State Electricity Board (WBSEB) had been accepted by the Board subject to the results of a feasibility study on the implementation of the suggested measures. This feasibility study -- again prepared jointly by IEI and WBSEB -- evaluates the requirements for the extension of electricity to all homes and for each efficiency-improvement measure individually; it estimates the viability of each suggestion in terms of financial costs involved, ways of recovering these costs, the electricity requirement or saving, and a practical time-frame.

IEI's training efforts have therefore been successful, in the case of this SEB, in developing planning skills among those involved in the exercise and, more importantly, in promoting the shift of the decision makers towards unconventional options rather than increased generation alone.

24. **Solar Water-Heater Report – "Large-scale Dissemination of Solar water heaters to reduce electrical energy and power for water heating"**, A.R.Shivakumar, Sudhir Chella Rajan and Amulya K.N. Reddy, 1999

Solar water heaters (swhs) are known to use solar energy to heat water and store it for later use. However, the value of their use in terms of energy and monetary saving to the consumer and the utility are not that well known. In addition, if swhs were to be popularised and adopted in large enough numbers to appreciably lessen the state's peak demand, the scale of manufacture would also have to increase considerably. A report was prepared detailing the basic features of an swh and its installation, the economic advantages, and, particularly, the requirements for large-scale dissemination such as finance, training, manufacturing process, quality control and supportive policies.

25. **"Reference Energy System for India (1995-96)"**, Centre for Monitoring Indian Economy Pvt. Ltd. (Nitin Madkaikar, Leena Venkateshwaran and Mahesh Vyas) and the International Energy Initiative (Antonette D'Sa, Gladys D.Sumithra and Amulya K.N.Reddy), *Energy for Sustainable Development*, Special Issue on India, Volume IV, No.1, June 2000, pp. 5-12.

A reference energy system (RES) is a representation of the structure of the energy system of a region (at present or as it obtained in the immediate past). It extends from all the energy sources that are exploited, via the intermediate forms or carriers into which these sources are transformed, the (sub-) systems for transmission/ transportation and distribution of these energy carriers, to the end-use devices that are used to obtain the desired useful services such as cooking, lighting, process heating, shaft power, etc. An All-India RES for the available data (1995-96) was presented as an introduction to the Special Issue on India.

26. **"Energy for a sustainable road/rail transport system in India"**, Amulya K.N.Reddy, Y.P.Anand[6] and Antonette D'Sa, *Energy for Sustainable Development*, Special Issue on India, Volume IV, No.1, June 2000, pp. 29-44.

The main motivation for this study was that the strong transport-energy nexus has not received the attention is deserves, although energy is a crucial constraint on transport, and transport is a major determinant of energy demand. Also, many detailed treatments of the transport sector have not scrutinised the sustainability of the present pattern of development of this sector. In this paper, the prevailing paradigm guiding the development of the sector is made explicit and critiqued because it is often the root cause of its unsustainability; and, because discussion of transport policy issues tend to proceed without a definite statement of the goals aimed at and the strategies recommended, the entire hierarchy of interventions – from goals to policies – has been discussed. Finally, an attempt has been made to deal with both the supply and demand aspects of the transport sector. (The study is restricted to road and rail transport since air and water modes handle relatively small fractions of the total demand). Detailed discussions are preceded by overviews of the main features of the Indian transport system as well as of the energy sector as pertaining to transport.

27. **"Captive generation – air pollution impacts due to increased capacity utilisation"**, Sudhir Chella Rajan and Antonette D'Sa, *Energy for Sustainable Development*, Special Issue on India, Volume IV, No.1, June 2000, pp. 77-85.

A comparison was made of the air pollution (SO_2, NO_x, CO_2, and particulates) impacts of increased capacity utilisation at the existing dispersed captive generating units based on diesel, with new centralised coal-based thermal stations of equivalent generating capacity, in the state of Karnataka. It included a district-wise assessment of electricity generation and the consequent emissions at

[6] Dr Anand, retired from the Indian Railways, was then at the National Gandhi Museum, New Delhi.

increasing levels of capacity utilisation, comparing these with the alternative of a single thermal plant. It also compared the costs of removing additional pollutants (due to increased captive generation) through advanced coal-based technology, with that of captive sets fitted with emissions control.

28. Preliminary Analysis of **KPTCL's Transformer Centre Meter Readings for 1998-1999** (August 2000) and **Additional Note on the Analysis of KPTCL's Transformer Centre Meter Readings for 1999-2000**, October 2000, Antonette D'Sa and Amulya K.N.Reddy

    These are reports on statistical estimates of electricity use by un-metered irrigation pumpsets in Karnataka. When metering of the electricity use by agricultural pumpsets was discontinued, the sector's use appeared to increase dramatically, so much so that it came to account for 40% of the state's electricity use. However, agricultural use could also provide a politically expedient way to hide commercial and technical losses in distribution. The Karnataka Power Transmission Corporation Ltd. has, in recent years, installed meters at over 1,000 transformer centres (TCs) catering chiefly to agricultural consumers and has estimated agricultural electricity use on this basis. The handwritten/typed data (from the samples of TCs servicing over 10,000 pumpsets in each year) was entered in worksheets and statistically analysed, to estimate the total (and regional) electricity use per pumpset, distinguishing between bore (deep) wells and open (shallow) wells.

    While several insights into the sector have been obtained, the incomplete information hampered the estimation procedure. It has been suggested that rather than increasing the sample, the recording of electricity use be made more accurate, so that realistic estimates of the total agricultural use are ensured.

29. **"California Energy Crisis and its Lessons for Power Sector Reform in India"**, Amulya K.N. Reddy in *Economic and Political Weekly*, Vol.XXXVI, No.18, 5th-11th May 2001, pp.1533-1540

    What appeared to be an unstoppable and unquestionable consensus regarding the necessity of restructuring/reforming the electricity sector in India has been shattered by the unbelievable news of the California energy crisis. In a state at the forefront of the IT revolution, there have been unscheduled interruptions of power and rolling blackouts covering hundreds of thousands of consumers. Suddenly, the situation there appears no different from cities in backward developing countries. This paper is addressed to the task of understanding the California energy crisis through a factual description of the crisis and a discussion of the causal factors responsible for it. It concludes with drawing lessons from the California energy crisis particularly with regard to power sector reform in India.

30. **"Indian Power Sector Reform For Sustainable Development: The Public Benefits Imperative",** Amulya K.N. Reddy, *Energy for Sustainable Development*, Special Issue on Public Benefits and Power Sector Reform, Volume 5, June 2001, Issue no.2, pp. 74-81.

The crises of utilities in developing countries led to a World Bank diagnosis of their problems and to a prescription of remedies for the situation. The resulting approach had been assessed with a case study of the power sector in Karnataka state carried out by the International Energy Initiative. This bottom-up approach has yielded remedies that overlap with the top-down World Bank approach as far as liberalisation from government control, corporatisation and the establishment of an electricity regulatory body are concerned. However, the bottom-up approach does not lead to other World Bank solutions such as "unbundling" of generation, transmission and distribution, removal of all subsidies and cross-subsidies, and privatisation, which appear to follow, not from ground realities, but from global trends of reform/restructuring. It appears that the reform process in the industrialised countries has been driven primarily by technical developments, rather than by the financial crises that are the justification for reform in the developing countries. Despite this, there is an epidemic of "reform" in India. It appears that a bootstrap operation coupled with some elements of reform can rejuvenate the utilities. What may not result from this financial rejuvenation are several crucial public benefits – access, self-reliance/empowerment, environmental soundness, research and development and sustainability over the long term. This larger goal requires that the invisible hand of the market be assisted by the visible hand of regulations and the intervention of the state.

31. "**End-uses of electricity in Karnataka households**", K.V.Narasimha Murthy, Gladys Sumithra and Amulya K.N.Reddy, *Energy for Sustainable Development*, Vol.5, No.3, September 2001, pp. 81-94.

A survey of electricity use was carried out for a sample of households in four districts of Karnataka. Analysis of the survey results has revealed patterns of service-wise electricity use in different categories of households; these include the stock of electrical appliances, differences between urban and rural areas, the use of other sources of energy for domestic purposes, and the degree of penetration of energy-efficient appliances/devices.

32. **"Power sector reform in India – An Overview"**, Country paper contributed to the IEI-sponsored project on **Delivering public benefits as power sectors in developing countries are reforming,** Antonette D'Sa, September 2001.

The Public Benefits project began with reports on Power Sector Restructuring from each of the seven countries being studied. The paper on India summarised the reasons for Indian power sector reform, the chronology of reform events that have taken place (at the national and state levels), the main stakeholders and the problems envisaged.

33. **"Energy Technologies and Policies for Rural Development"**, Amulya K.N.Reddy, Chapter 4 in **Energy for Sustainable Development – A Policy Action Agenda**, IEI & UNDP, 2002, pp.117-138.

This chapter, a part of the joint effort of IEI and the United Nations Development Programme, discusses how policies that improve rural energy systems have a synergistic effect on an array of social problems. The choice of which energy sources and systems to encourage should be guided by the degree to which they support sustainable development, including accessibility to the entire rural population, particularly the rural poor, compatibility with high efficiency end-use devices, decentralised systems that can be manufactured or repaired locally, utilisation of renewable locally available resources, and systems that can simultaneously produce heat and power.

34. **"A generic southern perspective on renewable energy"**, Amulya K.N. Reddy, *Energy for Sustainable Development*, Vol.VI, No.3, Special Issue on Bioenergy and Renewable Energy Policies in Asia, September 2002, pp.74-83.

This article indicates the interrelationships between biomass energy, renewable energy and sustainable (urban and rural) development. To advance the goal of sustainable development, it then lists the generic energy strategies for renewable energy, in general, and for biomass, in particular. A brief description of the barriers to renewable energy is supplemented with a strengths-weaknesses-opportunities-threats (SWOT) analysis. Following a discussion on some guidelines for the dissemination of renewable energy technologies (RETs), the characteristics of a renewable energy policy package (REPP) for sustainable development are outlined. Finally, an indication is given of the RETs for the near, medium, and long term and of the general positive implications of renewable energies.

35. **Linking a dairy scheme to the existing biogas-fuelled village water-supply system**, Antonette D'Sa and K.V.Narasimha Murthy, 2002.

An analysis has been made of the purchase of cattle (on loan) for a village dairy co-operative, as an addition to the existing biogas-fuelled electricity and water supply utility. The existence of a co-operative helps in obtaining loans for purchasing the cattle. The net income (after loan repayment) from the sale of milk benefits the purchasers financially. It also facilitates regular payments to the utility. Simultaneously, it can force an increased supply of dung (without additional payment) to the biogas plant and thereby allow energy services through the system to be increased.

36. Chapter on **"Integrated Resource Planning (IRP) as power sectors are reformed"**, Antonette D'Sa, in the IEI-Report on **Delivering public benefits as power sectors in developing countries are reforming**

The chapter begins with an explanation of what is meant by Integrated Resource Planning (IRP), why this planning approach is considered a public benefit, and what its practice involves. Section 2 looks at the position of IRP in power sector planning before reforms began, and assesses whether or not the reform process has affected its use. This leads to a discussion on the barriers to the IRP approach. Section 3 makes the case for IRP in terms of the benefits that could be derived. Section 4 follows with suggested ways forward, particularly by whom and with what tools some form of IRP could be carried out.

The chapter concludes that while power sectors are being restructured and market-driven systems are being put into place in developing countries, the existing problems have not been addressed adequately. IRP is required because problems – chiefly inadequate resources, poor access for large proportions of the population in many places, and environmental degradation – necessitate it. These issues, in turn, force decision-makers to make difficult choices; IRP assists in making these choices systematically and transparently. The development of enabling government policy, the commitment of an independent regulator/system operator vested with adequate authority, as well as appropriate technical expertise and information seem to be crucial for IRP to be actually carried out. Reform and restructuring are now affording the sector new opportunities for adopting better planning practice through the formulation of new policies and regulations, and the development of new institutions and associations.

37. **"The evolution of an energy analyst: Some personal reflections"**, Amulya K. N. Reddy, *Annual Review of Energy and the Environment*, 27, 2002, pp. 23–56

The evolution from an electrochemist was motivated by a growing conviction that Indian science and technology should be reoriented. A cell was created in the Indian Institute of Science in 1974 to initiate and promote work of rural relevance as a weapon against poverty. Surveys led to a detailed empirical study of energy consumption patterns in villages and to the design and construction of rural energy centers. The lessons from this village work are described.

The principal outcome of the collaboration with J. Goldemberg (Brazil), T.B. Johansson (Sweden), and R.H. Williams (United States) was the book *Energy for a Sustainable World* that contributed significantly to the new paradigm for energy. The application of this paradigm resulted in a detailed electricity demand scenario for the South Indian state of Karnataka. Following mandatory retirement from the Indian Institute of Science, the International Energy Initiative (IEI) was set up in 1991 as a Southern-conceived, Southern-led, Southern-located South-North partnership. Persisting personal concerns about the ethical implications of science resurfaced through opposition to India's nuclear tests in 1998 and a visit to the concentration camps at Auschwitz. The associated human

dimensions of energy were emphasized in the acceptance speech at Göteborg of the Volvo Environment Prize 2000. The penultimate endgame involved retirement.

38. **Karnataka's power sector and suggested ways forward**, Antonette D'Sa and K.V. Narasimha Murthy, 2002

A summary of Karnataka's Power Sector has been prepared, briefly describing the power sector, and listing the steps taken as part of the reform process. Data on the number of consumers and connections, on system load met, on estimated transmission and distribution (T&D) losses, and on tariffs (existing and proposed) have been provided, for a complete picture. The study then provides a schematic representation of the system as a whole, with links between the stakeholders, on the basis of authority permitted and activities required. It goes on to discuss the problems encountered and suggests ways forward, by considering the objectives of each entity and practicable strategies to meet these goals.

39. **"Towards a new paradigm for power sector reform in India",** Amulya K. N. Reddy, *Energy for Sustainable Development*, Vol.VI, No.4, December 2002, pp.22-29.

The purpose of this discussion note is to describe briefly the paradigms[7] that have guided the power sector of India, starting with the pre-1991 classical electricity utility paradigm which gave way to the current World Bank-led paradigm for power sector reform. Sankar's new innovative proposal[8] for addressing the problem of the power sector in India suggests the possibility that a shift may take place to a new paradigm. The contours of this emerging paradigm are the subject of this note.

40. Comments on **"Power Reforms in India – the search for an indigenous model for promoting competition"**, Antonette D'Sa, January 2003

A "people's" power plan for a state had been published (referred to above), in which generation stations would be assigned to particular consumer categories on the basis of tariff levels and the "people" – the domestic and agricultural consumers – would be charged the lowest rates i.e. those based on generation at the oldest stations. A revised version of this plan avoided explicit mention of the earlier suggestion of "partitioning" the power sector according to the unit costs of

[7] At any period in history, according to Thomas Kuhn, there is a ruling paradigm (for pattern of thinking or framework) within the constraints of which most thinking takes place. When its effectiveness diminishes and it begins to break down, a paradigm shift takes place and a new paradigm comes into being.

[8] Sankar T.L., 2002. "Towards a people's plan for power sector reform", Economic and Political Weekly, XXXVII (40), October 5, pp 4143-4151 and Sankar T.L., 2002. "Power reforms in India – the search for an indigenous model for promoting competition", *Energy for Sustainable Development*, VI, No.4, December 2002, pp.5-16.

generating plants and income-wise categories of consumers.

In response to this request for comments, a study was conducted and several issues discussed. In particular, it was emphasised that the problems of transmission and distribution (T&D) and reduction of such system losses had to be addressed rigorously as electricity would continue to be delivered from the existing generating stations to lower-income domestic and agricultural consumers all over the state irrespective of the allocation of output from generating stations and the tariffs imposed.

41. **Explanatory note on the ongoing estimation of the transmission and distribution (T&D) losses through Karnataka's electricity system** (Annexure to Karnataka's Power Sector & Suggested Ways Forward), Antonette D'Sa and K.V.Narasimha Murthy, January 2003.

Transmission and distribution (T&D) losses had not been accurately noted for several years, with the official figure gradually reduced from 22% (in 1977-78) to 18.6% in 1997-98. As a result, T&D losses could be attributed to any of the non-metered consumer segments. In 1998-99, the total T&D losses were, for the first time reported to be 30.2%, of which, it was admitted that commercial losses (or theft) could constitute over 10%. It is important to assess these system losses more accurately, so that they can be reduced and also so that the use by each category of consumers can be correctly assessed (particularly with the unbundling of the electricity distribution system). Hence, efforts have been made to estimate system losses, so far on the basis of other reports. Studies by M/s Mecon Limited for the year 1998-99 and Karnataka Power Transmission Corporation Ltd. (KPTCL)'s estimates of investment towards system improvement have been obtained. But while the measurement of technical losses through the transmission system can be verified, estimation of losses through the distribution system is still incomplete. A note indicating the information collected so far has been prepared.

42. **Report on IEI's village-based water-supply project with special reference to Mavinakere (Arsikere taluk, Hassan district, Karnataka)**, Antonette D'Sa, K.V. Narasimha Murthy, and B.T. Chandru, September 2003, (currently available at http://www.iei-asia.org/IEIBLR-REWSUReport.pdf)

This report begins with IEI's Rural Energy and Water-supply Utility (REWSU) project. It briefly gives the status of the REWSUs originally invested in; it also lists causes for their discontinuation. A detailed report is then given on the operation of the plant at Mavinakere village. This includes quantitative input/output information on the diesel and dung used for fuelling the engine, electricity generated, and water supplied, and other performance indicators such as the number of break-downs, and the tariff collection, particularly since the IEI research staff came to be involved in the year 2001. The life-cycle costs of electricity generation from a biogas-diesel plant (@ 2003 prices) have been computed, for the purpose of comparison with other options; however, the costs of

water distribution through other schemes have not yet been obtained and therefore the comparison of water-supply costs through alternative schemes has not been made.

The report concludes with a section on the lessons learnt so far from the REWSU project and suggestions for the successful functioning of such rural utilities. These lessons pertain chiefly to technical and sociological factors in the selection of a village, the tasks of promoters/implementers of the project, the role of the operator/s, and the prevailing state policies regarding finance, and integrated development.

43. **Report on LPG use for domestic cooking in India,** Antonette D'Sa and K.V.Narasimha Murthy, April 2004, (currently available at http://www.iei-asia.org/IEIBLR-LPG-IndianhomesReport.pdf)

According to the Census of India (2001), nearly 91% of rural households[9] depend on traditional fuels (chiefly fuel-wood, animal and crop waste and charcoal) for cooking. It is well known that these fuels have adverse effects – to individuals, in terms of the health effects (of smoke inhalation, the emission of unburned hydrocarbons through traditional stoves, and soot deposits when washed off vessels, etc.) and the time on fuel gathering, and to the community through the ambient pollution created by simultaneous cook-fires and land degradation in cases where fuel-wood is gathered in an unsustainable manner.

Thus far, the thermal (cooking) needs of the population have not been adequately addressed. LPG can be considered as one of the "clean" fuel options, vis-à-vis traditional fuels available to homes; moreover, LPG stoves are more efficient than even "improved" biomass-based stoves. There are other important alternatives to traditional cooking fuels in the form of modernised biomass-fuels; however, the use of LPG is being considered as a short/medium term option, i.e. a transition fuel (or a complement) to bio-based fuels.

In the report, we have enumerated the requirements for and barriers to increased adoption of LPG for cooking in the rural and semi-urban areas of India, based on the data collected and a survey of the available literature. Considering scenarios with different proportions of cooking requirement to be met, we have estimated the possible increase in demand. An appropriate supply network has now to be tracked. Supply data has been very difficult to procure as the Public Sector organisations are in the throes of government disinvestments (privatisation). There also appear to be several problems regarding increased LPG use in rural and semi-urban areas, particularly with regard to accessibility and availability -- the supply, storage and distribution network. These challenges have to be adequately addressed through policy options.

The experiences with the expansion of LPG use in other countries and with LPG/other cooking fuel programmes in India have also been considered, to derive

[9] 31% of urban homes also depend on traditional fuels.

factors that would either help or inhibit the successful implementation of LPG use programmes.

44. **Report on an effluent treatment-cum-electricity generation option at coffee estates**, Antonette D'Sa, K.V. Narasimha Murthy and Gaurav Kapur, July 2004, (currently available at http://www.iei-asia.org/IEIBLR-Coffee-Biogas.pdf)

    This report is based on a study of the environmental effects of the coffee processing effluents and the feasibility of using a bioreactor to generate biogas and thereby electricity. Data was obtained from a coffee estate in Karnataka, and market prices were used for the estimates of costs and benefits. The benefits resulting from such a method of wastewater treatment include: production of biogas that can be used with diesel to fuel a dual-fuel generator, reduction in pollution of the surrounding area, and recycling of water. However, as penalties for effluent discharge have not yet been levied and the charges for water supply are low, financial returns on the bioreactor investment are obtained only through the avoided cost of the amount of diesel replaced by biogas. The estimates obtained from the case study indicate that this effluent treatment process is financially viable with diesel replacement alone. If environmental policies were more stringent, this effluent treatment-cum-electricity generation option would be even more attractive. A study of the feasibility of investment in this effluent treatment process is particularly useful because of the importance of coffee production in South India.

45. **"LPG as a cooking fuel option for India"**, Antonette D'Sa and K.V.Narasimha Murthy, *Energy for Sustainable Development*, Vol. VIII, No.3, September 2004, pp.91-106.

    The use of clean fuels like liquefied petroleum gas (LPG) instead of the biomass-based fuels used for cooking in India would be beneficial in several ways. However, only about 33.6 million or 17.5% of all Indian homes use LPG as their primary cooking fuel, with 90% of rural homes still dependent on some form of biomass. Hence this paper considers the possibility of enhancing the household use of LPG. From an overview of the cooking fuels used in India, it focuses on LPG, analysing the factors affecting current demand and projecting future scenarios. Salient features of the LPG supply and distribution system are also discussed. Based on the existing situation, barriers to increasing LPG use -- in particular, the problems regarding affordability, pricing and reliable distribution -- have been identified. In this context, experiences with the expansion of household LPG use in other countries and a programme in India have been considered. Finally, based on the challenges recognised, suggestions are being made regarding the policies through which the problems can be overcome.

46. **"The economics of nuclear power from Indian heavy water reactors"**, M.V Ramana[10], Antonette D'Sa and A.K.N. Reddy, *Economic and Political Weekly*, Vol.XL, No.17, April 23-29, 2005, pp.1763-1773.

An estimation of the costs per unit of electricity from the existing and proposed nuclear (pressurised heavy water reactor) power plants in India has been made, for the purpose of comparison with other (such as coal-based thermal) electricity generation plants. While such costs have been estimated earlier, the need for newer analysis has arisen because of the proposals to build more reactors. An additional reason for the renewed study is that the proposed capital costs of nuclear plants and those actually incurred for the construction (including the overruns due to delays and other problems) are not available to the public, so that comparisons are not possible.

47. **"Integrated Resource Planning and power sector reform in developing countries"**, Antonette D'Sa, *Energy Policy*, Vol.33, No.10, 2005, pp.1271-1285, (abstract available at http://www.sciencedirect.com/science/article/pii/S0301421503003707)

The integrated resource planning (IRP) approach is one that considers both supply and demand-side options to meet the need for a resource, while minimising the costs accruing to the firm and to society. This paper focuses on IRP as a tool for the power sector in the light of the existing problems and the ongoing reforms in developing countries. It looks at the advantages that IRP would afford, juxtaposing these with the barriers to such a planning process -- those encountered in the past as well as the possibilities in view of structural changes. It then discusses the policies that would enable the IRP approach to be usefully employed to mitigate the problems of the power sector. Although IRP has receded in importance in some areas of the world, there are perceptible benefits for developing countries; these could adopt such planning methods through the agents and the instruments suggested.

48. **"Environmental Reform in the Electricity Sector: China and India",** Antonette D'Sa and K.V.Narasimha Murthy, *The Journal of Environment and Development*, Volume 15, Number 2, June 2006, pp. 158-183, (abstract available at http://jed.sagepub.com/content/15/2/158.abstract)

This article analyzes the challenges to effective environmental protection in the power sectors of China and India. Its analytical framework consists of identification of environmental policies and regulations affecting electricity generation, assessment of problems faced when implementing these policies and regulations, and finally recommendations for surmounting the barriers encountered. Environmental issues in the electricity sector have been addressed directly, through laws and governmental orders, and indirectly, through policies on alternative technologies and efficiency improvement. Successful environmental

[10] Dr Ramana is currently at Princeton University, USA.

regulation has been hampered in these large developing countries, however, by the compelling need for energy and the consequent rapid increase in electricity generation. Solutions to these problems lie in combinations of cleaner and more efficient generation, appropriate control equipment, and more efficient end-use devices. Among factors which facilitate effective adoption of these solutions are state prioritization, fiscal and financial incentives, appropriate technological choices, institutional involvement, integrated planning, public participation and international commitments.

49. "**An effluent treatment-cum-electricity generation option at coffee estates: Is it financially feasible**", Antonette D'Sa and K.V. Narasimha Murthy, In focus - Special Issue on Effluent Treatment for Process Industry, *Water Digest*, Volume II, Issue 4, November-December 2007, pp.38-53.

This article has been included in a Special issue of *Water Digest*, focusing on Effluent Treatment for Process Industries. It discusses the environmental effects of the effluents discharged from coffee processing units and the feasibility of an effluent treatment process involving a bioreactor. The benefits from using such a method for wastewater treatment include: reduction in pollution of the surrounding area, recycling of water, and production of biogas that can be used with diesel to fuel a dual-fuel generator. A study of the feasibility of investment in this effluent treatment process is therefore warranted, particularly because of the importance of coffee production in South India. At present, penalties for effluent discharge have not been levied and the charges for water supply are low, hence financial returns on the bioreactor investment are obtained only through the avoided cost of the amount of diesel replaced by biogas. The estimates obtained from the case study indicate that this effluent treatment process is financially viable. If environmental policies were more stringent, this effluent treatment-cum-electricity generation option would be even more attractive.

50. "**Energy enterprises for development in rural areas: the case of clean cooking fuel**", Final Report prepared for WISIONS of the Wuppertal Institute for Climate, Environment and Energy, Antonette D'Sa and K.V. Narasimha Murthy, International Energy Initiative, June 2008, (currently available at http://iei-asia.org/IEI-Bangalore-CleanCooking-RuralDevelopment-Report.pdf)

IEI's Regional Initiative for Asia, located in Bangalore is promoting rural co-operative enterprises that integrate income-generation with improved household energy-services. The main aim of this model is to enable people in villages to use cleaner and more efficient energy services for domestic purposes that do not yield direct financial returns and also to stimulate economic growth and development.

This Report describes the implementation of a project that demonstrates this approach and was selected for funding by the Wuppertal Institute at the through the 3rd Round of their Sustainable Energy Project Support Programme. The demonstration was carried out in a village (*Chikkana Devara Hatti*, Tumkur

district, Karnataka State), where a dairy and biogas-plants have been constructed. The dairy employs the local people, its waste fuels biogas generation, in turn delivering fertilizer, and its milk and manure sales financially support the operations. Biogas (chiefly CH_4 + CO_2) is supplied to all homes, increasing efficiency and avoiding fuel-gathering, indoor pollution, and carbon emissions. This model is unique because improved (clean and efficient) energy services reach even the poorest in the community (rather than only those who can afford cattle/biogas plants), is financially feasible (due to the revenue earned), stimulates village-based development (by providing employment and value-addition within the village/cluster of villages), is environmentally sustainable (because it is based on waste rather than competing for land), and uses proven indigenous technology.

Extension of services – such as generation (using a dual-fuel biogas-diesel generator) and distribution of electricity, for household as well as income-generating services in the village, is being considered. More importantly, public-private partnership for the replication of this energy-development model in other villages is intended. The successful demonstration of the feasibility of the enterprise in the selected village is likely to expand the opportunities for replication of such village-based energy-development enterprises elsewhere – reducing fuel-wood and fossil-fuel use and the consequent environmental impacts, and stimulating economic development in rural areas.

51. "**Integrating energy conservation practices towards sustainable agriculture: The case of small farms in India**", Final Report prepared for WISIONS of the Wuppertal Institute for Climate, Environment and Energy, Antonette D'Sa and K.V. Narasimha Murthy, International Energy Initiative, April 2010, (currently available at http://iei-asia.org/IEI-Bangalore-SustainableAgriculture-DemonstrationReport.pdf)

The project objective was to demonstrate improvement in the efficiency of energy-resource use in agriculture, and thereby conservation of resources and sustainable improvement in livelihoods, integrating benefits for the rural folk, the infrastructure utilities, and the environment. This Report describes the project; it was selected for funding by the Wuppertal Institute at the through the 5th Round of their Sustainable Energy Project Support Programme.

The planned demonstration of improved farming practices was implemented at a sample of 50 farms located in the *Tumakooru* and rural *Bengalooru* (now called *Ramanagara*) districts of Karnataka state. The main activities during the year-long project included: assessment of baseline resource use, installation and operation of efficient resource-use systems, and monitoring and assessment of post-efficiency-improvement resource-use.

The assessment of baseline cropping patterns and fertilizer use were on the basis of answers to questionnaires. However, to measure the electricity used for pumping water for irrigation, energy meters were installed, while the water pumped was estimated by the discharge rate method. Once the baseline resource use was evaluated, a series of efficiency improvements with respect to resource

use was implemented. These included efficient water-pumping, efficient water application through micro-irrigation (drip and sprinkler) systems, and cost-effective and environmentally-beneficial soil enrichment. For energy-efficiency, all the existing pumps were replaced with new efficiency-certified multi-stage submersible pumps, while those without any irrigation were provided with shared access to irrigation wells with efficient pumps. For water-conservation, each farm was also provided with sprinkler and/or drip systems for a specified acreage. For natural soil-enrichment, three options – rotating the usual crops with a leguminous crop whose output is for sale, inter-cropping of a plantation with leguminous plants mainly for soil enrichment, and generation of natural manure in compost heaps on site, were adopted.

Post-installation, resource-use was re-assessed using the same methods as for the baseline. Noteworthy aspects include: the reduction of electricity use by 41.5% for the pre-irrigation farms, and 31.4% for the sample (because of additional provision of irrigation to un-irrigated farms), and reduction of water use by 60% at the fields provided with micro-irrigation, and 22% for the sample as a whole. Important conclusions were that *improved efficiency can provide for extension of irrigation and increased output* without increasing, *and even reducing*, the total water/energy requirement in the locality, and *shared-access enables greater equity and improved livelihoods*. However, successful functioning of efficient improvements requires that conditions -- such as appropriate training of the farmers and local mechanics – be fulfilled.

52. "**Efficient groundwater-based irrigation in India - Experiences with implementing irrigation efficiency**", Antonette D'Sa, International Energy Initiative, August 2010, (currently available at http://iei-asia.org/IEI-Bangalore-EfficientGWIrrigation-Compilation-Report.pdf)

Irrigation in India has become increasingly dependent on wells, with the consequent impacts on groundwater availability and on energy use for its extraction. Efforts have been made over the past three decades – from local pilot projects, to state-wide programmes – towards improving the efficiency with which groundwater is pumped, and, for its re-charge and conservation. In this report, we have compiled the information available, from published reports and papers as well as news bulletins, on the field activities and studies carried out with respect to efficient water extraction and use for agriculture. Numerous programmes have been included – ranging from cases where a few pump sets were focused on, to large programmes addressing thousands of pump sets. However, most of the cases involve the replacement/retrofitting of electrically-powered irrigation pump sets.

This compilation has two purposes. Firstly, we are beginning a repository of such reports that is publicly accessible and can be expanded with more documents. As importantly, we intend eliciting lessons from past experiences that would benefit future programmes, thereby improving irrigation efficiency and

contributing to the conservation of energy and water. The study was funded by Prayas Energy Group, Pune.

53. "**Integrated Resource Planning (IRP): Part 1 – Recent Practice for the Power Sector**", Antonette D'Sa, International Energy Initiative, March 2011, prepared for the Regulatory Assistance Project (RAP), USA, (currently available at http://iei-asia.org/IEI-IRP-RecentPowerSectorPractice.pdf)

    Integrated resource planning (IRP) is a planning method in which the requirement of a resource is met through combinations of supply increases and conservation of demand, while minimising the costs to the firm and to society. Countries around the world have programmes devoted to promoting renewable sources of electricity and/or improving the efficiency with which it is used. But, there are relatively few cases where the comparison of both supply- and demand-side options, and their externalities, is an integral part of the evaluation process.

    This document briefly describes the concept of IRP and then focuses on how IRP is being carried out for the power sector in various parts of the world. Cases included are those where IRP has actually been carried out, or at least where the IRP-approach can be discerned in some form – through portfolio optimisation or with an inclusion of demand side measures for meeting requirements, or where IRP has recently been recommended. Finally, pertinent questions on integrated planning for the power sector are considered. The study was funded by the Regulatory Assistance Project (RAP), USA.

54. "**Integrated Resource Planning (IRP): Part 2 – Options for the implementation of an IRP process in the Indian electricity sector**", Antonette D'Sa, International Energy Initiative, March 2011, prepared for the Regulatory Assistance Project (RAP), USA, (currently available at http://iei-asia.org/IEI-IRP-IndiaOptions.pdf)

    In this document, potential structures and policy measures through which the Indian power sector could employ integrated resource planning (IRP) methods in its planning processes are discussed.

    Based on the Indian experiences with power sector planning thus far and the recent legal, policy and institutional changes that have taken place, the policy instruments through which IRP could be carried out and the policy agents (institutions/organisations) who could wield them are evaluated. Policy instruments range from mandatory requirements (laws/regulations) and directives/policies to capacity building and encouragement of public participation. Appropriate policy agents who could carry out the required planning processes depend on the extent of integrated planning – ranging from exhaustive comparison of alternative demand and supply options at the national level, to a partial consideration of some alternatives by local utilities.

    In conclusion, those aspects likely to contribute to the adoption of IRP

methods are considered. The study was also funded by the Regulatory Assistance Project (RAP), USA.

55. "**Powering a village sustainably: Generating electricity from waste-based biogas**", Final Report prepared for WISIONS of the Wuppertal Institute for Climate, Environment and Energy, Antonette D'Sa, International Energy Initiative, June 2012, (currently available at http://iei-asia.org/IEI-Bangalore-DairyWaste-SustainableElectricity-DemonstrationReport.pdf)

This Report describes IEI-Asia's village-based income-generation and waste to electricity project, selected for funding by the Wuppertal Institute through the 6th Round of their Sustainable Energy Project Support Programme. The project has the objective of providing sustainable rural access to electricity through a community enterprise that generates electricity from local renewable resources, integrated with employment- and income-generation activities.

A village-based dairy has been established; this consisted of the construction of cattle-sheds and related (e.g. water-supply) facilities and the purchase of cows and training of local people for cattle-caring activities. A biogas plant, consisting of a floating-drum digester and inlet and outlet tanks, has been constructed nearby. Here, cattle-dung from the dairy is regularly deposited for the generation of biogas through anaerobic digestion. A room has been constructed adjacent to the biogas plant to house a 20 kVA engine-generator, running 100% on biogas; a pipeline links the gas-holder of the biogas plant to the engine. The existing electricity distribution grid has been extended to include the un-connected homes, school, and pump for water-supply. Electricity is generated daily for supply to the entire village, when supply from the state-run regional distributing utility (BESCOM) is not available. Efficient lighting (through CFLs using about 25% of the energy used by incandescent bulbs) has also been introduced, because the low end-of-line voltage from the grid did not permit fluorescent lamps to glow. The electricity generated through the project is being recorded and the corresponding avoided carbon emissions through replacement of conventional electricity and lighting sources by biogas has been estimated.

Through this project, all the occupied dwellings have been electrified, the entire village enjoys electricity-based services including efficient lighting, at times when grid supply is not available, and this electricity is derived from a continuously-available renewable source.

56. "**Value addition to food-crop processing: converting banana plant-waste to cooking fuel**", Final Report prepared for WISIONS of the Wuppertal Institute for Climate, Environment and Energy, Antonette D'Sa, International Energy Initiative, January 2014

The purpose of this project is to demonstrate rural development through improvements in agricultural productivity and rural living standards, by

integrating: efficient farming practices and thereby increased harvests among subsistence farmers, processing of the crop-residues for a renewable-energy source, generating clean fuel from this renewable source and delivering it as cooking fuel to rural homes, with the integration ensuring the long-term sustainability of the system. Here, the waste of newly-established banana plantations is being used to generate biogas for fuelling stoves.

Banana cultivation was initiated on plots of land owned by small farmers (in Ramanagara district in South-east Karnataka). This involved land preparation, the provision of efficient irrigation through shared access to water and drip micro-irrigation systems, and the provision of banana saplings. It is intended that the costs of these facilities will be recovered in instalments over about 7 years, from a share of the net banana sales revenue. As bananas yield within a year, the first crop has already been harvested and sold and the new crop is awaited.

Simultaneously, two large digesters have been constructed in the village where families were interested in purchasing gas for stove-fuelling, and pipeline connections have been drawn to the houses. While the available waste organic material (dung, crop waste) with most households is inadequate for generating enough gas for their cooking-fuel requirements, banana plants emit additional "pseudo" stems around the main fruit-bearing stalk; these have to be chopped down to preserve nutrition for the fruit. Hence, banana waste is adequate for fuelling gas generation throughout the year. Fuelling of the digesters consists of daily input of chopped banana stems, carefully weighed and mixed with the required amounts of water.

The renewable sourced fuel replaces not only biomass burning (and its adverse impacts), but also the need for state-sponsored LPG. The N_2-rich effluents from the digesters are being used as field manure. While the farm-owners have increased earning from banana sales, the labourers (at the farms and at the digesters) have benefited from increased employment.

57. Report on "**Integrated Resource Planning (IRP) for Electricity Distributing Utilities in India with special reference to the Bangalore Electricity Supply Company (BESCOM)**", Antonette D'Sa, International Energy Initiative, December 2014

Integrated resource planning (IRP) is a method that considers both supply and demand-side measures to meet the need for resources, while minimising the costs accruing to the firm and to society. IRP enables planners to assess a range of options through which the demand-supply gap could be bridged in a sustainable manner.

However, despite the advantages of such an approach, IRP has not been used by Indian electricity utilities. Further, as most state utilities have been "unbundled", it can be expected that individual distribution companies (Discoms) would face barriers to conducting integrated planning.

The objectives of this study are therefore to identify the barriers that discourage Indian Discoms' adoption of IRP and locate feasible conditions in which these could be overcome. Using the case of the Bangalore Electricity Supply Company (BESCOM) and the available documentation, these barriers have been classified as financial, technical, and operational; for each, a possible solution is suggested. While these solutions would be necessary, the study also identifies conditions that would be sufficient for IRP to be practiced. Apart from mandatory requirements, these conditions include the provision of at least a specified level of electricity-services, and the minimisation of costs, environmental impacts, and future investments.

58. "**Integrated Resource Planning for electricity distributing utilities in India"**, Antonette D'Sa, *Economic and Political Weekly*, 27th June – 5th July, 2015, Vol.50, Issue No.26-27, pp.74-82.

The report on the barriers to conducting IRP at electricity distribution utilities in India, with special reference to the Bangalore Electricity Supply Company (BESCOM), was summarised for publication in the *Economic and Political Weekly (EPW)*, the purpose being to share the study with the larger public.

Identifying the barriers that discourage the adoption of integrated resource planning by Indian power distribution companies, this article points to feasible conditions in which these hurdles could be overcome. Using the case of the Bangalore Electricity Supply Company and the available documentation, these barriers have been classified as financial, technical and operational; for each, a possible solution is suggested. The study also identifies conditions that would be sufficient for integrated resource planning to be practised, including providing at least a specified level of electricity services, and minimising costs, environmental impacts and additional investments.

59. "Value addition to food crop processing: converting banana plant waste to cooking fuel – Up-scaling Strategy", Final Report prepared for WISIONS of the Wuppertal Institute for Climate, Environment and Energy, Antonette D'Sa, International Energy Initiative, May 2016

This report describes the purpose, activities carried out, and results of the project *Value-addition to food crop processing: converting banana plant-waste to cooking-fuel – Up-Scaling Strategy*, implemented in the state of Karnataka (India), by the Asian Regional Initiative of the International Energy Initiative (IEI-Asia), and funded by the Wuppertal Institute for Climate, Environment, and Energy, Germany.

The purpose of the initial project was to demonstrate value-additions along the food growing and preparation chain. This project extension includes those objectives, but *focuses on the aspects relevant to replication*.

The objectives of this upscaling-phase were therefore to:

- reiterate that food production can be increased on existing crop-lands with effective resource-use, and that clean fuel can be generated regularly if based on the crop waste;
- assess the requirements for replication – resources, implementation process, operating models, financing;
- demonstrate that integrated plantation-to-fuel systems, as developed during the initial phase, are replicable at different scale and location;
- develop feasible models in which families can independently continue the fuel generation and delivery system;
- contribute to propagation efforts, by systematically documenting the necessary information required for implementing such systems.

60. Handbook on **"*Sustainable farming systems integrated with energy from waste* – Banana plantations and clean cook-stove fuel"**, Antonette D'Sa, International Energy Initiative, *in progress*

This "how-to" hand-book is being prepared in order to provide, at one location, the relevant information for the implementation of integrated banana-growing and biogas-generation systems. Accordingly, the handbook provides approximations based on the experiences (with corresponding photographs), as well as helpful hints and precautionary measures. It also provides theoretical explanation where necessary. Detailed sections include:- Pre-requisites for biogas generation from plantation residues, Banana cultivation activities, Biogas plant construction and generation activities, and Assistance with payments.