Need for an Integrated Energy Modelling Institution in India

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India's several interlinked energy-related challenges can only be met by long-term planning and coordinated action by various stakeholders. By highlighting the Planning Commission's Integrated Energy Policy report, this article proposes the creation of a government-supported statutory energy modelling institution – the Bureau of Energy Information and Analysis – that works under the guidance of the Planning Commission to develop an in-house modelling and analysis capacity for India. It argues that such an institutional approach will strengthen India's existing energy modelling efforts and help create a community of committed energy specialists.

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Sustained economic growth in India requires significant investment in energy infrastructure over the coming decades. Development of new energy infrastructure requires the country to tackle several key challenges at the same time. These challenges include: (a) increasing energy security at a time of escalating global resource constraints; (b) financing large energy infrastructure with substantial capital outlays; (c) increasing growth in the interlinked support infrastructure; (d) reducing social and environmental impacts of a growing energy infrastructure; and finally; and (e) addressing climate change impacts, adaptation and mitigation. Successfully dealing with these energy-related challenges will necessitate changes in the country's socio-economic policies and institutional structures.

Although a lot of attention has been (and is still being) paid to reforming India's energy institutions and corporations with an orientation towards market-based economics, there is a major lacuna: building institutions for energy modelling and analysis. Dealing with the multifaceted energy challenges in the coming decades requires India to develop substantial capacity in energy-environment-economy modelling analysis and forecasting, using complex modelling tools.[1] The importance of modelling in the energy sector has been highlighted in the recently released Integrated Energy Policy (IEP) report by the Indian Planning Commission. The report noted the need for supporting long-term "energy policy modelling" at a selected institution through a proposed National Energy Fund [Planning Commission 2006].[2] Energy policy modelling would include activities ranging from data collection, analyses and model-development to use and cross-comparison of models for energy policy analysis and evaluation.

As the IEP report indicates, energy modelling and analysis has been pursued in an ad hoc fashion by the government, by individual researchers in various academic institutions, and by non-governmental agencies, despite repeated calls for a coordinated institutional structure. It is towards this end that we discuss some of the past and present institutional structures for energy modelling in India, highlight the details of other worldwide energy modelling organisations, and finally present the key elements of an effective institutional framework for energy modelling and analysis in India.

1 History of Energy Modelling

Modelling for energy policies and demand projections has a long history in India,[3] with the Planning Commission being the focal point of such endeavours within the government. Most of the early modelling were simple assessments of the short-term demand and energy resource availability that were needed for the country's planning process. Typically, individual ministries led such efforts, and they made five-year forecasts and developed plans to meet these short-term goals. These forecasts were then fed into the Planning Commission's national plans through the plan's working groups. Beyond these plan-related activities, there have been four major government-led exercises on energy modelling for policy: the energy survey committee (ESC), the fuel policy committee (FPC), the working group on energy policy, and the most recent IEP committee. In addition to these government-led efforts, individual researchers and institutions have been supported by national and international funding sources since the mid-1970s, to pursue energy modelling activities in India.

The first comprehensive survey of energy resources and projections of future energy demand was undertaken in 1963, with the creation of the ESC by the ministry of irrigation and power [Sankar 1985]. Over the course of two years, the committee collected all available energy data, organised it in forms amenable for policy analysis, made forecasts of future energy demand up to 1980, and recommended energy policies that could secure the required energy supply at least cost to meet demand [ESC 1965; Sankar 1985]. Most of the modelling relied on foreign experts and consultants from US and UK,[4] and unfortunately, most of the ESC's policy recommendations were not very useful as they were based on "an inadequate examination of Indian conditions" [Sankar 1985]. Nonetheless, they emphasised the use of coal, suggested increasing firewood supply for household use, and recommended reviews of the energy sector every five years (however, they did not propose any institutional structures for such periodic energy assessments).

In 1970, a FPC was sponsored by the department of coal to undertake a survey of resources, estimate future demand, and study the efficiency of fuel use in the country [FPC 1974]. Unlike the 1963 committee, the FPC consisted entirely of Indians and was chaired by S Chakravarty.[5] Support for the modelling effort was provided by various Indian government agencies, and coordinated by the Planning Commission [FPC 1974]. The study accepted the Planning Commission's economic growth assumptions, and relied primarily on a regression model that correlated the growth of both the total and commercial energy consumption to growth in national income.[6]

The FPC recommended that coal become the primary energy source for India, in order to reduce oil dependence. The FPC also recommended that energy policies and plans (and their associated modelling) be reviewed "at least once in three years and the planning horizon extended at each time to 15 years" in the future [FPC 1974]. The FPC also provided specific proposals for institutions that focus on energy surveys, modelling, research, and analysis.[7] The key role of the proposed energy institutions was to coordinate and organise energy research and studies conducted in different institutions, rather than try to centralise the interdisciplinary research effort in the country. The government accepted most of the FPC recommendations in principle, but did not fully implement them [Ganapathy 1984; Sankar 1985]. The only significant actions taken were the creation of a ministry of energy – which combined the departments of coal and power – and the recruitment of an energy adviser in the Planning Commission [Ganapathy 1984]. Soon after the FPC report was released, the Ford Foundation supported a separate independent assessment of the long-term (25-year) energy demand, the resources to meet the expected demand, and various other policy options [Parikh 1976].[8] The Ford Foundation and the USAID also funded an earlier programme in the 1960s on the development of linear programming models applied to Indian development planning [Eckaus and Parikh 1968].

Later, in 1978, the Working Group on Energy Policy (WGEP) was set up by the Planning Commission to once again reassess demand, survey energy supplies and outline a national energy policy. The WGEP was headed by the secretary of the ministry of energy (department of power) and had high-level officials, many of whom were involved in the earlier FPC [Sankar 1985]. The WGEP also had interactions with academic researchers on energy modelling [WGEP 1979; Parikh 1981].[9] The WGEP's reference level energy demand forecasts were based on "harmonising the forecasts obtained by different methodologies", such as time trends, regression analysis, and end-use methods [WGEP 1979]. The WGEP emphasised the need for an integrated, long-term view of the energy sector, and called for continuous energy policy assessments and an institutional structure for coordination of energy-related activities in the country. In 1982, an advisory board of energy (ABE) was set up to provide energy policy input directly to the prime minister's cabinet [Ganapathy 1984]. Following up on the WGEP study, the ABE produced a demand forecast study based on a more disaggregate sectoral approach and extended the time period to 2004-05 [Sengupta 1992]. The ABE also commissioned many studies by independent researchers on various energy-related topics.[10]

In the mid-to-late 1980s, energy modelling was seriously taken up by the Planning Commission, under the leadership of Hiten Bhaya [Sengupta 1993]. A steering group on energy modelling was created and Ramprasad Sengupta was recruited to work on a major integrated energy modelling exercise related to commercial energy (op cit). The Sengupta study was conducted between 1986 and 1989, and a report entitled 'Perspective Planning and Policy for Commercial Energy' was submitted to the Planning Commission in 1988-89. The study involved the development of an integrated model based on models for (1) demand projection, (2) availability of coal resources, (3) coal production and supply linkages, (4) upstream and downstream components of the oil and natural gas industry, and (5) electricity generation [Sengupta 1993]. The models were consistent with the Planning Commission's macroeconomic assumptions and were based on detailed technical discussions and data inputs from the government and various energy industries. This work illustrated how a government-led energy modelling effort (led by an independent academic) could successfully interact with government agencies and industries, and train a cadre of junior officers in various agencies interested in energy modelling and planning. In addition to the Sengupta study, the Planning Commission (1991) also carried out a study to forecast the sectoral energy demands. Unfortunately, the energy modelling expertise built up in the Planning Commission was not maintained because of political instability and a lack of interest to continue long-term energy modelling (ibid) – especially as India became embroiled in sorting out its 1990-91 macroeconomic crisis.

Starting in the 1980s, academics and non-governmental organisations also started to play a more important role in energy modelling. Sensing that much of energy-related data and information flow in India was inadequate and spread out in the country [Ahuja et al 1984], Tata Energy Research Institute (TERI),[11] a non-governmental organisation, began to collate energy data and also undertake some modelling effort.[12] Academics, such as Jyoti Parikh at the Indira Gandhi Institute for Development Research (IGIDR), P R Shukla at the Indian Institute of Management, Ahmedabad (IIM-A), and Amulya K N Reddy at the Indian Institute of Science (IISC) Bangalore took the lead in developing energy-economy-environment models for India.

The IGIDR researchers developed several econometric models for forecasting energy supply and demand and undertook surveys and modelling of rural energy use.[13] The IIM-A group also developed econometric models at the regional and local levels [Shukla 1997], and has, more recently, focused on energy and climate change modelling for India, based on adaptations of MARKAL and AIMS models [Loulou et al 1997].[14] Similarly, TERI developed several different econometric models for India [Shukla 1997], and has used MARKAL-based models for understanding India's energy, economy, and climate-change linkages. Recently, TERI has used a MARKAL model to project energy demand and supply dynamics for the country under different scenarios [TERI 2006]. Over the course of two decades, both IIM-A and TERI have been continuously adding to their modelling capacity, and they currently have the most expertise in integrated energy-economic models with a climate component. In general, an increasing concern about climate change impacts in the 1990s (in part through the IPCC process) led to the development and greater use of India-focused integrated climate-energy-economy models – thereby, building up a modelling capacity within the country.

Finally, Amulya Reddy and colleagues at the IISC undertook village-level energy surveys and developed an independent energy model for local and regional levels. They criticised the existing modelling approaches for not effectively including least-cost planning, and proposed a new methodology for energy planning: "Development-Focused End-Use-oriented Service-directed"

Table 1: Key Institutions for Energy Modelling and Policy Assessment in Other Countries

Name	Country	Host Institution	Staff Strength	Budget	Activities	Public Access to Information
Energy Information Administration (EIA) http://www.eia.doe.gov/	US	EIA is the independent statistical agency of the US department of energy (DOE).	370	$ 85 million in 2006	• Provide policy independent data • Analyses for policymaking and understanding economy-environment interaction. • Modelling and forecasts of energy demand, technology, prices, and other factors in short and medium term. • Flagship report – Annual Energy Outlook.	Extensive documentation on web site, including model documentations and reports; EIA is also subject to the US Freedom of Information Act.
International Energy Agency (IEA) http://www.iea.org/	OECD	IEA is an autonomous agency under the OECD.	150	–	• Energy policy advisor for OECD countries • Collect energy data and modelling for the flagship publication – *World Energy Outlook*. • Fund and establish research institutions (e g: IEA clean coal centre, IEA greenhouse gas, etc) • Publication of energy studies and R&D reports on technology	Most reports and studies except for the most recent ones are free on the web. Data is restricted to paying subscribers only. Model documentation is not provided.
Australian Bureau for Agricultural and Resource Economics (ABARE). http://www.abareconomics.com/	Australia	ABARE is an independent research agency under the ministry of agriculture, fisheries and forestry.	150	–	• Independent economic research, analysis, and forecasting For Australia • Extensive energy database, including some corporate data. • Advise government on national and international energy policy, including climate negotiations • Produce quarterly and medium-term forecasts for export commodities.	Documentation available on web site, including some models and data.
Tyndall Centre http://www.tyndall.ac.uk/	UK	Distributed institutional structure. Centre located within six academic institutions in UK.	110	Initial five-year grant of 10 million pounds	• Research and integration of climate change science, mitigation and adaptation. • Influence design and achievability of climate change mitigation strategies • Promote informed and effective dialogue across society about future climate • Policies for minimising adverse effects of climate change and for transitioning to a more benign energy and mobility regime	Technical reports of projects, working papers, testimonies to the parliament and journal articles are posted on line.
Energy Research Institute (ERI) www.eri.org.cn	China	ERI is an independent agency under the Chinese National Development and Reform Commission (NDRC).	100	–	• Research on China's energy-economics-climate issues for China's decision-makers, particularly for the NDRC. Research is partly guided by the Chinese Academy of Sciences. • Publishes a monthly journal, *Energy of China*, with information about Chinese energy policies, markets, technology research, and national data. • Has six research centres that support various energy-related activities, including energy modelling and database development, energy efficiency, climate change, and energy economics and strategies.	Contents of *Energy of China* available on web site, but payment required for full text.

(DEFENDUS) [Reddy et al 1995a, 1995b].[15] Although the DEFENDUS approach has been criticised for its lack of "implementability" and explicit inclusion of prices,[16] the approach was novel and it explicitly included end-use and generation efficiency, demand management, energy conservation, and least-cost planning. While the DEFENDUS has mostly been used at local and regional levels, the methodology has also been applied to assess the national long-term energy demand [Sarma et al 1998].

2 Modelling Institutions

Similar to India, the global interest in energy modelling, data collection, and forecasting increased in the aftermath of the oil crises of the 1970s. But unlike India, however, industrialised countries created strong government-supported energy modelling institutions: for example, the US Energy Information Agency (EIA) and the International Energy Agency (IEA) were established during this period. Broadly, the structure of these institutions can be described as (a) single integrated units (EIA, IEA and ABARE) or (b) distributed units with a centrally coordinating board (Tyndall Centre), and the key attributes of several different energy modelling organisations are summarised in Table 1 (p 66).

3 Towards an Energy Modelling Institution in India

India lacks a unified energy modelling and analysis institution similar to the ones discussed above. The absence of such an institution has led to a piecemeal approach towards planning in the country, with the Planning Commission (through its working groups) mainly engaged in business-as-usual "consistency planning", without much consideration of alternative least-cost/optimal scenarios. The working groups of the five-year national plans are mainly dominated by concerned industries and ministries, and hence, there can be a "built-in bias" for projecting high demand for sectoral products [Sengupta 1992]. While the sporadic energy policy exercises (ESC, FPC, WGEP and IEP) have tried to provide a broader energy policy approach, their main impact has been to provide demand forecasts and policy suggestions for the Planning Commission working groups. Furthermore, energy modelling and analysis by academics and non-governmental agencies have been constrained by funding and driven by agendas of individual researchers and funding agencies.

Therefore, it is essential for a government-supported energy modelling and analysis institution to be created in India. In terms of institutional structure, our assessment of different energy modelling institutions in other countries has several implications for India (Table 2).

After weighing the pros and cons of the different institutional structures, we believe that it is best for India to have a single institution that can be the main centre for the collection of energy-related data, data analysis, energy modelling and forecasting capacity. Although it might be faster to simply coordinate the existing modelling capacity in various Indian institutions (in the Tyndall Centre), we believe that creating a nodal modelling agency would be beneficial for India in the long term. Given the current disparate nature of energy modelling in the country, it is important to for the Indian government to build its own modelling capacity to deal with issues related to energy, economy, environment and climate change. Such an institution can provide relatively objective analytical inputs to policymakers in helping them devise appropriate energy policies for India. Moreover, given that the government dominates India's energy institutions, it is unlikely that a distributed centre will have much influence on the ministries.

Openness and public access to information from this institution should be enshrined under the law in order to reduce political influence and to include different points of view (especially views antagonistic to official government position). All data, products, models, and analyses of the modelling institution should be subject to the Right-to-Information Act.[17] Furthermore, the permanence[18] and independence of the modelling institution will be guaranteed if it is an independent statutory body with well-defined goals and organisational structure – similar to the Bureau of Energy Efficiency. This new institution must work under the guidance of the Planning Commission, as the commission has been a central player, and often a leader, in previous energy policy modelling, analysis, and planning. Moreover, long-term perspectives and macroeconomic parameters from the Planning Commission are essential for energy modelling.

Thus, we call for a Bureau of Energy Information and Analysis to be created within the Indian government. This institution should include the following basic elements:

Energy (and environmental) data collection and statistical analysis for both supply and demand;[19] short-term (one to two

Table 2: Comparison of Integrated and Distributed Institutional Structures

	Single Integrated Unit	Multiple Distributed Units
Institutional structure	Single, independent agency with data collection, analysis, modelling and forecasting capacity. Agency is directly funded by the government.	Distributed modular units with central funding and administrative structure. The units can be in different universities or ministries. A central coordinating body decides broad goals and funding, with the units defining specific tasks and projects.
Guiding principles	• The independence of the data analysis, policy recommendations and forecasts to be enshrined in law. • All products and analyses to be in the public domain.	• An independent coordinating council will meet regularly to set broad goals and evaluate performance. • Different units will propose projects to meet these goals and bid for funding. • All products and analyses should be in the public domain.
Pros	• A single agency for the collection and analysis of all data can be more efficient. • Minimises administration costs.	• Lower investment and time to set up the institutional framework, as it utilises the already existing capacity in the country. • Provides a platform for different points of view, useful in the analysis of such complex issues. • Lower risk of political influence.
Cons	• Significant investment and time may be required to set up the institution. • Higher risk of political influence.	• Higher administration overhead. • Possible issues of non-compatibility between assumptions and modelling frameworks used by different units.
Illustrative examples	EIA, IEA, ABARE, ERI	The Tyndall Centre for Climate Change Research

years, with reports every quarter) and long-term (20-30 years, with annual and five-yearly reports) energy-economics models, and forecasts of the economy with detailed sectoral modelling of commercial and non-commercial fuels (from primary resources to final end-use services); capacity to report to policymakers on the impact of economic and policy measures on the Indian energy infrastructure, economy, social infrastructure and local/global environment; developing long-term models for each energy supply and consuming sector, which can then be integrated into a national energy model; integration of climate-change impacts into energy/economy modelling; linking of national energy-economy models with other international models to assess availability and economics of essential energy resources; capacity to address demand for detailed analyses and forecasts at the regional and state levels; and assistance to states for their energy modelling needs.

The importance of regular data collection, coordination, collation and statistical analysis must be emphasised here. The analysis of large amount of data and information is precisely what allows energy modellers to get a better understanding of the current energy system and its determinants [Chikkatur and Sagar 2006]. In turn, such analyses also provide valuable feedback into the data collection process.[20] Currently, some data collection and collation happens in different ministerial agencies, and recently the Central Statistical Organisation (CSO) has been collating the statistics from different energy ministries [MOSPI 2006]. The proposed bureau, however, can take up the coordination of energy and environment data collection on a regular basis as one of its primary duties. In order to obtain information from the private sector, some parts of the detailed data can be treated as proprietary and confidential, and only certain consolidated parts of the database can be made public.[21] The bureau should work in coordination with the Census Bureau, CSO and the relevant energy ministries and agencies to collate and critically analyse data from various sources, determine data gaps, and follow through on action plans to fill these gaps. If necessary, the BEIA can also have regional offices to help with the data collection and development of regional models.

The bureau needs to become the key agency for supporting the development of indigenous modelling capacity. Existing modelling capacity in India is mostly based on models that were initially developed for advanced economies in the west.[22] While some of these models have been adapted to reflect the realities specific to India, new indigenous models (such as DEFENDUS) might be more appropriate. New models could explicitly include specific features of the Indian economy, such as the extensive informal and non-market component of the economy, persistent disequilibrium between supply and demand of power and basic commodities, relatively high cost of finance, and underdeveloped corporate debt market. Developing such indigenous models will help in better understanding of non-commercial fuels used in the rural sector and in assessing the potential for increased use of renewables – especially, biomass power and biofuels. On the other hand, the BEIA should not centralise or try to control the growth of energy modelling in the country. Given that there is already a significant amount of modelling capacity in various ministries, academia, non-governmental agencies, and the private sector, the BEIA can help integrate these disjoint efforts.

While it is important for the BEIA to have in-house expertise, it should also be open to seeking outside expertise whenever required by commissioning projects and analyses on a system of open and transparent competitive bidding process to researchers in academia, think tanks and the private sector. It can also support unsolicited proposals for analysis and data collection, as required. Most importantly, the BEIA staff should have enough capacity to be able to distinguish between "useful" and "perfunctory" modelling. While the best balance between in-house modelling and supporting outside efforts will have to be determined organically over time, this procedure will, in the long run, build a community of competent energy modellers. It will also lead to the development of centres of modelling expertise in various academic institutions and research groups, so that a hierarchy of models can be created at different levels of detail to target various sectors and geographical segments of the economy.

It is also crucial that an eminent, experienced, and well known expert leads the BEIA, so that he/she can attract and retain the right kind of talent into the BEIA. Such a person should have the ability to recruit from both inside and outside the government. It is also beneficial to have a part of the technical staff rotate in and out of competent modelling and analysis groups in the country. Such rotations can allow the BEIA staff to determine what constitutes good modelling and analysis, what kind of data to assemble, how to collect such data, who to train and recruit, etc. The rotations can also help build confidence among different stakeholders and help to inject outside perspectives into the BEIA, to help ensure that it remains a dynamic and relevant agency.

The BEIA should be governed by an advisory board consisting of academics, energy experts and representatives from concerned ministries and private sector, in order to inject different perspectives into the BEIA. The board can evaluate project proposals and resulting products. An annual stakeholder meeting can also be convened with all concerned participants – modellers, policymakers, and representatives from energy industries and environmental NGOs. This meeting can be a forum for helping to shape the activities of the BEIA, as well as to coordinate the modelling work in academic and non-governmental energy institutions.

In terms of funding, a long-term, sustained allocation for the BEIA is essential – hence, the bureau should get funds directly from the central government as grants-in-aid. It should maintain a fund (similar to the central electricity regulatory fund) to which all grants/loans from the government are credited, and from which all expenses of the bureau are debited. The bureau should be able to independently operate the fund and make appropriate allocations to meet its functions.

In conclusion, we have provided here a skeletal outline of the necessary elements of an energy information and assessment institution that can contribute enormously to securing India's energy future. A detailed proposal should be devised with an extensive stakeholder input, and as such, a stakeholder process[23] is necessary for ensuring the legitimacy of the institution and for ensuring that its activities begin as soon as possible.

NOTES

1 Models are most useful in simplifying and making explicit key relationships, organising data, and presenting the results in quantitative terms. Energy-economy models should be seen as tools that provide the possible trajectories that the economy might take under various policy, technology and financial choices. Modelling frameworks generally fall under two basic paradigms – bottom-up and top-down. Bottom-up models have a very detailed description of the energy use, transportation and production segments of the economy. Macroeconomic factors including growth rates and energy consumption are exogenous to the model and feedback from price signals, labour-capital substitution, and structural changes in the economy are not included. Top-down models have a broad-based description of macroeconomics and take into account the above-mentioned macroeconomic factors. Most modern large-scale models are often a hybrid of these two paradigms and consist of a bottom-up model loosely coupled to a macroeconomic module.

2 Interestingly, the IEP committee itself outsourced some of their key energy modelling effort to a third-party, Observer Research Foundation. The Observer Research Foundation is a think tank aimed at influencing public policy formulation, financed by Reliance Industries. See: http://www.observerindia.com/

3 Energy surveys were undertaken even before India's independence. For example, a "Power and Fuel" subcommittee of the National Planning Committee (1938-45) made one of the first general surveys of resources for power generation. See Shah (1949).

4 Two of three joint-chairmen for the survey committee were from US (Walker Cisler of Detroit Edison Company) and UK (Austin Robinson of Cambridge University). Robinson, in fact, wrote much of the report for this committee. Energy demand analysis and resource assessment was primarily done by USAID consultants, who worked for nearly a year. They were assisted in their work by a staff of Indian specialists [ESC 1965].

5 R Venkataraman (member, Planning Commission) chaired the committee until July 1971. Upon his resignation, Chakravarty took over [FPC 1974]. The FPC had a separate secretariat, headed by T L Sankar, and Kirit Parikh, the chairman for the recent IEP report, was also a member of the FPC.

6 The regression model was cross-checked against an end-use model that relied on norms of energy consumption in various sectors of the economy. The end-use model is an effective input-output model whose coefficients depended on past trends, price of fuel, and technology shifts [FPC 1974; Sankar 1985]. Other sectoral models, including a linear programming model for petroleum sector, were also employed to assess, for example, the location and capacity of refineries and the choice of fertiliser feedstock [Sankar 1985].

7 The FPC suggested three options: (a) an Energy Commission to periodically review energy planning in India, collect systematic data and information about Indian and international energy situation, and organise research and analysis that contribute towards better energy policies; (b) an Energy Board, consisting of ministers from concerned ministries, to meet the urgent need for inter-ministerial coordination; and (c) an independent Institute of Energy Studies for systematic data collection and organising research and analysis of energy policies.

8 The Ford Foundation supported these studies to "stimulate a further, systematic examination of India's opportunities and problems in the future" [Parikh 1976].

9 For example, the WGEP interacted with Jyoti Parikh, who was a consultant to the Planning Commission's energy division. At that time, she was working to apply models from the International Institute of Applied Systems Analysis (IIASA) to the Indian context, with support from the World Bank [WGEP 1979; Parikh 1981]. The IIASA models included the SIMA model for generating macroeconomic indicators, the ENDIM model for simulating sectoral energy demand, and the INVEST model that related energy requirements to economic growth [Parikh 1981]. The model supplemented the simpler input-output model used by the Planning Commission, and it provided a more detailed modelling framework and sensitivity studies for the policy recommendations of the WGEP.

10 Personal Communication, E A S Sarma, April 2007.

11 The Tata Energy Research Institute has recently become "The Energy Research Institute".

12 The TERI Energy Data Directory and Yearbook (TEDDY), started in 1986 has now become the premier publication on energy statistics in India. In fact, one of TERI's first externally funded projects was to develop an energy model for India. See: http://www.teriin.org/about_origin.php.

13 Much of this work in energy was led by Jyoti Parikh, who was at IGIDR from 1986-2003. See: http://www.irade.org/jp/index.html. Jyoti Parikh is currently with a new organisation: Integrated Research and Action for Development (IRaDE).

14 For a description of these models, see TERI (2006).

15 The DEFENDUS approach first requires a reference energy system (RES) with detailed information on the conversion of energy sources to energy services. The RES is then used to create DEFENDUS demand scenarios and least-cost supply options are formulated to meet the different demand scenarios [Reddy et al 1995a]. Appropriate policies can then shift the RES towards the DEFENDUS scenarios and least-cost supply planning.

16 See, for example Sengupta (1992).

17 Nearly all energy data should be available to the public, as this is a necessary and important step for promoting transparency and in engendering multiple analyses. The proprietary nature of some data, however, might exclude the detailed data from being public, and such data in a suitable aggregated format should be made public and subject to the RTI Act.

18 Permanence of the modelling institution is important for creating a cadre of committed energy modelling specialists.

19 Reddy et al (1995a) points out that there is far more data on the supply aspects of the energy system than on the demand aspects, and moreover the demand data is in highly aggregate forms.

20 In fact, one of the major benefits of the energy-related committees and the recent IEP report is that they collated energy data, analysed it, and presented it in one place.

21 For example, collection and maintenance of such confidential data is a common practice within the USEIA, and for a specific suggestion of this kind in the Indian context, see Chikkatur et al (2007).

22 See Reddy et al (1995a) for a brief summary of the range of models that have been borrowed from different countries for use in India.

23 This can perhaps be furthered by holding energy modelling workshop (supported by government) to get a better understanding of the current state of modelling in India, and for soliciting opinions on how to best put together a government-supported energy modelling institution.

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