DECEMBER 2004 | VOLUME 1 | NR

reCOMMEND 2

reCOMMEND IS A NEWSLETTER OF THE COMMUNITY FOR ENERGY, ENVIRONMENT AND DEVELOPMENT

EDITORIAL

You are looking at the second issue of reCOMMEND, which addresses a number of issues pertinent to energy planning: household energy substitution, energy security, the cycles that international energy policy has gone through, a comparison of the LEAP and MARKAL tools, and a South African study into renewable energy targets.

We warmly welcome your feedback on this issue, as well as suggestions for articles for publication in future issues of the newsletter.

Happy reading,
reCOMMEND EDITORIAL TEAM

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Community for Energy, Environment and Development

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ELECTRICITY

Meeting South African Renewable Energy Targets

Thomas Alfstad
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This article gives an overview of a study on renewable targets for the electricity sector in South Africa. The study used the LEAP model to provide estimates of the financial costs of reaching specified levels of renewable generation.

BACKGROUND

The South African Department of Minerals and Energy (DME) has finalised its White Paper on Renewable Energy. In this document a target of 10 TWh is set for renewable energy contribution to final energy consumption by 2013. This is to be produced mainly from biomass, wind, solar and small-scale hydro resources. In addition it has been suggested that at least 4 TWh of this target should come from the electricity sector.

To date, here has been limited activity in terms of concrete projects to follow up on the targets set by government. A strategy is needed to indicate how these targets can be met. Since no detailed plan has been announced, the way forward is uncertain. This article presents a study that seeks to help bridge this gap by identifying alternative plans and providing estimates of their costs.

METHODOLOGY

The objective for this study was to give a preliminary estimate of what the financial costs of meeting various renewable targets for the electricity sector would be. This was done by

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Newsletter of the COMMEND initiative

COMMEND –COMMunity for ENergy, environment and Development- aims at fostering a professional community among Southern energy analysts. COMMEND is an open community intended to be accessible to all energy analysts, and designed to foster mutual assistance between its members.

COMMEND is being funded by the Government of the Netherlands and undertaken as a collaboration between the Boston Center of the Stockholm Environment Institute (SEI-B) and four leading international institutions working on sustainable energy development: the Institute for Energy Economics of the Fundación Bariloche in Argentina (IDEE/FB), ETC Foundation in the Netherlands, ENDA-TM in Senegal, and the Energy Research Centre in South Africa (ERC).

The newsletter is distributed free of charge and is available through the COMMEND web site.
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Design
Labl.nl, Zeist

Printing & Layout
Koninklijke BDU Grafisch Bedrijf B.V., Barneveld

Funding
This newsletter is supported by the Netherlands Directorate General of International Cooperation (DGIS).

comparing the costs of a non-renewable reference scenario with the costs of scenarios with renewable targets.

Scenarios were designed with four main criteria in mind. Firstly, it was a requirement for each scenario that the specified target for contribution from renewable energy sources was met. Secondly, the contribution from each renewable technology was not allowed to exceed the potential estimated by the South African Department of Minerals and Energy (DME)*-1. Thirdly, each scenario was designed to have diversity in the renewable electricity generation expansion. Finally, an attempt was made to keep costs low.

Technical and economic data for generation technologies were taken from three main sources; the National Integrated Resource Plan (NIRP)*-2, the DME and the International Energy Agency (IEA)*-3. Costs were evaluated by producing levelised cost curves for all options and thereby allowing for the comparison of generation costs from various technologies at different load factors. The curves were produced for three time periods 2003, 2010 and 2020, as some technologies were assumed to show significant cost reduction over time. These curves were then used in a screening process where the most expensive options were eliminated and the cheaper ones ranked based on their levelised cost of generation.

A reference case and four scenarios were created. The reference case was taken from the NIRP and is a least cost expansion plan with no renewable targets, developed by the National Electricity Regulator. This reference case was used as the base for the four other scenarios which represented different levels of renewable generation. These levels ranged from the case where only the minimum requirement of 4 TWh of renewable generation from the electricity sector is met to one where the entire 10 TWh are met by the electricity sector. The two other scenarios represent intermediate levels of renewable contributions at 6 and 8 TWh. Renewables were assumed to replace baseload coal fired generation and were also assumed to be first on the power station merit order. The scenarios were also required to maintain the reserve margin at the same level as the reference case.

The Long range Energy Alternatives Planning (LEAP) software was used to develop a model of the South African electricity supply industry. All power stations (existing and future) were represented individually in the database. Scenarios were entered through exogenous specification of expansion plans.

Only costs relating to electricity generation were included in the analysis. These costs were broken down into investment costs, fixed operation and maintenance costs, variable operation and maintenance costs and fuel costs. The power stations were dispatched according to a specified merit order, with renewable generation assigned to come online first. Electricity demands were modelled in aggregate and were the same in all scenarios.

RESULTS

The main purpose of this exercise was to determine the financial cost of different renewable targets. Figure 1 shows the added cumulative cost of each scenario in 2013 over the reference case. The values are thus the total added cost incurred due to the enforcement of a specified renewable contribution to total generation. We see from the chart that to reach the minimum requirement of 4 TWh, an additional 10 billion Rands will have to be spent over the next 9 years. This is equivalent to an increase of 8% over the reference case. The added cost is not only a reflection of the higher levelised costs of renewable technologies compared to those they are replacing but also of the fact that more total capacity is needed to maintain the reserve margin due to the intermittent nature of some renewable resources.

Figure 2 shows the difference in electricity generation by technology between the reference case and the different scenarios. Positive values indicate additional generation while negative values indicate less generation. Thus, the introduction of renewable technologies reduces the load factor of existing coal fired stations and delays the construction of new pulverised coal fired and fluidised bed combustion stations.

CONCLUSIONS

It is clear that the renewable targets will involve significant economic costs. The scenarios developed here indicate that the cumulative cost of meeting a target in the 4-10 TWh range is roughly 2.5 to 3.0 billion Rands per TWh.

The introduction of renewable electricity sources mainly displaced generation from coal fired stations. Although not quantified here this should lead to substantial reductions in green house gas emissions and other pollutants.

Wind generation has the largest potential, but is not among the cheapest alternatives, even at 35% load factor. Co-generation from biomass is competitive, although the economics of this form of electricity production have been simplified in this analysis as related

Figure 1

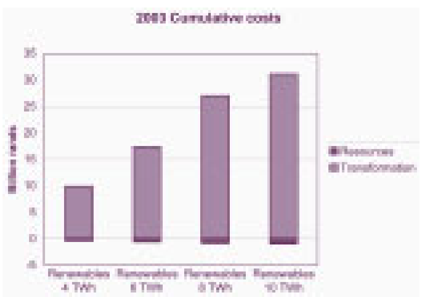
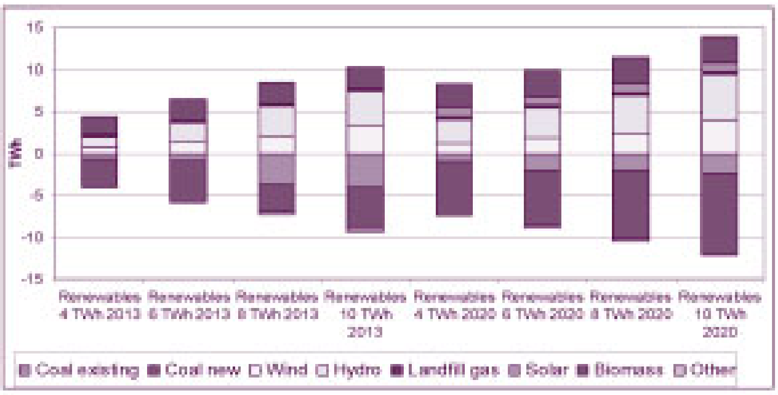


Figure 2: Electricity Generation by Technology



operations have been ignored. The costs of hydro installations vary widely, but there should be substantial potential *1 for generation at reasonably low cost. Currently, solar thermal generation has very high costs but with the cost reductions estimated by the IEA they become highly competitive towards the end of the period. The IEA projections must however be seen as highly uncertain and very optimistic.

It should be possible to meet the targets at lower costs than those derived here. The scenarios have not been optimised and there is little reason to believe that the suggested expansion plans are the most cost effective, even when the diversification criteria introduced earlier is taken into account. It is therefore suggested that further studies into the matter include some form of optimisation routine.

The targets apply to energy consumption rather than production and an issue that warrants further examination is that of system losses. In this study all generation options have been charged with the same transmission and distribution losses, while in reality the decentralised nature of renewable generation suggest that the incurred losses may be smaller than the system average. By differentiating losses from different generation options the estimated costs of meeting the targets might be brought down further.

Renewable energy has a vital role to play if the world is going to tackle the long-term challenge of global climate change. South Africa has recognized this challenge and is committed to promoting greater use of renewable energy in its electric sector. However, this study highlights some of the difficulties of introducing renewables in a country where fossil fuels (in this case coal) are available in huge quantities and at very low cost. Indeed, the electricity produced in South Africa (primarily from coal) is among the cheapest in the World. In part, the low cost reflects the fact that significant environmental costs have not been included. Fully accounting for the greenhouse gas and air pollution impacts of coal will undoubtedly make renewables look more attractive.

The LEAP data set described in this article is available for download from the COMMEND website.

***1** Government of South Africa, Department of Minerals and Energy (February 2004) Economic and Financial Calculations and Modeling for the Renewable Energy Strategy Formulation

***2** The National Electricity Regulator (2004) National Integrated Resource Plan 2003/2004

***3** International Energy Agency (2003) Renewables for Electricity Generation – Status and Prospects

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ENERGY SECURITY ANALYSIS

A New Framework

Based on work done as a part of the Nautilus Institute's "Pacific Asia Regional Energy Security" project (PARES), this paper offers a new definition of Energy Security, and describes an analytical framework designed to help compare the energy security characteristics of different of scenarios. The results of an application of the framework to a case study of Japan are also briefly summarized.*-1

David von Hippel
Associate of TELLUS INSTITUTE

REDEFINING ENERGY SECURITY

Many of the existing definitions of energy security begin, and usually end with a focus on maintaining supplies of energy, particularly oil. This focus has as its cornerstones reducing vulnerability to foreign threats or pressures, preventing a supply crisis from occurring, and minimizing the economic and military impact of a supply crisis once it has occurred. National energy policies today are being challenged on multiple fronts. The substance of these challenges needs to be incorporated into a new concept of energy security. Current national and international energy policies have been facing many new challenges, and have at their disposal new tools, that need to be considered as key components of new energy security concepts. At least five key components -environment, technology, demand side management, social and cultural factors, and post-Cold War international relations- are central additions to the traditional supply-side point of view.

Considering the addition of these concepts, we offer this new definition of Energy Security:

A nation-state is energy secure to the degree that fuel and energy services are available to ensure: a) survival of the nation, b) protection of national welfare, and c) minimization of risks associated with supply and use of fuel and energy services. The five dimensions of energy security include **energy supply, economic, technological, environmental, social and cultural**, and **military/security** dimensions. Energy policies must address the domestic and international (regional and global) implications of each of these dimensions.

What distinguishes this energy security definition is its emphasis on the imperative to consider extra-territorial implications of the provision of energy and energy services while recognizing the complexity of actualizing (and measuring) national energy security. The definition is also designed to include emerging concepts of environmental security, which include the effects of the state of the environment on human security and military security, and the effects of security institutions on the environment and on prospects for international environmental cooperation.

TESTING ENERGY SECURITY IMPACTS OF DIFFERENT SCENARIOS

Given this definition of energy security, how should a framework for evaluating the energy security implications of different policies be organized? The challenges include deciding on manageable but useful levels of detail, incorporation of uncertainty, risk considerations, comparison of tangible and intangible costs/benefits, comparing impacts across different spatial levels and time-scales, and balancing analytical comprehensiveness and transparency.

In meeting these challenges, a framework was devised that is based on a variety of tools, including the elaboration and evaluation of alternative energy/environmental scenarios for a nation and/or region diversity indices, and multiple-attribute (trade-off) analysis. Central to the application of the framework is its application to search for "robust" solutions -set of policies that meet multiple energy security and other objectives at the same time. The framework for the analysis of Energy Security (broadly defined) includes the following steps:

- Define the objective and subjective measures of security to be evaluated.
- Collect data, and develop candidate energy scenarios that provide roughly similar energy services.
- Test the relative performance of scenarios for each security measure.
- Incorporate elements of risk.
- Compare scenario results.
- Eliminate scenarios that lead to clearly sub-optimal or unacceptable results.
- Iterate the analysis as necessary to reach clear conclusions.

Table 1: Dimensions and Attributes of Energy Security

Energy Supply	Economic	Technological	Environmental	Social and Cultural	Military/Security
Total Primary Energy (lower preferred)	Total Energy System Costs (lower preferred)	Technology Diversity for key industries such as power generation (higher preferred)	GHG emissions (CO2, CH4, lower preferred)	Exposure to Risk of Social or Cultural Conflict over energy (lower preferred)	Exposure to Military/Security Risks (lower preferred)
Fraction of Primary Energy as Imports (lower preferred)	Total Fuel Costs (lower preferred)	Diversity of R&D Spending (higher preferred)	Acid gas emissions (e.g. SOx, lower preferred)		Relative spending on energy-related security (lower preferred)
Diversity of supply by fuel and supplier (more preferred)	Import Fuel Costs (lower preferred)	Reliance on Proven Technologies (higher preferred)	Local Air Pollutants (PM, VOCs, etc. lower preferred)		
Stocks as a fraction of imports (higher preferred)	Fuel Costs as fraction of GNP (lower preferred)	Technological Adaptability (higher preferred)	Other pollutants, solid and nuclear wastes, ecosystem and aesthetic impacts and exposure to environmental risk (lower preferred)		
Key: Gray boxes indicate primarily qualitative indicators					

Some of the possible measures of energy security, and dimensions and attributes are summarized in Table 1.

An energy scenario describes the evolution -or potential evolution- of a country's energy sector assuming that a specific set of energy policies are (or are not) put in place. The level of detail with which an energy scenario is described will be a function of the degree of realism required to make the analysis plausible to an audience of policy-makers, as well as the analytical resources (person-time) and data available to do the analysis.

"Bottom-up" quantitative description of energy paths -like the one summarized below for Japan- offer the possibility to specify fuels and technologies used, as well as energy system costs, and key environmental emissions, in some detail, but can require a considerable amount of work. Simpler econometric models (or models that combine econometric and end-use elements) can also be used, providing that model outputs can include measures of energy security like those presented above.

A major criterion to keep in mind is that the scenarios chosen should be plausible yet different enough from each other to yield significant insights into the ramifications of the energy policy choices when their attributes are compared.

Some of the data requirements in defining an energy scenario include:

- Data on current demands and supplies of fuels by sector.
- Any existing projections for the evolution of the energy system over the next 15 to 30 years.
- Costs, applicability, availability, inputs, and efficiencies of the technologies being considered.
- Information on expected environmental impacts of the technologies being considered.
- Estimates of the environmental costs of major accidents (e.g. nuclear melt-downs, oil tanker accidents).
- Any existing methods for ascribing costs to environmental impacts.
- Any existing analyses of the likely security impacts of proliferation of nuclear power in the region.
- Costs of security arrangements, including military hardware, armed forces readiness.

Of course, not all of the above information may be applicable to (or available for) a particular energy security analysis. If not, proxy variables or estimates based on the situation in other parts of the world may have to be used instead.

Once the energy scenarios have been specified, the next step is to evaluate the objective and subjective measures listed in Table 1 above, or as large a subset of those measures as is practicable. Here a range of approaches can be adopted such as:

Scenario Analysis: a simple "what if" approach in which a range of plausible scenarios are explored and the resulting indicators of security are examined.

Sensitivity Analysis: where plans are examined by varying key uncertain parameters (often done in conjunction with scenario analysis).

Probabilistic Analysis: where probabilities are assigned to different values of uncertain variables, and outcomes are obtained through probabilistic simulations.

Stochastic Optimization: where a probability distribution for each uncertain variable is assigned during an optimization exercise, incorporating uncertainty in the discount rate used in an economic analysis, and a robust solution is sought.

In our analysis of Japan (see below), a combination of scenario analysis and sensitivity analysis was used to test the response of the different scenarios to large changes in key variables.

Once attribute values (and qualitative assessments) have been compiled for each of the scenarios, the next step is to compare results across scenarios. Here, it is possible to ascribe weights to each attribute and thus devise one or more overall indices or scores for energy security. However, this final weighting step is not required. Attributes can be left as separate but explicit elements of the analysis. Either way, the key is to search for differences, both qualitative and quantitative, that are truly meaningful.

The comparison of candidate scenarios should, if the set of scenarios considered was sufficiently broad, allow the elimination of some that are clearly worse in several (or key) dimensions. The process of elimination should, however, be approached in a systematic, transparent, and well-documented way.

JAPAN CASE STUDY

As a part of the Pacific Asian region, two medium-range (1990 to 2020) energy scenarios were assembled that describe the possible evolution of energy demand and supply in Japan. The general outlines of the two scenarios are as follows:

1. Business-As-Usual Scenario: The BAU scenario largely extrapolates recent trends in energy demand, energy supply investment, and environmental emissions controls, with continued emphasis on fossil fuel use and only modest increases in energy efficiency and in the use of renewable energy. Nuclear power has an approximately constant fraction of total generation, oil for transport increases, and natural gas continues to substitute for other fuels in end-use sectors.

2. The Alternative Scenario: The ALT scenario increases the substitution of natural gas for coal and oil in both end-use demand sectors and electric power generation. It also reflects aggressive increased end-use efficiency and renewable energy. The fraction of power supplied by nuclear energy stays roughly constant, but absolute generation and capacity are reduced due to efficiency improvements.

We used LEAP as the main organizing tool for creating the energy scenarios. The figures show some of the results as modeled using LEAP. Figure 1 shows that the ALT scenario provides the same energy services as the BAU path with virtually no growth in overall energy use, and with a marked increase in the fraction of primary energy coming from renewable sources. Figure 2 compares the costs and benefits of the two scenarios: the ALT case costs more on the demand side, and slightly more for transformation processes (such as power plants), but saves money relative to the BAU case in terms of resource costs such as crude oil imports. Overall, the net direct benefits of moving from the BAU to the ALT scenario are strongly positive. The net environmental benefits of the ALT case relative to the BAU case are also strongly positive, with the ALT case resulting in over a third less annual greenhouse gas emissions by 2020, than the BAU case.

Table 2 presents a side-by-side comparison for each energy security attribute of the two energy scenarios considered. Formatting an energy security analysis in this way allows policy options to be clearly and directly compared across attributes. Given the multiple dimensions of energy security that must be evaluated today, this type of transparent evaluation can be a key ingredient to effective, carefully developed energy policy.

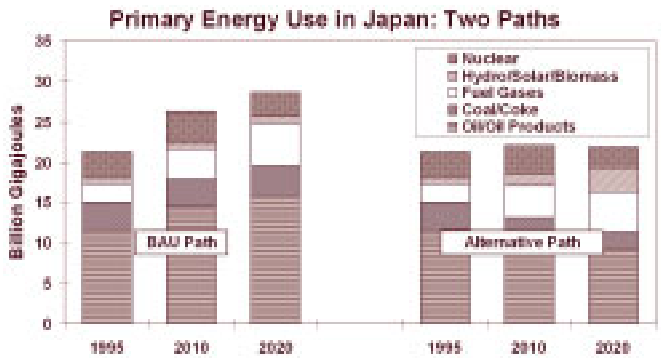

Figure 1

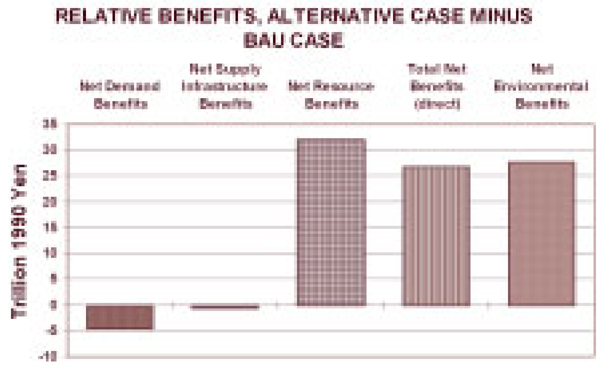

Figure 2

Table 2: Energy Security Comparison: BAU versus ALT scenario

Energy Supply	Economic	Technological	Environmental	Social and Cultural	Military/Security
Total Primary Energy (lower preferred)	Total Energy System Costs (lower preferred)	Technology Diversity for key industries such as power generation (higher preferred)	GHG emissions (CO2, CH4, lower preferred)	Exposure to Risk of Social or Cultural Conflict over energy (lower preferred)	Exposure to Military/Security Risks (lower preferred)
Similar	Lower in ALT	Higher in ALT	Lower in ALT	Likely lower in ALT, but requires social & cultural adjustment	Likely lower in ALT
Fraction of Primary Energy as Imports (lower preferred)	Total Fuel Costs (lower preferred)	Diversity of R&D Spending (higher preferred)	Acid gas emissions (e.g. SOx, lower preferred)		Relative spending on energy-related security (lower preferred)
Lower in ALT	Lower in ALT	Likely higher in ALT	Lower in ALT		Likely lower in ALT
Diversity of supply by fuel and supplier (more preferred)	Import Fuel Costs (lower preferred)	Reliance on Proven Technologies (higher preferred)	Local Air Pollutants (PM, VOCs, etc, lower preferred)		
Likely lower in ALT	Similar	Higher in BAU	Lower in ALT		

***1.** Additional details on this work can be found in the report 'A Framework for Energy Security Analysis and Application to a Case Study of Japan'. This report was prepared by Tatsujiro Suzuki, David Von Hippel, Ken Wilkening, and Dr. James Nickum for the PARES project, representing a group of collaborating energy-sector researchers from the USA and Japan convened by Nautilus Institute and the Institute for Global Communications. Much of the text in this article is adapted from the PARES report. The report is available from Nautilus Institute at: http://nautilus.org/archives/pares/PARES_Synthesis_Report.pdf

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From Economic Input to Human Right

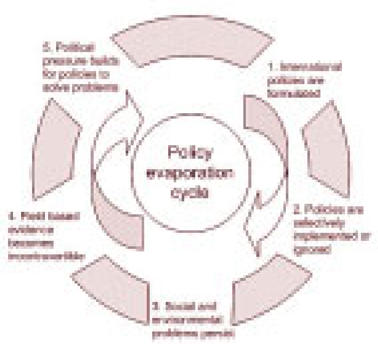
This article attempts to cover some aspects of the current debate on energy and development that have not yet been fully addressed and to broaden the discussion beyond a choice between different technologies and the modes for their dissemination. Attention is given to problems related to the implementation of energy policy over the past several decades and some suggestions are made for further debate on how this might be improved in future.*-1

Ian Tellam
ETC FOUNDATION

THE POLICY EVAPORATION CYCLE

Since the end of the Second World War, energy policy has gone through successive cycles of creation, evaporation and recreation. This is shown graphically in figure 1.

Figure 1: The Policy Evaporation Cycle



The cycle consists of a number of steps:

1. After stakeholder consultations, a set of policy recommendations are drafted, then revised, and finally officially adopted.
2. For a variety of reasons (some of which are described below), energy policies are implemented selectively rather than thoroughly or consistently. In other words, energy policies *evaporate* within the institutions that are charged with their implementation.
3. The main problems within the energy sector of poverty and environmental degradation persist due to policy evaporation.
4. Evidence of social and environmental problems in the energy sector is usually produced first in informal – usually non-governmental – circles. Over time the body of evidence increases in both width (geographic scope) and depth (quality of methodologies applied; thoroughness of sources used). Finally, officially sanctioned documents confirm the findings of unofficial reports.
5. An official process is organized to scope out the problems and to produce plans to solve them. Non governmental organizations and others are invited to contribute to this process through consultations or by commenting on officially produced 'think-pieces', which leads back to number 1.

REASONS FOR POLICY EVAPORATION

The reasons for policy evaporation are complex and a comprehensive analysis is beyond the scope of this article. The following summary draws out some of the main and most recent issues at three levels:

Systemic (the level of the overall policy environment)

Sustainable development policies require a level of central planning and government intervention that is not commensurate with the still prevailing paradigm of market-led development (in which governments are expected to change their role from central planning to supporting markets). The private sector prefers to concentrate on more lucrative contracts to generate electricity and to supply industrial and urban customers. Without government intervention, sustainable energy remains marginalized. And creating urban-based energy markets by itself does not provide rural energy.

Institutional (the level of organizations and agencies)

Donor agencies use 'input targets' or 'lending targets'. This creates a disincentive for donor agency staff to carry out time consuming capacity building activities associated with systematically building decentralized markets for rural energy. Legal provisions in developing countries are often too weak to allow institutions dealing with sustainable development (such as environment ministries) to control powerful business interests.

Individual (the level of individual persons)

It takes four to five years before field evidence of social and environmental problems becomes so incontrovertible that a decision is taken to produce new policies. By this time most of the people who had been involved in the previous round of policy formulation have moved on. A new set of actors face the problem 'for the first time' and set out to invent 'new' solutions.

RECENT ENERGY POLICY EVAPORATION CYCLES

Since the end of the Second World War energy policy has undergone several cycles of creation, evaporation and recreation. The first cycle lasted until the beginning of the 1980s, the second cycle took place from the end of the 1980s to the beginning of the twenty first century, and the most recent cycle began around 2001.

Creation and Evaporation of State-owned Energy Monopolies

Until the mid-1980s, public ownership of the energy sector was generally accepted to be the most effective way to meet the development goal of universal access to affordable energy services. This view was reflected in international development cooperation, which encouraged and supported state-owned monopolies. It was believed that this arrangement would ensure that an appropriate level of investment would take place and that generating capacity would be available when needed.

Energy was viewed as a sector with strategic importance for developing countries to promote socio-economic development. But state-owned energy monopolies in many developing countries failed to meet the energy needs of their populations, mainly because ineffective legal provisions were not dealing with poor governance and corruption.

Soon after right wing politicians like Ronald Reagan and Margaret Thatcher came to power in the U.S.A. and the U.K. in the beginning of the 1980s, a sharp turn in policy could be discerned, which was more in favor of the belief that free market forms of social organization are inherently superior to any kind of welfare state arrangement in which governments intervene in the economy in order to achieve social goals. The turn in policy was first made by the United States Agency for International Development, which began to exert various forms of influence on the World Bank, the regional development banks and other bilateral aid agencies to adopt a free-market approach to development problems[*-2]. This was accompanied by International Monetary Fund loans for 'structural adjustment', which were intended to restrain government intervention and spending

Creation and Evaporation of Market-driven Energy Policies

In developing countries, lack of public finance to provide energy services combined with growing energy demand was exacerbated by poor governance and corruption. This resulted in the perception that the sector was in crisis and in need of urgent reform. The mainstream discourse on energy policy shifted so far to the right that in 1992, the World Bank announced a new 'reform agenda' in which it promised to: "aggressively pursue the commercialisation and corporatisation of, and private sector participation in, developing country power sectors".[*-3] The Bank's lead was followed by all other multilateral and bilateral donor agencies and privatisation of developing country energy sectors became the accepted paradigm.

The adoption of market principles can be an impetus for the extension of energy services to rural areas and the promotion of new and renewable energy technologies in developing countries. Further, it can help to remove government subsidies that have been created to appease various political constituencies rather than to meet any genuine needs. Commercialization, liberalization and privatisation can have public benefits if these are factored into the reform process.[*-4] Nevertheless, private sector participation in the power sector since the 1990s failed to achieve development goals.

Private investors were attracted mainly to the 'richest' developing countries and most investments have gone to the 'top ten' countries: Brazil, China, Argentina, Philippines, Indonesia, India, Pakistan, Malaysia, Colombia and Thailand.[*-5] The majority of countries, meanwhile, continued to suffer from lack of finance to provide energy services.

New and renewable energy technologies also tended to be perceived as risk prone ventures by many investors, making them relatively expensive to finance. Meanwhile, oil, coal and gas continued to enjoy a competitive advantage in the form of large government subsidies. During the 1990s the Global Environmental Facility made US$1 billion available for 'clean energy' projects.[*-6] This is small compared to government subsidies to fossil fuels during the same period of US$2 trillion.[*-7] Little has been done to level this playing field and most private investment has gone into large new fossil fuel power generation projects on greenfield sites, while new and renewable energy technologies have tended to be marginalized.

Rural energy has also not benefited substantially from the shift towards increased private sector participation in the energy sector. This is explained by the World Bank as follows: "Liberalizing energy markets, however important, may not be the complete answer. Despite the progress made in encouraging private investment in the electricity industry since the beginning of the 1990s, for example, private companies have shown little interest in extending electricity supplies to rural areas. They have instead preferred to concentrate on more lucrative contracts to generate electricity and to supply industrial and urban customers. There is evidence, in other words, that creating urban-based energy markets by itself will fail to provide rural electricity."[*-8]

Photo: Y. Beaulieu-IDRC

Creation of Energy as 'A Tool for Sustainable Development'

This failure of the market driven approach to the energy sector during the 1990s resulted in political pressure for new policies. In April 2001 the ninth session of the UN Commission on Sustainable Development (CSD9) focused on energy as a tool for sustainable development and framed the discussions that took place at the August-September 2002 World Summit on Sustainable Development (WSSD). At the WSSD energy was back on the agenda as an instrument for socio-economic development and the final text stated that governments would:

Take joint actions and improve effort to work together at all levels to improve access to reliable and affordable energy services for sustainable development sufficient to facilitate the achievement of the Millennium Development Goals, including the goal of halving the proportion of people in poverty by 2015, and as a means to generate other important services that mitigate poverty, bearing in mind that access to energy facilitates the eradication of poverty.

HALTING THE CYCLE

The energy-related Millenium Development Goals (MDGs) will not be reached unless the energy policy evaporation cycle is brought to a halt. Unless specific action is taken to prevent the causes of policy evaporation then the cycle will continue, and a (mostly) new set of actors will be dealing with the same (or worse) set of energy and development problems in ten years from now. An adequate analysis of how to ensure thorough policy implementation would be a major effort and is beyond the scope of this article. The following set of suggestions is intended to generate debate on the subject.

Deal with Systemic Problems

Within energy policy circles, the discourse has recently shifted away from a belief in the power of the market to a more pragmatic approach that emphasizes 'public private partnerships' and the importance of 'good governance' in regulating the energy sector. Many people in developing countries are at the fringes or even outside the market system and will never be reached by purely market driven measures to provide access to energy services. Public private partnerships can deliver benefits and should therefore be encouraged. But public private partnerships are not a panacea and are too small in size and in number to meet the challenge set by the MDGs. Systemic problems are part of the energy problematique and require attention.

Adopt a Country Driven Approach

Policies must be tailored to the specific circumstances of each country. Rather than focusing attention on promoting international targets for renewable energy investments in developing countries, governments and international NGOs working on international energy issues should focus attention on empowering civil society in developing countries to make informed choices concerning energy options.

Use Precise Language

The energy and development debate is complicated. It is not merely a techno-economic dispute concerning which technologies meet energy needs at least (internalized social and environmental) cost and how barriers can be removed to their introduction. The energy debate has a political dimension that goes to the heart of the discussion on the relative roles of the state, the private sector, and civil society.

The energy debate is often confused by the imprecise use of the terms 'development' and 'poverty'. Different communities assign different meanings to these terms. Recognition of these cognitive aspects of the debate can help to clarify the discussion. In particular it is important to work towards specific, precise, identifiable and common meanings for 'poverty' and 'development' as these relate to energy. If the use of language remains imprecise then so will be the aim of the current exercise: energy for whom, to develop what, and for whose benefit?

***1** This article is a shortened version of a paper prepared for the NGO 'Energy for Development Workshop', held on 26 October 2004 in the Netherlands. The full paper is available through the author.

***2** Martin, B. (1993) In the Public Interest, Zed Books

***3** World Bank (1993) The World Bank's Role in the Electric Power Sector

***4** Dubash, N. (2002) Power politics: Equity and environment in electricity reform, World Resources Institute

***5** World Bank, Private Participation in Infrastructure (PPI) Database

***6** World Energy Council (2002) Energy and Sustainable Development

***7** Calculation by Ophelia Cowell (2002) , from Data of Global Green USA, Transnational Institute

***8** World Bank (1996) Rural Energy and Development

For more information

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Applications of Energy Models in the South

The Energy Research Centre (ERC) at the University of Cape Town has for a number of years applied models in their work for Government and other clients. The following text gives some pointers, based on ERC's experience, for analysts in developing countries who are considering applying energy models in their work.

Thomas Alfstad
ENERGY RESEARCH CENTRE

When analysing energy, or other social and economic systems, a seemingly infinite number of factors needs to be taken into account. It is not uncommon for an energy model to have thousands of data entries. As humans are unable to deal with all this information themselves they use computer based models to assist them. These models are abstractions. They are simplified mathematical representations of some real world system or problem. It is this simplification that makes them so useful, as it puts the problem into a form that it is possible to comprehend. As a tool, computer models are comprehensive and able to interrelate a great number of factors simultaneously. Moreover, they do not make computational or logical errors.

Models are not constructed for the sake of modeling itself, rather they are tools designed to help with the analysis of some real life situation. That is, a model is created for a distinct purpose and meant to be applied to a particular problem. It follows that the modeling approach should be determined by this purpose.

There is a wide range of options and techniques available to energy analysts who wish to use such models. Here, we will focus on two widely used modeling frameworks, with different areas of application, namely LEAP and MARKAL. They are both pre-developed, ready-to-use model-building tools that save the user the trouble of programming themselves. The ERC has used them both extensively and found them to be particularly useful.

Photo: K. Spierkel - IDRC

LEAP

LEAP (Long range Energy Alternatives Planning) is an accounting tool that balances production and consumption of energy in an energy system model. Just as assets have to equal liabilities in a financial balance sheet, supply has to equal demand in an energy balance. LEAP is deterministic, in the sense that all outcomes are specified by the user. As such, it is a "what if" tool in that it calculates the implications of a set of assumptions and tells the user what would happen if these were true. In mathematical terms it would be described as having zero degrees of freedom. This implies that there is one equation for every variable and thus there is only one feasible solution.

Based on the assumptions provided by the user, LEAP balances the energy flow equations, thereby identifying the energy transformation and primary energy supply requirements. The requirements are back-calculated from a set of final energy demands, which form the "fixed" side of the first set of the equations of the accounting process.

The entire energy system is (can be) included in the model and the level of detail is really decided by the user, although making the models immensely detailed will usually not be appropriate. This means that the data requirements are mainly determined by the user's preferences and can be made to fit the information that is available. Analysts in developing countries will find this particularly useful as good data tends to be a scarce commodity in these countries. LEAP is also flexible in terms of the format of input data, which makes it easy to reconcile and compare data from various sources. Cost of fuels and capacity can also be included at the user's discretion, as can environmental effects such as GHG-emissions and pollution.

Data is entered either directly with the mouse and keyboard or by importing from Excel spreadsheets. It is organised in a hierarchical structure much like that used in Windows. LEAP results are generated in annual increments and presented as time series data. Time horizons will vary but LEAP is most commonly used for long term (more than 20 years) analysis. The results can easily be viewed as graphs, charts or tables.

The analysis is scenario-based, meaning that assumptions for a set of potential futures are compiled. Results are calculated by LEAP and then compared. The user can thus gain insight into how different decisions or events may affect the future.

Getting started is relatively easy. LEAP demands very little from the user as only basic computer skills are required. Training material is available and a new user should be conversant in the use of LEAP after a couple of days. The software is provided free of charge to qualified users in developing countries.

The main benefit of LEAP is that it is a tool that helps the user to combine and assess data in a consistent framework.


Photo: K. Spierkel - IDRC

This makes it easier to organise the data in an intuitive and accessible manner, and to get a grasp on the information. Creating scenarios allows the user to evaluate the implications of various decisions and to identify the significance of different assumptions. The fact that it is easy to use and provided free of charge, makes it particularly beneficial for users in developing countries, who are frequently strapped for resources.

LEAP is a convenient tool as far as gaining basic insights into the workings of an energy system is concerned. Furthermore, it is a useful and appropriate introduction to energy modeling. The LEAP software can be downloaded from the COMMEND*-1 web site.

MARKAL

MARKAL (MARKet ALlocation) on the other hand is an optimisation tool. Optimisation models are prescriptive rather than descriptive and tell the user how to make the best of a given situation in relation to a predefined goal. As opposed to accounting models, optimisation models have several degrees of freedom and therefore there is not only one feasible solution to these problems, but many. The objective is to identify the best, from all these solutions.

For MARKAL users, the goal will usually be to minimise costs under the condition of a partial equilibrium, which is equivalent to maximising consumer and producer surpluses. MARKAL models are demand driven, in the sense that meeting demand is a requirement for all feasible solutions. The optimal solution to a MARKAL modeling problem is thus the solution that meets these demands and satisfies all other constraints while having the lowest total cost. Perfect markets conditions are assumed and all actors in the market are assumed to possess perfect foresight.

People rarely make decisions based purely on economic considerations. In terms of forecasting and predicting actual behaviour one should therefore be very careful when applying optimisation models like MARKAL. The output of an optimisation model should be seen as the best way of accomplishing a goal, rather than a prediction. So instead of being a "what if" tool, MARKAL is a "how to" tool. "If you want to minimise costs, then this is how you should do it".

MARKAL is most useful in situations were the problem is to chose the best from a set of well defined alternatives. This applies in particular when the problem relates to technology choice. In fact, identifying an optimal technology mix is the main application of MARKAL.

Since MARKAL is a cost minimising tool, it is important that both technical and economic data be included in the database. To provide useful results the technological specifications should be disaggregated as far as is practical. It follows that MARKAL is relatively data intensive.

Getting started with MARKAL involves significant costs. The MARKAL software itself is not very expensive. However, to run MARKAL you also need a GAMS compiler with a solver, and a user interface. Depending on preferences this will cost US$ 10,000-13,000 for GAMS and about US$ 5,000 for either the ANSWER or VEDA user interfaces. Maintenance fees are about 20% per annum. These costs are based on the assumption that the user is able to negotiate an outreach license. All the required software can be acquired through the Energy Technology Systems Analysis Programme (ETSAP)*2.

Becoming familiar with MARKAL is also a little more demanding than LEAP. To be able fully to understand and utilise MARKAL the user should have good computer skills, be conversant in equilibrium economics and preferably have a basic understanding of linear programming. With that said, it is important to note that MARKAL is a more powerful tool than LEAP and has a range of prescriptive capabilities that LEAP does not support.

Like LEAP, MARKAL is scenario based and the users can explore different futures and evaluate the importance of various assumptions. Input data is kept in an Access database for both the VEDA and ANSWER shells. Data can either be entered directly or imported from Excel spreadsheets.

The VEDA user interface offers convenient post processing with great flexibility and facilities for viewing results in user defined tables and graphs. Importing (and deleting) data can however be a rather slow process. ANSWER only allows data viewing in tables, but both interfaces support exporting of data to Excel.

THE USE OF LEAP AND MARKAL AT THE ERC

The ERC has used both LEAP and MARKAL for numerous studies, most notably the National Integrated Energy Plan that was developed for the South African Department of Minerals and Energy in 2002.

LEAP was used in the first phase of the project. An extensive data collection exercise was conducted and stakeholders were invited to participate with their information and views. The resulting LEAP dataset served as a platform for the first fully integrated description of the national energy system. Through model runs in LEAP, it was possible to identify gaps and weaknesses in the dataset which could subsequently be attended to. Based on this input, a business as usual scenario was developed to act as a general forecast and a reference along with an alternative scenario that represented more progressive policies and greater efficiency improvements. None of the scenarios were intended to serve as recommendations, but rather they represented two different views of the future based on expert views and opinions. The scenarios provided valuable insights, helped to build consensus amongst stakeholders and clearly illustrated the costs and environmental implications of their different views and assumptions about the future.

Photo: P. Bennett - IDRC

The second phase focused more on specific issues and MARKAL was used to find least cost supply alternatives. The analysis was done by comparing different fuel and technology options for each economic sector to identify least cost alternatives. In this way, new "optimal" scenarios based on the scenarios simulated in LEAP were developed. This provided input to the final analysis, which sought to provide specific policy recommendations, as well as advice on energy infrastructure investments.

In addition to the national LEAP and MARKAL energy models, the ERC maintains and develops energy system models for low income communities, multi criteria decision analysis tools and models for other African countries. The ERC also runs an energy modeling course as part of a postgraduate degree program in energy studies.

***1** www.energycommunity.org
***2** www.etsap.orgS

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A Model of the Household Sector

As part of the COMMEND initiative, the Argentinean Institute for Energy Economics/Fundación Bariloche (IDEE/FB) is developing a model for the analysis of substitution among energy technologies in the household sector. This article presents the background theory and also introduces the use of the model.

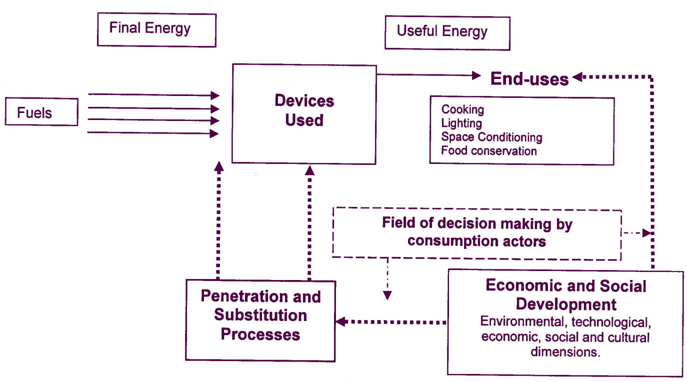
Raúl Landaveri and Nicolás Di Sbroiavacca
IDEE/FB

FACTORS EFFECTING ENERGY CONSUMPTION IN HOUSEHOLDS

Some of the most important decisions made by households regard their choices about energy end-uses. These decisions are especially important for low income households in the developing world where energy costs can represent a very large fraction of household incomes. Such decisions are influenced by a wide set of economic, technological, social, cultural and environmental factors. For those wishing to study how household energy consumption patterns might evolve in the future, it is of the utmost importance to identify the dynamic incidence of those factors correctly.

Our model starts by considering the amount of useful energy required to satisfy a given level of a particular end-use, such as cooking, lighting or heating. The economic and social development process may imply changes in these needs and, therefore, changes in the range and type of energy end-uses, the technologies used to provide these end-uses, and the fuels with which those uses will be fulfilled. This set of interactions and decisions are represented in Figure 1.

Figure 1: Energy Consumption Subsystems



The analysis of substitution processes between fuels (and/or technologies) requires the identification of the main factors determining the major decisions made by households. Prior to any attempt at representing a substitution model in a formal way, it is therefore necessary to discuss which factors influence decision making about energy consumption in household sector.

Neoclassical consumer theory supposes an optimizing rationality in resource allocation, in the context of consumers behaving in a homogenous manner and having perfect information. This approach is poorly adapted for practically modeling the realities of complex substitution processes in which households face very diverse circumstances, have very different cultural values, and tend to have incomplete information about energy systems. This is particularly true when studying systems such as energy consumption in developing country households where relatively rapid, but poorly understood transitions are taking place and where in any case precious little data is available for use in conventional econometric models.

An alternative and more practical approach is therefore suggested, one that privileges the influence of structural aspects linked to the economic and social development process. The main characteristics of this approach are that[*-1]:

- Choices in the household sector are not independent of consumers' social, cultural and environmental contexts.
- Decisions whose consequences extend into the future, or which are directly related to some future event, are assumed to occur under uncertainty.
- The approach is based on the quest for satisfactory rather than optimal solutions.
- The approach recognizes a hierarchical system of homogenous needs, dynamically influenced by the evolution of the contextual conditions in which they occur. In other words, its is assumed that one need cannot be substituted by another.
- Saturations of certain needs are assumed to occur at finite levels of income and positive levels of prices.
- Finally, the overriding importance of income is emphasized, especially as regards the costs of technologies and the income levels at which these become affordable.

CURRENT PATTERNS OF ENERGY CONSUMPTION

The first step in using the model is to specify the current patterns of energy consumption, by considering the following aspects:

a) definition of the homogeneous end-uses;

b) energy consumption in the base year;

c) analysis of consumption by end-uses;

d) availability of fuels and technologies.

FACTORS AFFECTING HOUSEHOLD DECISIONS

In step 2, the user considers the factors influencing the penetration of new fuels and technologies. These factors can be classified into those of a *social* and those of an *individual* nature.

Social factors are those affecting society as a whole. Examples of such factors are: the influence of the local economic activity, the employment of local labor force, foreign exchange saving and impact on the environment, among others. It should be noted that the choice of social factors results from the objectives of the socio-economic policy in general, and of the energy policy in particular, and are defined during the policy formulation stage. They are included in the substitution analysis when considering those factors or indicators that determine individual users' choices of one fuel/technology rather than another.

The factors affecting individual decisions are varied. Consumers typically consider several, each of which has a different significance. The four most relevant individual factors are:

- Annualized (levelized) Cost (AC)
- Investment Cost (IC)
- Quality of Service (QS)
- Environmental Impact (EI)

The choice of these individual factors is based on the elasticity of family consumption on the variability of fuel and technology prices (AC), on the resistance to the adoption of a certain fuel and/or technology given the investment it implies (IC), on consumers' willingness to pay for higher quality technologies (QS), and on decisions motivated by a greater environmental awareness.

These factors are then the objectives that determine consumer decision-making: *minimizing* Annualized (levelized) Cost, *minimizing* Investment Cost, *maximizing* Quality of Service and *minimizing* Environmental Impact.

THE SUBSTITUTION INDEX AND COMPUTATION OF PROGRESSION AND REGRESSION PERCENTAGES

Once individual factors that influence consumers' choices of technology have been identified, it is necessary to rate the quality of devices in terms of each factor. A *Share Index (I)* is estimated, assigning a value from 1 to 10 to each device for each factor. A value of 10 is assigned to the device with the best quality, while for the rest of the devices, the *Share Index* is estimated in the following way (see a real case example in Box 1):

a) If a lower value of the factor is preferred:

$$I_{ij} = \frac{C_{mj} \times 10}{C_{ij}}$$

b) If a higher value of the factor is preferred:

$$I_{ij} = \frac{C_{ij} \times 10}{C_{Mj}}$$

where:

I_{ij}: Share index of device i in factor j

C_{mj}: the minimum possible value of factor j

C_{Mj}: maximum possible value of factor j

C_{ij}: value of device i in factor j

In the next step, the user assigns a weight to each factor in the household decision making process. In this way it is possible to obtain only one *Substitution Index (V_C)* for each device. This takes into account all the factors considered. It is calculated using the following expression:

$$V_{Ci} = \frac{\Sigma j \; Iij \times pj}{10}$$

where:

V_{Ci} : Substitution Index of device i

I_{ij}: Share Index of device i in factor j

p_j: weight of factor j.

V_C is an indicator of consumer preference for the device and fuel according to their qualities and in relation to the factors considered. In a choice between two devices, the consumer will choose the one with the largest V_C. The average value between the maximum and minimum V_C is adopted as a limit between "progression" and "regression".

$$V_{C\ average} = \frac{V_{C\ maximum} - V_{C\ minimum}}{2}$$

Those devices whose V_C terms are larger than the average V_C will be "in progression", and those whose V_C terms are lower than the average V_C will be "in regression".

At this point we determine the amount of useful consumption for the technology which is likely to be substituted. This percentage is called *Disputed Market*, and it is the sum of the shares of the devices and/or fuels in regression in the base year of the analysis.

Next comes the estimation of the *Maximum Substitution* for the set of devices in progression. This value must be estimated on the basis of the historical evolution of the sector, or the experience of countries with similar characteristics.

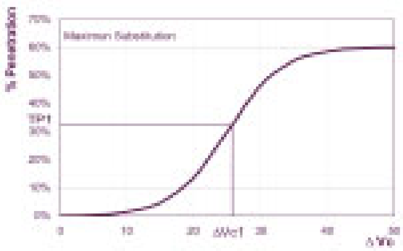
The total penetration (TP) percentage resulting in each case analyzed will always be less than or equal to the *Maximum Substitution*, and its value will be a function of the difference between the maximum and minimum V_C terms of the competing technologies:

$$\Delta V_C = V_{C\ maximum} - V_{C\ minimum}$$

Thus:

TP (%) = f (ΔV_C)

Figure 2: Total Substitution Level



The relation is a logistic curve, as shown in Figure 2, where small differences in the V_C terms induce only slow rates of substitution, while larger differences induce faster substitution. At a certain point, saturation effects start to occur and increase until the *Maximum Substitution* value is reached. The best way of representing this process is by means of a logistic function, whose expression is as follows:

$$TP = A + \frac{B - A}{1 + e^{(-a_{\Delta}Vc+b)}}$$

where:

PT: percentage of total progression of the penetrating fuels

A = 0

B = Maximun Substitution

a = 0.250 – 0.450 (this value is gauged by the expert)

b = 7

Once the total penetration (TP) percentage has been obtained, the next step is to distribute this among all the devices in progression. TP is assigned to each device in proportion to the difference between the V_C of each device in progression and the $V_{C\ average}$.

Likewise, the regression percentage of each device that is substituted is estimated by distributing TP in proportion to the difference between the $V_{C\ average}$ and the V_C of each device in regression.

CONSISTENCY CHECKING

After analyzing all likely substitutions in the different energy uses, the average energy expenditure per household is estimated for all the years of the analysis. If the expenditure increases beyond a level that is deemed unaffordable relative to the income of the household, then it is necessary to iterate and revise the model parameters or data assumptions.

CONCLUSIONS

Future projections of socio-economic and energy variables contain an element of fundamental uncertainty. The substitution model is not intended to obtain exact results. Rather, it aims to provide insights about the effects that certain determining variables such as prices, costs, and technical characteristics might have on future energy consumption patterns in households. Testing of the model has so far proved it to be a useful aid to energy planners who want to think through the possible substitution processes that might occur under a range of different assumptions about future socio-economic and technical developments. The model has so far been tested in Peru and the Dominican Republic.

Implemented as a simple and transparent spreadsheet, the model can be readily understood by energy planners. Its results, in the form of times series values for market penetration shares of technologies can also be readily incorporated into planning tools like SEI's LEAP system. A first draft of the substitution model, along with user's guidelines in Spanish and English, is now available for download from the COMMEND web site

***1** Cf. M. Lavoie: Foundations of Post-Keynesian Economic Analysis, Edward Elgar, 1992, chapter 2

An Example of the Progression and Regression Calculation

We will analyze cooking for an urban household, where the choice is between LPG and Wood. This example is based on data obtained from Peru, The base year shares of LPG and wood are 30% and 70% of useful energy consumption respectively. The characteristics of both devices are as follows:

	Unit	LPG	Wood	Weight
Annualized Cost (AC)	$/year	110	175	55
Investment Cost (IC)	$	60	23	20
Quality of Service (QS)	-	8.5	3.0	20
Environmental Impact (EI)	kg CO_2 eq./TJ	63463	7540	5

The resulting Share Indexes are:

$I_{LPG\text{-}AC}$ = 10
$I_{LPG\text{-}IC}$ = 23/60*10 = 3.83
$I_{LPG\text{-}QS}$= 10
$I_{LPG\text{-}EI}$ = 7540/63463*10 = 1.19

$I_{Wood\text{-}AC}$ = 110/175*10 = 6.29
$I_{Wood\text{-}IC}$ = 10
$I_{Wood\text{-}QS}$ = 3.3/8.5*10 = 3.53
$I_{Wood\text{-}EI}$ = 10

The resulting Substitution Indexes are:
Vc_{LPG} = (10*55 + 3.83*20 + 10*20 + 1.19*5) / 10 = 83.3
Vc_{WoodP} = (6.29*55 + 10*20 + 3.53*20 + 10*5) / 10 = 66.6

Thus, ΔVc = 83.3 – 66.6 = 16.7

Maximum Substitution for the following 5-year period will be 50% of the Disputed Market. If the logistic function is applied for ΔVc = 16.7, it gives a Total Progression of PT = 15.4 %, which, when applied to the Disputed Market, gives:

$Progression_{LPG}$ = 70% * 0.154 = 10.8%
$Regression_{Wood}$ = - 10.8%

Shares in Year 5 will then be 40.8% for LPG and 59.2% for Wood.

For more information

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Photo: Yves Beaulieu – IDRC

NEWS & EVENTS

COMMEND ACTIVITIES

PROGRAMME UPDATE

With funding from the Government of the Netherlands, the COMMEND initiative continued its activities in 2004 with the goal of fostering a community among Southern energy analysts working on energy for sustainable development. Activities in 2004 included continued development of LEAP and support to users; training workshops in Latin America and Southern Africa; the publication of the reCOMMEND newsletters; and a series of regional activities. LEAP development efforts have focused on the creation of Spanish, French and Portuguese translations. Highlights of the regional activities include the creation of a new technology substitution model by IDEE/FB (described in this newsletter) and an innovative city-level energy strategy study in Cape Town, South Africa. Visit the COMMEND web site at: www.energycommunity.org

COMMEND WEBSITE FEATURES NEW SOFTWARE PAGE

The page describes software and databases that you may find useful for sustainable energy analysis, including information on scope, methodologies and costs, and links to web sites. The tools included so far are: LEAP, MARKAL/TIMES, ENPEP, RETSCREEN, HOMER, COMPEED, CO2DB and CCP. We are looking to include additional tools, especially ones developed and supported by developing country organizations.
To view the software page, visit the COMMEND web site and click on "software".
To suggest additional tools, contact Charlie Heaps at: cheaps@tellus.org

PUBLICATION

PARTICIPATORY RURAL ENERGY PLANNING: A HANDBOOK

The Energy and Resources Institute (TERI)

This handbook is a direct response to the growing need for decentralised energy planning and rural energy interventions that actively involve local communities, especially women. The methodology, presented in this handbook as a step-by-step procedure, has been evolved by TERI researchers from a two-year action research conducted in villages in Haryana state in India. For more information, visit: www.teriin.org/pub/books/part.htm

NEWS FROM DONORS

EC PROPOSES €250 MILLION SUPPORT FOR ENERGY ACCESS

The European Commission is proposing a 250 million Euro "Energy Facility" to improve access to modern energy services in Africa, the Caribbean and the Pacific. The Facility should become operational in the course of 2005.
For more information, visit: www.hedon.info/goto.php/457/news.htm

REEEP SUPPORT FOR RENEWABLE AND ENERGY EFFICIENT PROJECTS

REEEP -Renewable Energy & Energy Efficiency Partnership- is seeking project proposals for its third funding round, for the period 1 April 2005 to 31 March 2006. REEEP is making €1 million available to fund renewable energy projects internationally.
Deadline: 22 January 2005
For more information, visit www.reeep.org/groups/callforbids

NEW INITIATIVES

ECOSYSTEM MARKETPLACE

This web site provides information on the various markets for ecosystems services, including markets for ecosystem-based carbon; water and watershed services; and biodoversity. Information on policy changes affecting these markets as well as on prices and the location of buyers and sellers can be found here.
For more information, visit: www.ecosystemmarketplace.com

ENPOWER TOOLKIT

This tool, developed by Future Energy Solutions (UK), Integrated Energy Solutions (South Africa), and 3EC (India), facilitates the provision of better energy services to poor communities. The tool is relevant for analyzing both household energy requirements and community energy services.
For more information, visit: www.etsu.com/energy_voices

HOMER

HOMER, developed by the National Renewable Energy Laboratory (USA), is a model that simplifies the task of evaluating options for both off-grid and grid-connected power systems for remote, stand-alone, and distributed generation applications. HOMER can be used to evaluate the economic and technical feasibility of technology options and to account for variation in technology costs and energy resource availability. We will be including an article describing HOMER in more detail in the next edition of reCOMMEND.
For more information, visit: www.nrel.gov/homer