DEVELOPMENT OF A SYSTEMS SIMULATION PLATFORM TO ANALYSE MARKET LIBERALISATION AND INTEGRATED ENERGY CONSERVATION POLICIES IN COLOMBIA

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ABSTRACT

With energy markets throughout the world moving rapidly into re-structuring, liberalisation and privatisation, this presents a major challenge to traditional modelling approaches. Econometric methods have limited applicability for a new environment and optimisation techniques of "planning" are less relevant in an era of market forces. This paper presents the use of system dynamics, in a generalised way, to provide a platform for integrated energy analysis. Issues of modularity and policy evolution are important in the design of the system to facilitate its use, and reuse. In the 18 months since this work began for the Colombian Ministry of Energy, it has had to evolve to support the analysis of a number of changing perspectives and constraints. Hence the concept of a ***platform*** rather than a ***model*** has to be implemented in a coherent way if it is going to provide sustained value for on-going governmental policy support.

The history of System Dynamics (SD) models in energy analysis and planning can be traced back to the early seventies when research conducted at MIT led to the creation of the SD model COAL2. Improved versions of this model have been used to support all US energy plans since 1977 and The National Energy Strategy 1991 (Naill, 1992). During the last fifteen years Ford (Ford and Bull, 1989) has applied SD to a number of issues in the electricity sector of the US.

In the UK, SD is being used to explore a diversity of issues related to the privatisation of the electricity industry (Bunn et al., 1992 and 1996), and in Colombia this tool has been used to study energy efficiency penetration and electricity substitution by gas in the residential and industrial sectors (Dyner et al., 1995).

ENERGY POLICY ISSUES IN COLOMBIA

Despite the recent Public Services and Electricity laws, the transition towards a more liberalised environment turns out to be a delicate affair as low prices, low reserve margin and high subsidies, appear not to be the most favourable initial conditions. Thus a number of open questions emerge concerning:

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- Evolution of prices
- Subsidies regime
- Supply reliability
- Supply alternatives
- Demand side management
- Competition in the market of large consumers
- Competition in the retailed market

In this sense, there is not an obvious recipe to follow, as a number of crucial interlinked problems arise: the selection of programmes, scheduling and prioritisation of projects (seeking possible synergies), incentives for private investors and market regulation, among many others. Therefore a framework for analysis capable of handling breath and depth will be required. Breath in terms of being able to address a number of connected policy issues. Depth in terms of supporting analysis at a detailed level, as in the case of specific Demand- Side Management (DSM) programmes.

Moreover, an incrementalist approach needs to be followed, both, to analyse the implementation of programmes and projects, as well as, for the purpose of policy making. In many aspects, with respect to data not yet available in Colombia, the modelling approach needs to make use of experiences from elsewhere. For example, in imposing upon Colombia the UK-like power pool, can we incorporate, as "archetypes" re-customised versions of the SD-type models that we have developed to understand the UK system and thereby investigate whether similar behavioural properties will be exhibited in Colombia? So much of the world-wide trend to re-structuring has been promoted by analogies, that we need a platform to verify if the analogies will transfer to new contexts. Similarly, can the insights from consumer choice models be assimilated and assessed into this context?

As a context testing framework, the platform construction process has to evolve through the adaptation of changing circumstances, including new components to address a diverse number of complementary and dynamic issues. Furthermore, transferability of the platform between different groups of modellers requires a modular and transparent structure. End users also need to be trained to use their "own" platform in order to develop it further as new policy issues emerge.

A SYSTEMS SIMULATION PLATFORM FOR COLOMBIA

Figure 1 shows the general platform structure along with its most relevant components and the corresponding interrelationships. This design facilitates the analysis of energy policies (DSM plans and programmes, the large scale gas plan and the indicative plan for the expansion of power generation). The platform is system dynamics based with about 350 vector equations (24 of which are differential equations) and about 1000 vector variables. Work started in 1995 as part of an 18 months development project for the Colombian Ministry of Mines and Energy.

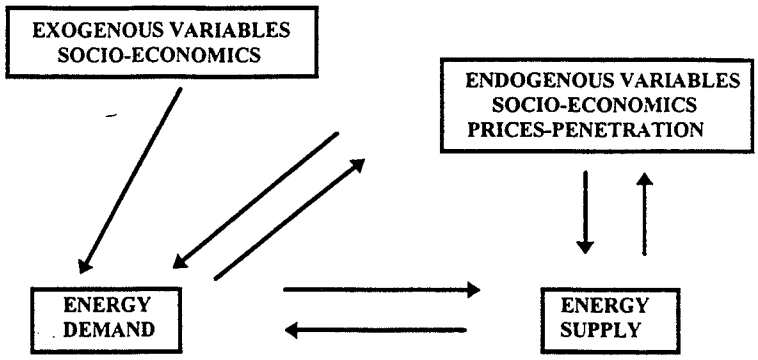

Figure 1 Platform structure

POLICY EVALUATIONS

We explored the implication of pricing policies, when these coincide with programmes and actions on DSM as well as on supply-side management. Simulation results in Figure 2 show the evolution of the increment on the average energy bill of domestic customers and the additional revenues available to electricity utilities under specific pricing scenarios.

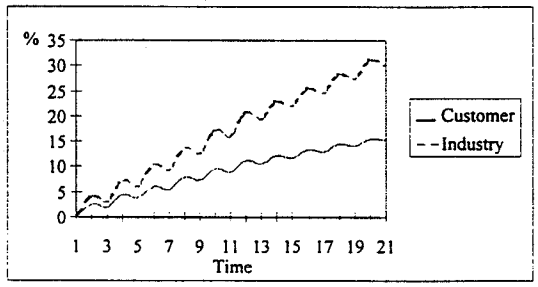

Figure 2 Increments on: average energy bill (customer) and industry revenues.

Figure 3 illustrates the effect of a gradual pricing policy on additional sales and on relative savings, and Figure 4 shows the average bill increment that customers may have to be prepared to pay if tariffs are to follow market prices.

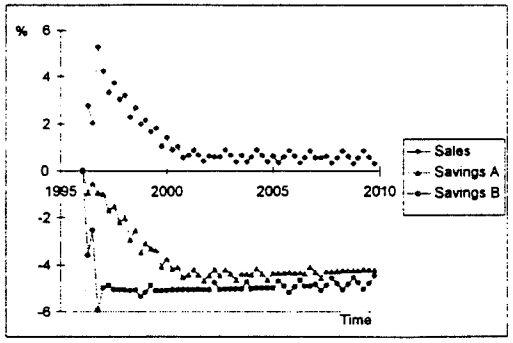

Figure 3 Electricity sales and savings

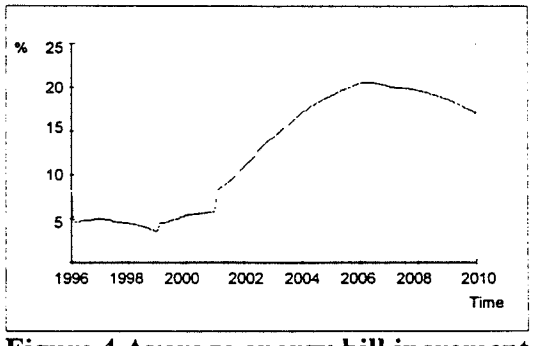

Figure 4 Average energy bill increment

CONCLUSION

The modelling protocol of the platform exhibited in this paper is based upon the need of implementing generic, modular, adaptable and transportable structures, capable of supporting the process of system analysis for intervention. The platform developed here therefore provides a context rich basis for investigating a number of different policy issues. Although a similar framework has been undertaken in the US continuously since 1976, the open literature gives limited information with respect to the modelling protocol that needs to be followed if such a platform is to provide a sustained level of policy support through changing circumstances.

As has been shown in this paper a System Dynamics based platform has the potential to provide such evolutionary policy support under complex policy environments, although it then needs to have a multifaceted perspective on its use. In particular, the application of SD in these circumstances goes beyond the single-focus of providing insight into a pre-selected policy issue. Yet, if the traditional approaches of optimisation and econometrics are losing some of their relevance in the new era of market liberalisation, and SD is well placed to fill the new modelling requirements, it seems that it must offer governmental energy advisors some of the same features of longevity, modularity, adaptability and detail that the other approaches have provided. The features then constitute requirements for a clearer modelling protocol to be developed upon a systems simulation platform.

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