Some of the difficulties of using even the extended, energy denominated input–output framework for analyze energy policy issues were alluded to in the closing sections of Chapter 6. In our analysis of Republica, for example, we saw the need to use an iterative approach if one were interested in determining that combination of economic activities that would result in oil imports of a given level. One way around such situations is to combine the input–output model with some kind of optimization framework, that in particular allows the solution of constrained optimization problems (whose constraint set might include, for example, upper bounds on energy imports, or lower bounds on particular levels of renewables). Moreover, given that we introduce an element of choice in the energy system, there is no reason why one cannot relax some of the more confining assumptions of conventional input–output analysis (only one industry producing one product using a single technology) to allow choice also in terms of the technologies of the productive sector: and include in the analysis, for example, the choice between say, electric arc, open hearth, or sponge iron processes in steelmaking. Indeed, there is no reason why industrial process models cannot be directly integrated into the energy system LP.

Given all of the previous emphasis on linear programming, it should come as no surprise that we turn once again to this technique. Because of the ease with which linear programming problems can now be solved, LP is a particularly appropriate tool in such situations, since it allows one to make many model runs at relatively low cost. This is important because in most planning applications one would want to exercise such a model using a variety of objective functions (minimization of system cost, minimization of capital or foreign exchange requirements, maximization of some macroeconomic indicator, and so forth), and under a variety of different assumptions (or, in the jargon of the trade, for a number of scenarios). And as noted earlier, one would wish in particular to vary those assumptions over which the planner has no control (such as the world oil price). Indeed, analyzing the robustness of decisions that emerge with respect to the underlying assumptions may be one of the most important reasons for a modelling exercise, and certainly
more important than making "forecasts" of what might happen (which usually turn out to be wrong anyway). Finally, another reason for using LP, as opposed to mere heuristics or simulation models, is the economic interpretation of the dual. As noted in Chapter 9, shadow prices can be extremely valuable as guidance for policy making.

To be sure, there are some rather obvious problems in applying linear programming models of developing country energy systems, although most of these shortcomings are by no means unique to LPs, being applicable to all attempts at mathematical modelling in developing countries. The first, obviously, is data: the model described in these pages presupposes the existence of an input-output table. Obviously, models of this kind are not suited to, say, the smallest countries of Africa, whose industrial sectors are presently still very small, and where the agricultural and final demand sectors consume the bulk of the energy. However, the mere fact that data is difficult to obtain for developing countries does not, in and of itself, make modelling inapplicable; even qualitative approaches will yield little of value without supporting data.

A more serious problem is the treatment of the non-commercial sector, which in many developing countries dominates the energy system. It is highly unlikely that an LP (or any other mathematical model, for that matter), will be able to model adequately the transition from non-commercial to commercial energy that is now occurring, determined as it is by complex forces of urbanization, migration and changes in social behavior. The best that can reasonably be accomplished within a modelling framework is to account for such developments in the form of upper and lower bounds on certain proxy variables (say the fraction of urban cooking met by firewood and charcoal as opposed to LPG); the advantage of an LP formulation is that the corresponding dual variables yield some direct insight on the sensitivity of the overall solution to such assumptions.