# Modelling the future of energy: What are the present tools missing?

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## Overview

Energy modelling is the process of creating computational or mathematical models of energy systems to analyze them. Modelling an energy system is inherently complex as it has to incorporate technology detail, macroeconomic feedbacks and behavioral patterns from a wide range of supply and demand sectors. Energy models provide a means of understanding possible future scenarios and evaluating competing policy options, especially in the contexts of energy security and low carbon growth. Standard modelling tools and approaches are commonly used by industry and academia to generate international or national models. The International Energy Agency (IEA) has estimated that developing countries would contribute majority of the growth of energy demand and hence emissions over the next twenty years [1]. Two broad contours would determine the energy usage path chosen by developing countries – the need for improved standard of living for its citizens and its implication of energy choices for climate change. Quality energy models customizable to local contexts are necessary to ideate transition policies.

The paper argues that while there are many modelling tools available, the widely used modelling tools have been developed with a particular worldview and there is ample scope for value addition. A list of available energy models were compiled using systematic literature review. The characteristics of the tools were studied and captured using twenty indicators falling under three dimensions. The tools were also ranked based from the perspective of their utility for energy planning at the district level considering the context of a middle income country. The study shows that while there has been a near standardization in modelling capabilities, there is scope to include more qualitative dimensions, demand side specificities, Geographic Information System (GIS) integration in the reviewed tools. Free availability, specifically in the form of interactive web based platforms or stand alone software could lead to widespread use of such tools by decision makers at all levels. The review provides a baseline manual for energy planners for choosing the right tool or approach depending on the context, scale, purpose, features and available resources.

## Methods

A three-step methodology was used for the study.

1. Identification of models for review
2. Qualitative review of their features
3. Ranking of the models based on a set of criteria to understand their suitability for local level energy planning.

A systematic literature review was conducted to identify the list of energy modelling tools to be studied. It was followed by a detailed analysis of the selected tools using documentation and scholarly publications reporting their usage. Open source and proprietary models were included in the survey. The methodology of analysis included qualitative review of the model documentation, creation of use cases and review of secondary literature. The analysis was systematiswd by creating a ranking framework with twenty indicators spanning three dimensions viz. a viz. general properties, ability to model energy systems and ability to generate results in desired form.

## Results

The study finds that energy modelling tools have widely been developed considering the context of developed countries as indicated by the country of origin, sectors considered and modelling objectives. There is considerable scope to include socio economic parameters, adjustments for data sufficiency etc. to make them more relevant in the context of developing countries. Web based dashboards with ability to model local energy systems would be a useful tool for planners at lower levels of governance. Availability of tools free of cost, availability of training material and GIS integration would be other desirable characteristics.

In the score based ranking exercise, software tools like LEAP and HOMER along with modelling framework MARKAL / TIMES have high scores followed by web based dashboard IESS 2047. High scores across all three individual dimensions have resulted in the high overall scores. Other tools like EnergyPRO and OSeMOSYS have high ability to model the system but fall marginally behind in other dimensions. Most tools perform badly for indicators like data requirements and visualization of results and GIS integration. Modelling softwares and modelling frameworks like LEAP, MARKAL / TIMES, HOMER and OSeMOSYS have high ability to model the system but are relatively less attractive general properties.

## Conclusions

The study reviews ten energy modelling tools and approaches with the aim of understanding their limitations in their present form and the utility for decentralized energy planning, specifically in the context of developing countries. The features of relevance have been captured and systematically recorded using twenty indicators across three dimensions viz. a viz. general features, ability to model an energy system and the ability to generate results. Energy modelling tools have widely been developed considering the context of developed countries as indicated by the country of origin, sectors considered and modelling objectives. There is considerable scope to include socio economic parameters, adjustments for data sufficiency etc. to make them more relevant in the context of developing countries. Web based dashboards with ability to model local energy systems would be a useful tool for planners at lower levels of governance. Availability of tools free of cost, availability of training material and GIS integration would be other desirable characteristics.