

## Energy Modeling Unit

The Energy and International Co-operation Vertical handles all aspects of the value chain of the energy sector – advising the energy ministries on various policies and their impact. Significant part of this impact evaluation and recommendation is dependent on the analysis, modeling, interpretation and dissemination of energy sector data along with range of other socio-economic and demographic information. Integrated energy modeling based on systems modeling framework allow these analysis with various dynamic components.

### Need for Integrated Energy Modeling in India

The energy sector administration in India is spread across different Ministries and Departments, including various PSUs for different functionality:

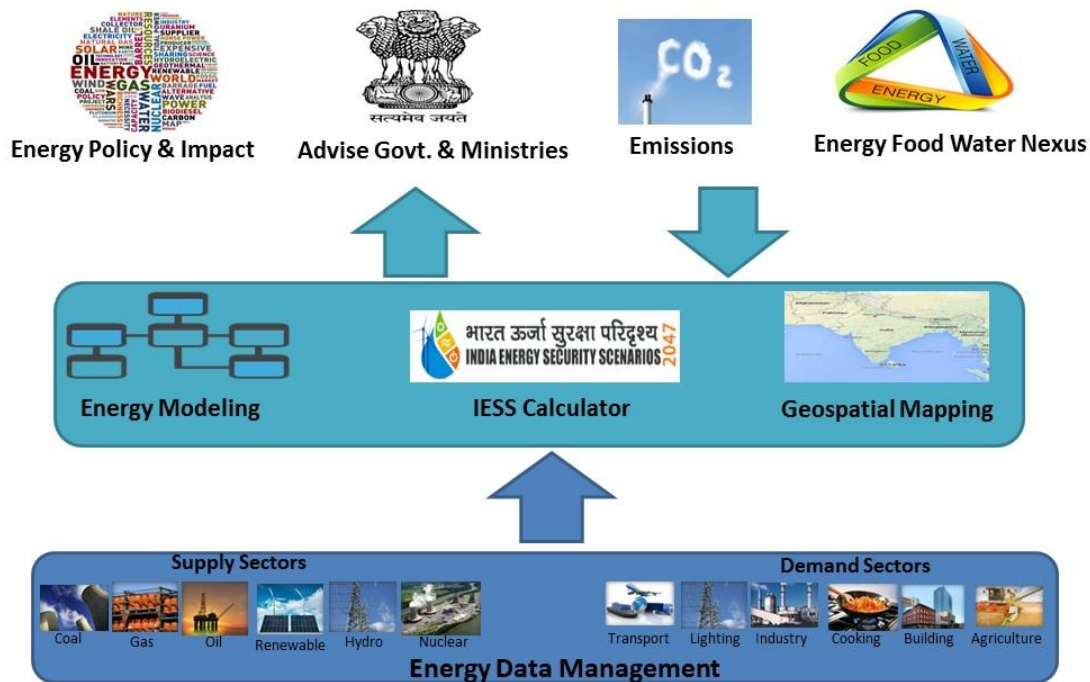
- Ministry of Power
- Ministry of Coal
- Ministry of New and Renewable Energy
- Ministry of Petroleum and Natural Gas
- Department of Atomic Energy

While the distributed administrative structure helps in managing and efficient functioning of these entities, it also leads to some challenges. Due to this distributed nature of Energy sector administration in India, we see a range of conflicting views from both the demand and supply sector of energy like:

- India's ambitious target of 175 GW of Renewable energy capacity by 2022
- Targets for 63 GW Nuclear Energy targets by 2032
- Targets for reducing oil imports in India
- Universal access to electricity and 24\*7 electricity for all
- Increasing the domestic coal production
- Reducing carbon emissions as per the INDCs
- Interruption in renewable energy supplies based on weather conditions
- Effect and cost of modernizing the power grids
- Increase operation hours of the thermal and hydro power plants

Energy modeling based activity helps in providing the recommended directions in the presence of such conflicting positions. NITI Aayog has been involved in various activities related to energy modelling in terms of developing the IESS (India Energy Security Scenarios) 2047 tool and model comparison activity in collaboration with SGWG (Sustainable Growth

Working Group). IESS is an accounting based energy scenario comparison modelled on the “UK 2050 Calculator” and initiated by BEIS, UK. NITI Aayog has been working on the IESS model since 2012 and the second version of the same was launched in 2015. Two major energy modeling areas covered under SGWG are “Decarbonisation of the transport sector” and “Energy water food nexus”. Through these various energy modeling activities, NITI Aayog would like to promote greater acceptability and appreciation of modeling across the various Government ministries, states, energy think tanks and in the process develop an vibrant and collaborative energy modeling community in India.



## Choice of tool for Energy Modeling Unit at NITI Aayog

The Energy Vertical at NITI Aayog would like to develop a better understanding and appreciation for energy modelling to deal with these conflicting views of the energy sector and decide the best way forward. Towards the same the Energy Modelling Unit has been setup at NITI Aayog to carry out cross-sector integrated energy modelling. The team engaged in a detailed review of the popular cost-optimization based Energy modeling tools along with consultation with some of the Energy domain think tanks for recommendation of the most suitable one for NITI Aayog. The following table provides a brief overview of the comparison activity undertaken by NITI Aayog.

CRITERIA	OSeMOSYS	TIMES/VEDA	MESSAGE
BRIEF	Open source developed and maintained by KTH, Sweden	Developed and maintained by ETSAP/IEA	Developed and maintained by IIASA

<b>FRONT END</b>	Web based interface, easy to understand and good for learning. Easy naming of the variables	Separate front end VEDA-FE available only for this purpose. Variables, process can be viewed in easy to use interface.	Front end allows for easy interpretation of RES model and base commodities. New version is also under development.
<b>EQUATION</b>	Equations are very easily readable and editable – makes it very easy to understand	Equations not visible from VEDA frontend. GAMS code needs to be edited to change the equations.	Easy front end available to edit the equation and another documentation front end for easy reading of equations.
<b>DATA</b>	Easy to enter data – concurrent data editing not possible.	Data entered through text files and excel files. Interface is suitable to people to work in parallel across sectors.	Data to be entered in flat files can be done in concurrent manner.
<b>DATABASE</b>	No concept of database – data stored in fat file and model file	Data stored in Access database, which comes as a component of Microsoft Office.	Data stored in ORACLE database.
<b>OPTIMIZE</b>	Optimization is done in free tool GPSOL – which might not be suitable for large number of variables.	Commercial GAMS to be used for optimization.	Free GPLK solver distributed with MESSAGE model. Commercial GAMS can be used for larger complex models.
<b>OUTPUT</b>	Interface with free tool LEAP to view the results.	Basic standard output can be viewed in VEDA-BE.	Provides free templates for the visualization that can be used.
<b>MODEL</b>	Free as the whole code is open source	TIMES code is available for ETSAP member countries	Model Code is freely distributed
<b>EXTENSION</b>	Not known	Specific to Energy Domain only	Extensions in Agriculture, Macro model, Emissions, Transport, etc.

The “Knowledge Hub” of NITI Aayog is divided into various verticals like Macro Economy, Energy, Healthcare, Water, Agriculture, Environment, Transport, Industry, Trade, etc. Based on the multiple sectorial interest of NITI Aayog, the MESSAGE model from IIASA would be the most suitable one from long term perspective as this model can interact with the other sectorial models. The following sectorial models are currently available at IIASA:

- MACRO for Macro Economy modeling
- WAT for Water and hydrology modeling
- TRANSPORT for consumer vehicle choice modeling
- ACCESS for fuel choice modeling
- MAGICC for long term climate pathways
- GAINS for Greenhouse gases (GHG) and air pollution mitigation

- G4M for spatially explicit forest management
- GLOBIOM for Integrated agricultural, bioenergy and forestry modeling

### **Details of the first Integrated Energy Model developed at NITI Aayog**

The first integrated energy modeling that is been developed at NITI Aayog captures the current state of the following factors in the MESSAGE model:

- GDP, Population and other Macroeconomic indicators
- Energy Supply Sectors:
  - Coal
  - Hydro and Thermal
  - Renewable (Wind and Solar)
  - Petroleum and other gases
  - Nuclear
  - Bio energy
- Demand Sectors:
  - Housing and Buildings
  - Transport (Railways, Road, Air and Shipping)
  - Industry
  - Agriculture
  - Cooking
  - Telecom and others
- Infrastructure and Network:
  - Transmission and distribution losses
  - Storage
  - Reliability of the Grid

A range of scenarios would be evaluated based on this model like:

- Business as Usual or Normal scenario
- Housing for all by 2022
- 24\*7 Electricity for all by 2022
- Low carbon growth scenarios

The first integrated energy model based on MESSAGE would provide as recommendation the following information for each of the chosen scenarios:

- Energy mix in the economy
- Water Utilization
- Land Utilization
- Carbon Emissions
- Import dependence for India's Energy security

## **Future Directions**

In the long run the team intend to develop integrated energy models on the following areas:

- Modelling and prediction of the key supply and consumption components in the India energy sector with some degree of certainty
- Dealing with the complexly linked Indian Economy, Social Development and Energy Sector
- Impact of INDCs on the Energy, transport, Industry Sectors and India's growth
- Model the complex interaction of federal and state structure with respect to energy resource allocation
- Economy-Energy interaction due to freer trade regime including energy commodities

Over time, other modelling activities can also be undertaken by the Energy Modeling Unit in consultation with the "Steering Committee" headed by the Vice-Chairman of NITI Aayog along with the representatives from the ministries involved in supply and consumption of energy in India.