Development of Dedicated Software for Energy Demand Modeling

(Assignment: 1) National Energy Planning

&

(Assignment: 2)Village Energy Planning

Guide
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Submitted By:

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Abstract

A software for Energy Demand Modeling has been developed, in view of actual the energy demand assessment at any level, which can be utilized from regional to national level, The Graphical User Interface of the software take the input from the user in a quite logical and sequential manner, and gives out put in two distinct form, first, it develops a Reference Energy System which, depicts the flow of energy from the source to sink with all the losses incorporated, and second, it give a MATLAB script file for some advance uses, analysis like graphing, visualization, optimizations etc. to develop and evaluate the right energy mix policy for certain region.

Keywords: Reference Energy System, Software, GUI, Planning, Energy Demand Model EDM.

NOMENCLATURE:
e = Energy Consumption (PJ)
F = Fuel Mix
A = Aggregation
Ω = Transmission and distribution losses
E = Electric sector generation mix
λ = efficiency of electric sector generation mix
B = Aggregation
Z = Aggregation
π = Refinery losses
r = Final energy consumption Vector (PJ)
D_i = Amount of fuel for an activity
e_i =Relative effective ness for ,which fuel i^{th} is used for the particular activity
E_{DQ} = Demand quality
a, b, c, d, e and f = Matrix dimension respectively.

1. INTRODUCTION

Energy is our basic need it has an enormous part to play in our life, development and economics. It will be not wrong to say that instead of this much importance and recognition real mix of fuel for a particular situation and location is still a concept of theory and the practical implication is not there to the extent, that it has to be, to remove the persisting anomalies in energy scenario in our country. Here in this work, we have attempted to translate a matrix analysis based procedure to software, which is other wise a cumbersome job to be done manually. The software will take some input and give a model out put which will help understand the planners to be acquainted with the energy flow, demand, losses and sources with a click of a button. Further the out put is in the form of raw matrix's which can be edited in MATLAB and other tool of optimization can be applied.

2. REFERENCE ENERGY SYSTEM

Reference energy system (RES) is a method of representing the activities and relationships of an energy system, depicting estimated energy demands conversion technology, fuel mix and the resources requirements to the to satisfy the demands conversion, technology fuel mix and the resources requirement to satisfy the demand the pictorial form RES is network of diagram indicating the energy flows and the associated conversion efficiencies of the technologies employed at various steps, of energy system. For energy resources a complete RES specifies technique employed in

1. Extraction
2. Refining or conversion
3. Transport of primary energy sources
4. Transportation of secondary energy sources
5. Decentralized conversion
6. Utilization in end use device

Basic energy demand, the amount of energy in Pita Joules, which represents the useful energy required by a particular demand category. This is a demand quality expressed as

$$E_{DQ} = \sum e_i D_i$$

2.1. R.E.S NETWORK DEVELOPMENT AND CALCULATION

RES Network diagram actually represents the flow of energy from source to actual consumption. It includes the intermediate losses in efficiency at various level of conversion. Basically, we starts with the input data of fuel consumption in various sector like if we are considering national level than mining, industry transportation , house hold and so on, its up to the planner that how deep he/she want to go this data is used to populate the sartorial energy consumption matrix e. The deep we go the more data is needed and other problem of organizing and identifying will persist, these will be the limiting factors, so finally, it would be a tradeoff between the data available and the accuracy we can afford. Each sector consumed energy from different energy mixes available, like house hold will be consuming gas for cooking electricity for lighting, space conditioning and solar etc and industry will be consuming electricity, oil products charcoal ,petroleum products, self generated electricity, baggasse and agriculture waste etc. Now once identify the sector, we need to identify the sources from where they are consuming the energy, this data is generally available from electricity company, petroleum corporation and government authorities. This data is required for populating the fuel mix matrix F. Now going ahead further, we have to identify the electric sector generation mix; it is defined as the various electricity generation unit e.g. thermal power stations, gas turbine power plant, hydro power plant nuclear power plant forms which the central grid is fed. Individual faction of each generation unit out of the total is required with there fuel conversion efficiency for populating electricity generation mix matrix E and electric sector generation efficiency λ respectively. Now there would be an aggregation matrix which is developed by simple logic of placing unity in rows of the matrix to sum up common sources in each sector, this matrix identified as A it also incorporate the efficiency of self generation if self generation is at all there in the data. Next matrix is to incorporate the transmission and distribution losses and it is denoted by Ω.Now B aggregation would aggregate the electric generation categories to their respective fuel. This B aggregation matrix would be generated in the same logic as the A aggregation is generated above. The data for refinery efficiency is required to populate the π matrix, which account for the refinery losses. Finally the Z matrix allocates the final energy resources to the final resources consumption vector r. The entire series of matrix calculation can be collapsed into the single equation.

$$r = |\pi|_{f\times f} \times |Z|_{f\times e} \times |B|_{e\times d} \times |\lambda|_{d\times d} \times |E|_{d\times c} |\Omega|_{c\times c} \times |A|_{c\times b} \times |F|_{b\times a} \times |e|_{a\times 1}$$

3. SOFTWARE DEVELOPMENT

The software is developed in Visual Basic 6.0 to exploit the powerful feature of graphical user interface GUI. Algorithm based on string comparison was developed to generate matrix arrays, which are further utilized in processing of data and development of Reference energy network. Individual array were generated through explicit function written in main form module and were called where ever they are used.

The strong GUI uses various input schemes. Some default values were given to them to let the user identify the scale of input required. The GUI uses check boxes and developed in such a way, that with every input the user makes initially, in the check boxes, by selecting or deselecting them, will let the software understand the structure of input that has to be done further, it is considered as the direction for software and the software would ask the user to enter the values for various energy sources in each individual sector in the same sequence. Various display list boxes were provided to let the user get the feel that what was input value for some specific source in some specified sector. Frames and command button were provided with the sequential heading and number, the number order has to be followed for respective input and out put from the software. It is recommended that the large unit such as pita joules (PJ) or (MTOE) Million Tons of Oil Equivalent has to be used so that the number of digits in any of the input does not exceed count of ten in numbers. Another limitation is the length of arrays which is thousand in this version. We didn’t incorporated more due to some software limitation and memory functioning. A snap shot of the GUI is given in the Fig 3.a.

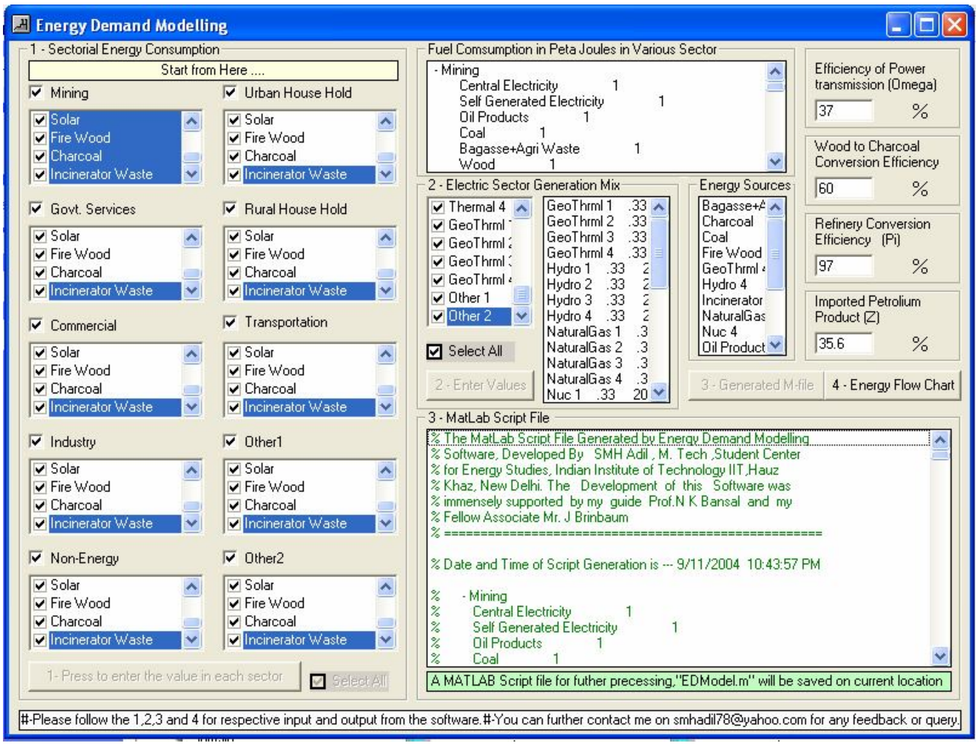


Fig 3.a. GUI of the Energy Demand Modeling Software.

3.1. R.E.S NETWORK AND MATLAB SCRIPT FILE.

The fig 3.b shows RES network developed by energy demand modeling software for certain arbitrary data. In the figure from left to right we are moving from consumption to source respectively. Colored boxes in between are depicting the energy flow and the with a red connecting line the linkage can be observed that certain specific fuel is used in how many

sector on the left hand side of the network and vice versa. RES also shows the cumulative fuel uses efficiency at the bottom of the form.
The program is complied in the form of an executable file, which can run on any PC containing Microsoft windows operating system environment the name executable file is “EDM.exe”. This program also generates a MATLAB friendly script file named “EDModel.m” and save it at the current location of “EDM.exe”. The user can copy this file to MATLAB work folder and edit it for required advance optimization operation.

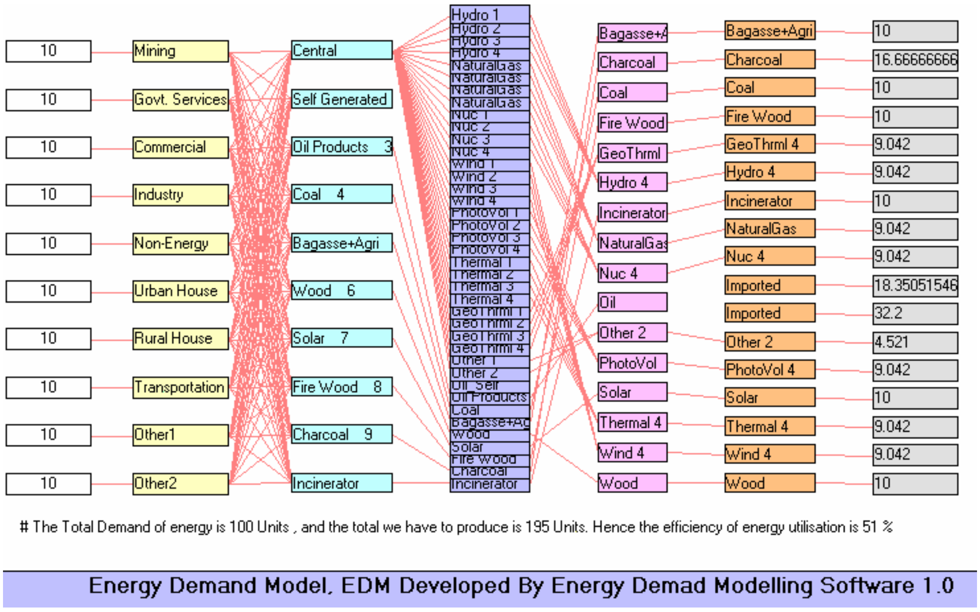


Fig 3.b. R.E.S Network developed by Energy Demand Modeling Software.

4. RESULTS AND DISSCUSSION

Results are discussed in appendix for both National and Village cases.

5. FUTURE WORK

This version of Energy Demand Modeling software is with limited flexibilities. We would carry out more development work for enhancing the interfacing and friendliness to scanty data. Further we have plan to work out for incorporating some optimization technique like Lagrangian multiplier, which can work on certain constraint like fuel cost factor, transportation route factor, efficiency of conversion and location. With this level of input we would try to evaluate the ***Right Energy Mix*** for certain situation. That energy mix would also consider the regional sustainable sources of energy production that can be harnessed with in the constraint of cost and size of conversion units etc.

Following the trend of sustainable development, we would also like the incorporate the Geographic Information System GIS based prediction of biomass resources and hence energy potential , solar power potential, hydro power potential from rain fall data etc., wind energy potential at various location. This would help planner to clearly see that they have to work in this much availability.

We would be incorporating some standard energy prediction model for assessing the increase in e.g. land area in case of wind energy harnessing system and capacity of power production units etc. If we observe the RES network the sum extreme left hand side and sum extreme right hand side or total sector energy consumption and total fuels energy respectively bear a highly complex and nonlinear relation ship. This depends on efficiency used at various stages of conversion and which would vary with development of new technologies in future ahead. We would try to incorporate this functionality to the software to accurately predict the rise in energy on the right hand side of RES network. Fig 5.a. is showing simple input out put flow of above discussed system.

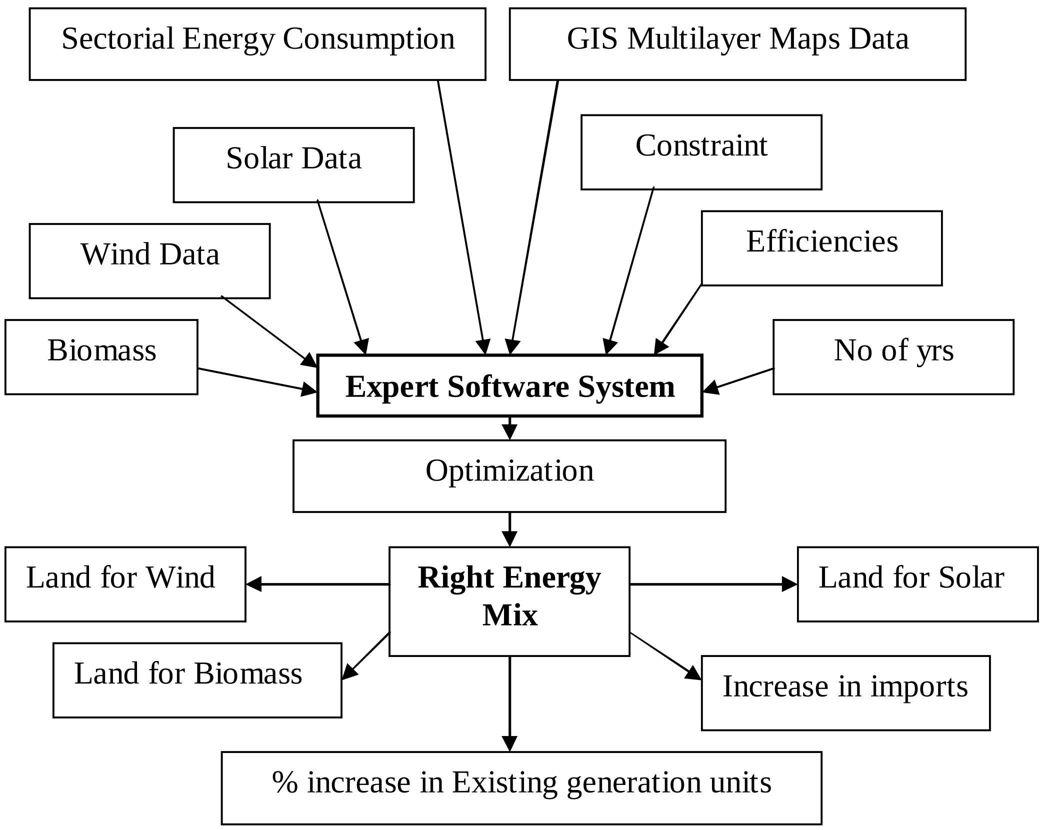


Fig 5.a. Broad over view of the Proposal

6. REFERENCES

1. Prof. NK Bansal, Lecture Notes, M.Tech in Energy & Environmental Management (Eve), Integrated Energy System 5th semester,2004
2. TERI Energy Yr. book 2001/2001

7. APPENDIX

Two case studies were separately considered to evaluate the feasibility of the software. Both the cases were of different sizes one is national energy planning and other is village energy planning. Both are presented in subsequent sections.

7.1. CASE STUDY- National Energy Planning

To start with, we have identified sector of energy consumption, broadly for our country and from [2] they are Agriculture, Industry, Household, Other Energy uses, Non-Energy and Transportation. The next step would be to identify the available energy sources in each sector like in our case study for industry they are; Central Electricity, Self generated Electricity, oil products, natural gas etc and used following data which was extracted from commercial energy balance from TERI's Yr. book

- **Agriculture**	
Central Electricity	10.5
Self Generated Electricity	7.94
Natural Gas	0.13
- **Industry**	
Central Electricity	11.73
Self Generated Electricity	4.07
Oil Products	8.34
Coal	71.11
Natural Gas	2.46
- **House Hold**	
Central Electricity	6.48
Oil Products	15.54
Natural Gas	0.29
- **Other Energy Uses**	
Central Electricity	1.54
Oil Products	6.34
- **Non-Energy**	
Oil Products	13.50
Natural Gas	9.13
- **Transportation**	
Central Electricity	0.62
Oil Products	32.81

Data is in MTOE (Million Tons of Oil Equivalent)

Electric Sector Generation mix was taken as

Thermal Power station	**24.8**
Gas Turbine Power Station	**2.26**
Hydro Power Station	**1.88**
Nuclear Power station	**0.43**

Data is in MTOE (Million Tons of Oil Equivalent)

7.1.1. Understanding the Energy Data

The data available for this kind of analysis is quit scanty in nature, so understanding of the data plays an important role in accuracy of the assessment. For example the TERI data which we have used do not take in to account the self generation part but with the understanding the diesel oil in industry will only be used for the purpose of power generation we can get the data for self generation as well.

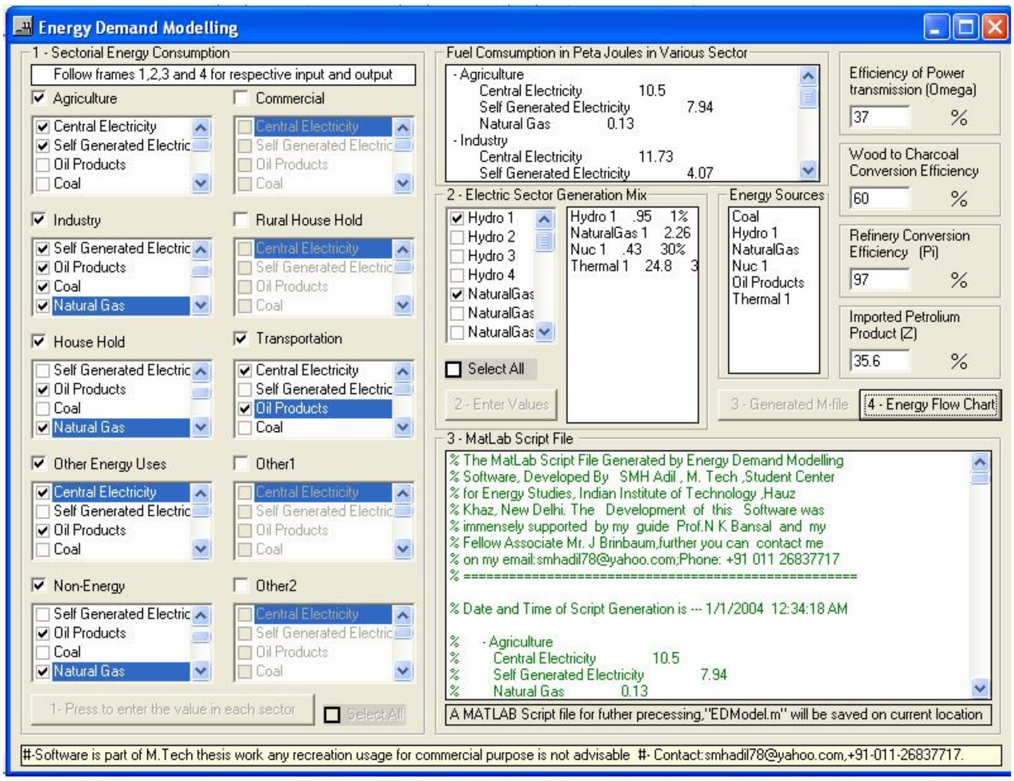
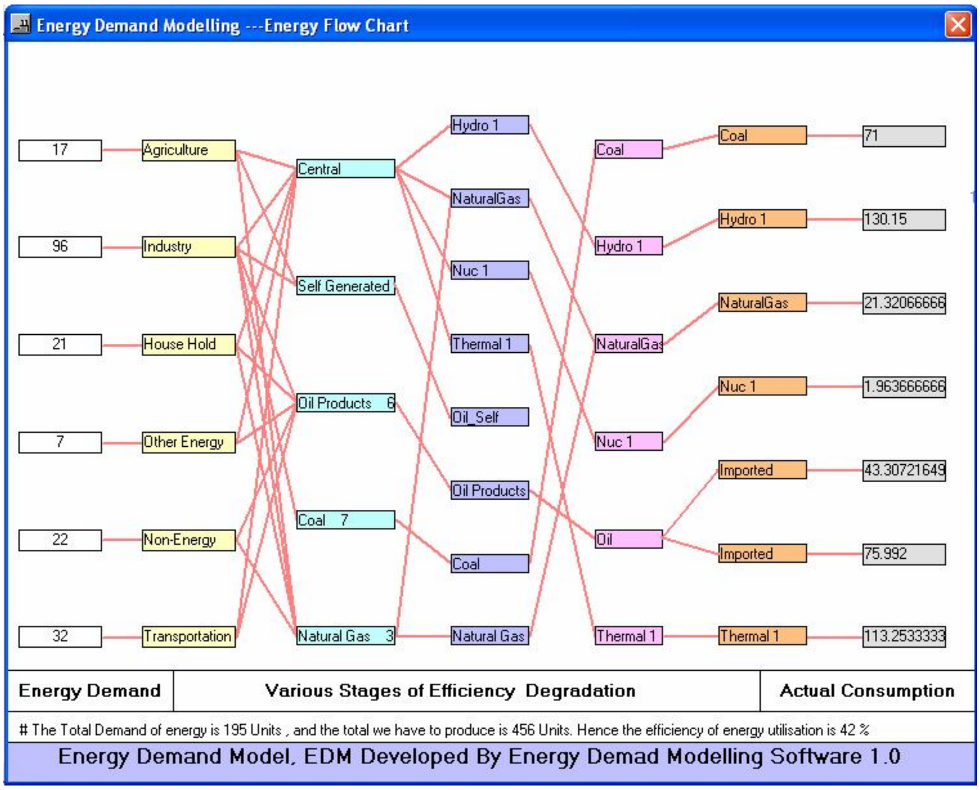


Fig 7.1: Software Interface loaded with Data

7.1.2. Energy Data Entry and Getting the Subsequent Output.

1. First check the needed option in the different sectors like in mining you can select central electricity; self generated electricity, coal, wood etc.
2. Then press button no 1 in the same frame to enter the values in the input boxes what ever you have selected in the above list boxes.
3. Generally the unit of energy may be taken as in pita joules for national energy modeling that is 1e+15. For village etc you can take Mega joules etc.
4. Then go to next frame "Electric Sector Generation Mix", select the power production units like Thermal, Nuclear, Gas Turbine etc, then enter there values by pressing the button 2 in the same frame.
5. It will ask you to enter value of energy production and efficiency sequentially.
6. When you press the button 3 it will generate MATLAB script file and it will also ask as efficiency of self generation enter.
7. The MATLAB file will be save on the location from where you are running the program.
8. Then press the button 4 to view the network model for energy flow.



7.1.3. MATLAB Script File (INDIA 2001/2002)

```
% ====================================================
% The MatLab Script File Generated by Energy Demand Modeling
% Software, Developed By   SMH Adil, M. Tech, Student Center
% for Energy Studies, Indian Institute of Technology, Hauz
% Khaz, New Delhi. The   Development of this   Software was
% immensely supported by my guide Prof.N K Bansal and my
% Fellow Associate Mr. J Brinbaum, further you can contact me
% on my email:smhadil78@yahoo.com; Phone: +91 011 26837717
% ====================================================

% Date and Time of Script Generation is --- 22/9/2004  12:34:18 PM

%      - Agriculture
%         Central Electricity              10.5
%         Self Generated Electricity              7.94
%         Natural Gas              0.13
%      - Industry
%         Central Electricity              11.73
%         Self Generated Electricity              4.07
%         Oil Products              8.34
%         Coal              71.11
%         Natural Gas              2.46
%      - House Hold
%         Central Electricity              6.48
%         Oil Products              15.54
%         Natural Gas              0.29
%      - Other Energy Uses
%         Central Electricity              1.54
%         Oil Products              6.34
%      - Non-Energy
%         Oil Products              13.50
%         Natural Gas              9.13
%      - Transportation
%         Central Electricity              0.62
%         Oil Products              32.81

%-------------------------
%V Fuel Comsumption Matrix
%-------------------------
V=[10.5;7.94;0.13;11.73;4.07;8.34;71.11;2.46;6.48;15.54;0.29;1.54;6.34;13.50
;9.13;0.62;32.81]
%Matrix Dimension --- (1X17).

%----------------------
%Agrigation Matrix G
%----------------------
G=[  1  1  1  0  0  0  0  0  0  0  0  0  0  0  0  0  0;
  0  0  0  1  1  1  1  1  0  0  0  0  0  0  0  0  0;
  0  0  0  0  0  0  0  0  1  1  1  0  0  0  0  0  0;
  0  0  0  0  0  0  0  0  0  0  0  1  1  0  0  0  0;
  0  0  0  0  0  0  0  0  0  0  0  0  0  1  1  0  0;
  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  1  1]
%Matrix Dimension --- (6X17).

%-----------------------------------
%Sectorial Energy Consumption Matrtix
%-----------------------------------
e=[17;
96;
21;
7;
22;
32]
%Matrix Dimension --- (6X1).
```

```
%----------------
% Fuel Mix Matrix
%----------------
F=[  .588235294117647  0  0  0  0  0;
  .411764705882353  0  0  0  0  0;
  0  0  0  0  0  0;
  0  .114583333333333  0  0  0  0;
  0  4.16666666666667E-02  0  0  0  0;
  0  8.33333333333333E-02  0  0  0  0;
  0  .739583333333333  0  0  0  0;
  0  2.08333333333333E-02  0  0  0  0;
  0  0  .285714285714286  0  0  0;
  0  0  .714285714285714  0  0  0;
  0  0  0  0  0  0;
  0  0  0  .142857142857143  0  0;
  0  0  0  .857142857142857  0  0;
  0  0  0  0  .590909090909091  0;
  0  0  0  0  .409090909090909  0;
  0  0  0  0  0  0;
  0  0  0  0  0  1]
%Matrix Dimension --- (17X6).

%---------------------------------------------
%A Aggrigation Matrix in the following sequence
%---------------------------------------------
% Central Electricity    1
% Self Generated Electricity    2
% Oil Products    6
% Coal    7
% Natural Gas    3
A=[ 1  0  0  1  0  0  0  0  1  0  0  1  0  0  0  1  0 ;
 0  4  0  0  4  0  0  0  0  0  0  0  0  0  0  0  0 ;
 0  0  0  0  0  1  0  0  0  1  0  0  1  1  0  0  1 ;
 0  0  0  0  0  0  1  0  0  0  0  0  0  0  0  0  0 ;
 0  0  1  0  0  0  0  1  0  0  1  0  0  0  1  0  0 ]
%Matrix Dimension --- (5X17).

%------------
%I_Dot Matrix
%------------
I_Dot=[28;
44;
74;
71;
11]
%Matrix Dimension --- (5X1).

%------------------------------------------------
% Omega Matrix, Transmission and Distribution Loss
%------------------------------------------------
Omega=[ 1.37  0  0  0  0 ;
 0  1  0  0  0 ;
 0  0  1  0  0 ;
 0  0  0  1  0 ;
 0  0  0  0  1 ]
%Matrix Dimension --- (5X5).

%-----------------------------------------
%Intermediate Energy Form Matrtix I_EnrForm
%-----------------------------------------
I_EnrForm=[38.36;
44;
74;
71;
11]
%Matrix Dimension --- (5X1).
```

```
%------------------------------------------------------------------------
% I_Star Matrix, Electric Sector Generation Mix with the following sequence
%------------------------------------------------------------------------
%Hydro 1
%NaturalGas
%Nuc 1
%Thermal 1
%Self Generated Electricity
%Oil Products
%Coal
%Natural Gas
I_Star=[1.3015
3.0962;
0.5891;
33.976;
44;
74;
71;
11]
%Matrix Dimension --- (8X1).

%------------------------------------------------
% Lambda Matrix,  Efficiency  of  Electric  Sector
% Gereation Mix, Efficiency of Charcoal Production
%------------------------------------------------
Lambda=[ 100  0  0  0  0  0  0  0 ;
 0  3.33333333333333  0  0  0  0  0  0 ;
 0  0  3.33333333333333  0  0  0  0  0 ;
 0  0  0  3.33333333333333  0  0  0  0 ;
 0  0  0  0  1  0  0  0 ;
 0  0  0  0  0  1  0  0 ;
 0  0  0  0  0  0  1  0 ;
 0  0  0  0  0  0  0  1 ]
%Matrix Dimension --- (8X8).

%----------------------------------------
% E Matrix, Electric Sector Generation Mix
%----------------------------------------
E=[ 3.34036568213783E-02  0  0  0  0 ;
 7.94655414908579E-02  0  0  0  0 ;
 1.51195499296765E-02  0  0  0  0 ;
 .872011251758087  0  0  0  0 ;
 0  1  0  0  0 ;
 0  0  1  0  0 ;
 0  0  0  1  0 ;
 0  0  0  0  1 ]
%Matrix Dimension --- (8X5).

%------------------------------
%Resource  consumption Matrix r
%------------------------------
r=[130.15;
10.3206666666667;
1.96366666666667;
113.253333333333;
44;
74;
71;
11]
%Matrix Dimension --- (8X1).

%------------------------------------------------
% B Matrix, Basic avaiable Energy Sources Aggrigation
%------------------------------------------------
%Coal
%Hydro 1
%NaturalGas
```

```
%Nuc 1
%Oil Products
%Thermal 1
B=[ 0  0  0  0  0  0  1  0 ;
 1  0  0  0  0  0  0  0 ;
 0  1  0  0  0  0  0  1 ;
 0  0  1  0  0  0  0  0 ;
 0  0  0  0  1  1  0  0 ;
 0  0  0  1  0  0  0  0 ]
%Matrix Dimension --- (6X8).

%----------
% S Matrix
%----------
S=[71;
130.15;
21.3206666666667;
1.96366666666667;
118;
113.253333333333]
%Matrix Dimension --- (6X1).

%-----------------------------------------------
% Z Matrix,Imported and curde oil
%-----------------------------------------------
Z=[ 1  0  0  0  0  0 ;
 0  1  0  0  0  0 ;
 0  0  1  0  0  0 ;
 0  0  0  1  0  0 ;
 0  0  0  0  .356  0 ;
 0  0  0  0  .644  0 ;
 0  0  0  0  0  1 ]
%Matrix Dimension --- (7X6).

%-----------------------------------------------
% Pi Matrix ,Refinary Losses
%-----------------------------------------------
Pi=[ 1  0  0  0  0  0  0 ;
 0  1  0  0  0  0  0 ;
 0  0  1  0  0  0  0 ;
 0  0  0  1  0  0  0 ;
 0  0  0  0  1.03092783505155  0  0 ;
 0  0  0  0  0  1  0 ;
 0  0  0  0  0  0  1 ]
%Matrix Dimension --- (7X7).

%-----------------------------------
% a Matrix ,The energy Resource vector
%-----------------------------------
%Coal
%Hydro 1
%NaturalGas
%Nuc 1
%Imported Petrolium Product
%Imported Crude
%Thermal 1
a_Final=[71;
130.15;
21.3206666666667;
1.96366666666667;
43.3072164948454;
75.992;
113.253333333333]
%Matrix Dimension --- (7X1).

% End of Data
```

7.2. CASE STUDY- Village Energy Planning

For village energy planning we would be considering smaller units. Such as (GJ).we would be starting in the same sequence as we did for national energy planning. First we will identify the sectors of energy consumption which are in this case study, Domestic, Agriculture, Education, Community and Industry etc. Then the sources of energy have to be evaluated.

Domestic	
Cooking (Cattle Dung, Fuel Wood, Agri. Waste, Kerosene)	3153
Lightening (Electricity)	149
Transport (Diesel)	1
Agriculture	
Soil preparation	1134
Irrigation (Diesel)	240
Education	
School (Electricity)	5.4
Community (Electricity)	1
Industry (Electricity)	50

7.2.1. Understanding the Energy Data

Sectors were identified and basic fuels are evaluated. The data below is ready for the software.

Domestic	
Electricity	149
Kerosene	148.8
Diesel	1.63
Cattle Dung	1404
Fuel Wood	911
Agricultural Waste	835.5
Agriculture	
Electricity	240
Diesel	1134
Education	
Electricity	5.4
Community	
Electricity	1
Industry	
Electricity	50

(Units are in GJ)

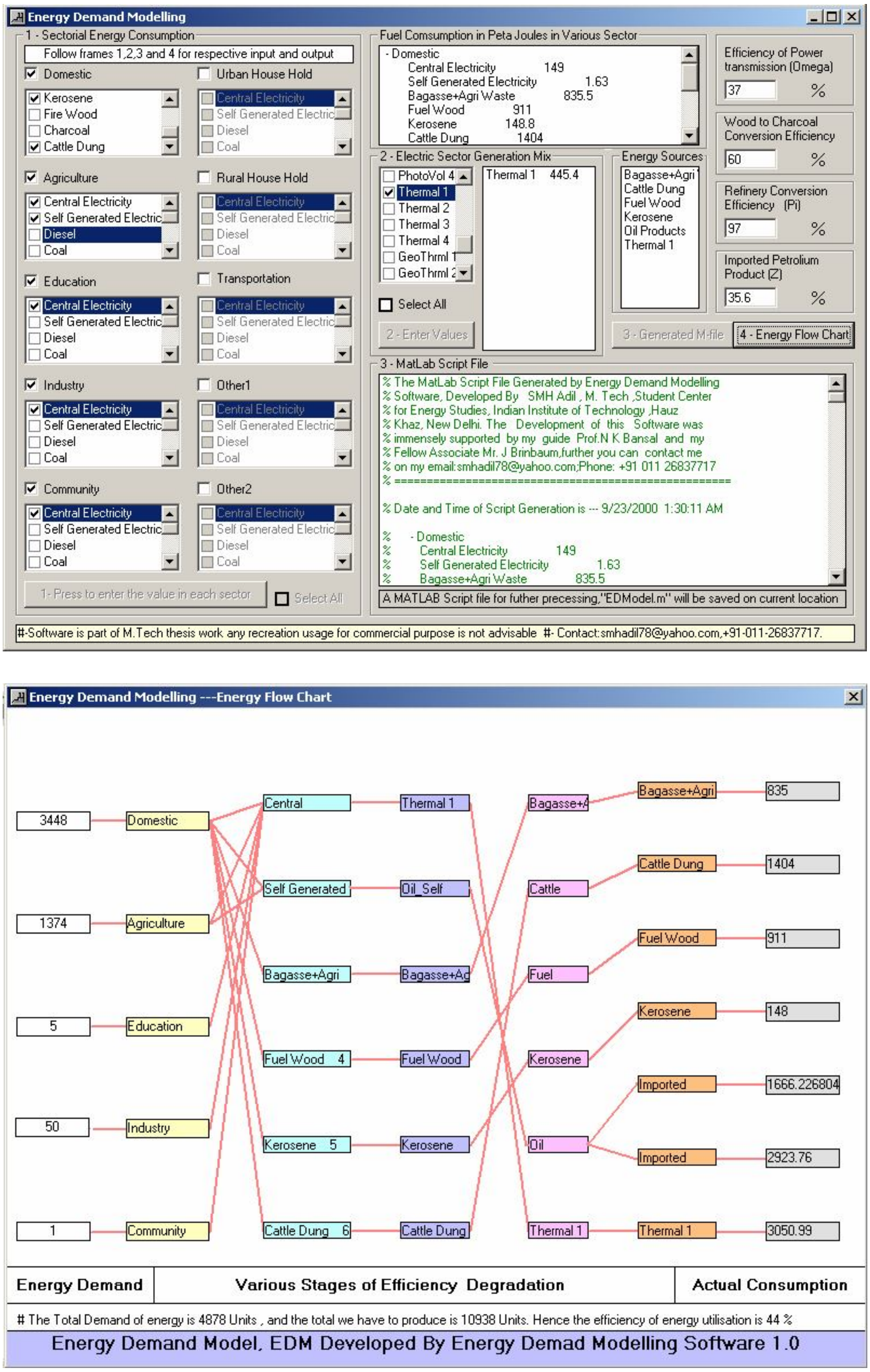


Fig7.2.1. Software GUI Loaded with data and RES Network for Village.

7.2.2. MATLAB Script File (Village)

```
% The MatLab Script File Generated by Energy Demand Modelling
% Software, Developed By   SMH Adil , M. Tech ,Student Center
% for Energy Studies, Indian Institute of Technology ,Hauz
% Khaz, New Delhi. The   Development  of  this   Software was
% immensely supported  by my  guide  Prof.N K Bansal  and  my
% Fellow Associate Mr. J Brinbaum,further you can  contact me
% on my email:smhadil78@yahoo.com;Phone: +91 011 26837717
% ====================================================

% Date and Time of Script Generation is --- 9/23/2000  1:30:11 AM

%      - Domestic
%         Central Electricity               149
%         Self Generated Electricity               1.63
%         Bagasse+Agri Waste               835.5
%         Fuel Wood               911
%         Kerosene               148.8
%         Cattle Dung               1404
%      - Agriculture
%         Central Electricity               240
%         Self Generated Electricity               1134
%      - Education
%         Central Electricity               5.4
%      - Industry
%         Central Electricity               1
%      - Community
%         Central Electricity               50

%------------------------
%V Fuel Comsumption Matrix
%------------------------
V=[149;1.63;835.5;911;148.8;1404;240;1134;5.4;1;50]
%Matrix Dimension --- (1X11).

%---------------------
%Agrigation Matrix G
%---------------------
G=[  1  1  1  1  1  1  0  0  0  0  0;
  0  0  0  0  0  0  1  1  0  0  0;
  0  0  0  0  0  0  0  0  1  0  0;
  0  0  0  0  0  0  0  0  0  1  0;
  0  0  0  0  0  0  0  0  0  0  1]
%Matrix Dimension --- (5X11).

%-----------------------------------
%Sectorial Energy Consumption Matrtix
%-----------------------------------
e=[3448;
1374;
5;
1;
50]
%Matrix Dimension --- (5X1).

%---------------
% Fuel Mix Matrix
%---------------
F=[  4.32134570765661E-02  0  0  0  0;
  2.90023201856148E-04  0  0  0  0;
  .242169373549884  0  0  0  0;
  .264211136890951  0  0  0  0;
  .04292343387471  0  0  0  0;
  .407192575406032  0  0  0  0;
  0  .174672489082969  0  0  0;
```

```
  0  .825327510917031  0  0  0;
  0  0  1  0  0;
  0  0  0  1  0;
  0  0  0  0  1]
%Matrix Dimension --- (11X5).

%--------------------------------------------
%A Aggrigation Matrix in the following sequence
%--------------------------------------------
% Central Electricity    1
% Self Generated Electricity    2
% Bagasse+Agri Waste    3
% Fuel Wood    4
% Kerosene    5
% Cattle Dung    6
A=[ 1  0  0  0  0  0  1  0  1  1  1 ;
 0  4  0  0  0  0  0  4  0  0  0 ;
 0  0  1  0  0  0  0  0  0  0  0 ;
 0  0  0  1  0  0  0  0  0  0  0 ;
 0  0  0  0  1  0  0  0  0  0  0 ;
 0  0  0  0  0  1  0  0  0  0  0 ]
%Matrix Dimension --- (6X11).

%-------------
%I_Dot Matrix
%-------------
I_Dot=[445;
4540;
835;
911;
148;
1404]
%Matrix Dimension --- (6X1).

%-----------------------------------------------
% Omega Matrix, Transmission and Distribution Loss
%-----------------------------------------------
Omega=[ 1.37  0  0  0  0  0 ;
 0  1  0  0  0  0 ;
 0  0  1  0  0  0 ;
 0  0  0  1  0  0 ;
 0  0  0  0  1  0 ;
 0  0  0  0  0  1 ]
%Matrix Dimension --- (6X6).

%----------------------------------------
%Intermediate Energy Form Matrtix I_EnrForm
%----------------------------------------
I_EnrForm=[609.65;
4540;
835;
911;
148;
1404]
%Matrix Dimension --- (6X1).

%----------------------------------------------------------------------
% I_Star Matrix, Electric Sector Generation Mix with the following sequence
%----------------------------------------------------------------------
%Thermal 1
%Self Generated Electricity
%Bagasse+Agri Waste
%Fuel Wood
%Kerosene
%Cattle Dung
I_Star=[610.198
4540;
```

```
835;
911;
148;
1404]
%Matrix Dimension --- (6X1).

%----------------------------------------------
% Lambda Matrix,  Efficiency  of  Electric  Sector
% Gereation Mix, Efficiency of Charcoal Production
%----------------------------------------------
Lambda=[ 5  0  0  0  0  0 ;
 0  1  0  0  0  0 ;
 0  0  1  0  0  0 ;
 0  0  0  1  0  0 ;
 0  0  0  0  1  0 ;
 0  0  0  0  0  1 ]
%Matrix Dimension --- (6X6).

%----------------------------------------
% E Matrix, Electric Sector Generation Mix
%----------------------------------------
E=[ 1  0  0  0  0  0 ;
 0  1  0  0  0  0 ;
 0  0  1  0  0  0 ;
 0  0  0  1  0  0 ;
 0  0  0  0  1  0 ;
 0  0  0  0  0  1 ]
%Matrix Dimension --- (6X6).

%------------------------------
%Resource  consumption Matrix r
%------------------------------
r=[3050.99;
4540;
835;
911;
148;
1404]
%Matrix Dimension --- (6X1).

%----------------------------------------------
% B Matrix, Basic avaiable Energy Sources Aggrigation
%----------------------------------------------
%Bagasse+Agri Waste
%Cattle Dung
%Fuel Wood
%Kerosene
%Oil Products
%Thermal 1
B=[ 0  0  1  0  0  0 ;
 0  0  0  0  0  1 ;
 0  0  0  1  0  0 ;
 0  0  0  0  1  0 ;
 0  1  0  0  0  0 ;
 1  0  0  0  0  0 ]
%Matrix Dimension --- (6X6).

%----------
% S Matrix
%----------
S=[835;
1404;
911;
148;
4540;
3050.99]
%Matrix Dimension --- (6X1).
```

```
%-------------------------------------------------
% Z Matrix,Imported and curde oil
%-------------------------------------------------
Z=[ 1  0  0  0  0  0 ;
 0  1  0  0  0  0 ;
 0  0  1  0  0  0 ;
 0  0  0  1  0  0 ;
 0  0  0  0  .356  0 ;
 0  0  0  0  .644  0 ;
 0  0  0  0  0  1 ]
%Matrix Dimension --- (7X6).

%-------------------------------------------------
% Pi Matrix ,Refinary Losses
%-------------------------------------------------
Pi=[ 1  0  0  0  0  0  0 ;
 0  1  0  0  0  0  0 ;
 0  0  1  0  0  0  0 ;
 0  0  0  1  0  0  0 ;
 0  0  0  0  1.03092783505155  0  0 ;
 0  0  0  0  0  1  0 ;
 0  0  0  0  0  0  1 ]
%Matrix Dimension --- (7X7).

%-------------------------------------
% a Matrix ,The energy Resource vector
%-------------------------------------
%Bagasse+Agri Waste
%Cattle Dung
%Fuel Wood
%Kerosene
%Imported Petrolium Product
%Imported Crude
%Thermal 1
a_Final=[835;
1404;
911;
148;
1666.22680412371;
2923.76;
3050.99]
%Matrix Dimension --- (7X1).

% End of Data
```