Electricity Distribution Model

1. Purpose and patterns

Here, our objective is to develop a model that would provide an effective tool for planning/checking the energy production and distribution system of a space (area/city/state), keeping India as the context .

Using ABM as a tool we plan to develop a model for the sustainable electrification of a space or to increase the efficiency of the electrification by creating various scenarios.

In the given research paper the authors have used Liberia as the example but we plan to make our model such that it would be applicable to Indian cities.

2. Entities, state variables, and scales

The model mainly consists of 6 breed-type agents namely Government, Organizations, Power Plants, Distribution Centers, Rural and urban centers, connected by a directed-link type ‘pipe’ in the respective order connecting the entities providing a more dynamic and realistic power-distribution-system.

Government consists of the ‘budget’ attribute showing the total expenditure the government has allotted for power distribution in the country.

Each of the Organizations consists of an internal budget-distribution for coal, management, transmission, etc. and an ‘under’ attribute connecting them under one of the Government-entity.

Each Power Plants have their internal budget-distribution for maintenance and stuff, including the information of which Organization and Distribution they are contracted with. They also have attributes listening to the production stats of the plant.

Each Distribution Center keeps the record of the amount of energy received and distributed under the ‘energy-got’ and ‘energy-distribution-ratio’ attributes.

Each of Urban and Rural Centers consists of attributes for population, number of households, for energy exercising, and their connection with their respective Distribution Centers.

3. Process overview and scheduling

In this Agent - Based Model we have used 1 tick to be equivalent to 12minutes in real time, so we can say that 5 ticks will be 1 hour, 120 ticks will be 24 hours. So, we get a complete cycle i.e. 30 days to be completed in 3600 ticks.

Here, we have the count of Rural and Urban centers and their respective population estimate, the Government Budget for electricity generation and recent coal-price to be given as user input using a slider as we have made this ABM model as a tool to test various distribution configurations and get the desired results.

There is a Government Body which provides a total budget to be distributed between the two organizations which own the power plants to generate electricity and supply the electricity to two distribution centers which are decentralized and not owned by any organization. These distribution centers in turn supply the electricity to various urban and rural centers depending on some conditions.

As I said, the distribution centers are decentralized, so we are connecting the power plants randomly to any distribution center. These power plants have their own maintenance cost which we have estimated to be 0.01 of the electricity generation budget of each power plant. The electricity generated at the power plants is stored and is supplied at 0.1 of the total per tick to the distribution centers and forward.

In the distribution of electricity from the power plant to distribution centers and then to urban and rural centers, there is an energy loss which we have estimated to be 0.01 of the transmission per unit wire.

From the distribution center, we have given priority first to the urban centers for electricity distribution and then to the rural centers. Within the urban centers, we calculate the total energy requirement for the particular urban center per 12 min , i.e. 1 tick and this we call as the measure of how posh the person is, we do the same for rural centers and for that it is a measure for the agricultural sector energy requirements. In urban and rural centers we give priority for the electricity distribution on how posh the person is or how much farming one does respectively.

4. Design concepts

Here, we have made an electricity distribution model. So, we have constructed a based electricity flow. The government assigns two organizations a budget in terms of money to generate electricity at a user specified coal price. Then each organization has control of power plants which generate electricity for supply to the distribution centers at some maintenance cost. Then these distribution centers supply electricity to urban and rural areas.

For the energy supply we have first given priority to the urban centers as in the real world we see that whenever there is an electricity shortage, the electricity is cut from the rural parts. For distribution within an urban / rural center we give priority to the household with more energy requirements i.e. how posh the person is or how much farming they do. In a household we have assumed that there are at least 2 people and at most 5 people.

$$energy\ requirement\ rural\ center = \{2 + 1.25 * [(population / (2 * population_{max}))$$
$$+ random_{float}(population / (2 * population_{max}))]$$
$$+ 1.5 * [(farming / (2 * farming_{max}))$$
$$+ random_{float}(farming / (2 * farming_{max}))]\}$$
$$* household_{count}$$ per day in kwh in a rural center

$$energy\ requirement\ urban\ center = \{2.5 + 1.5 * [(population / (2 * population_{max}))$$
$$+ random_{float}(population / (2 * population_{max}))]$$
$$+ 2 * [(farming / (2 * farming_{max}))$$
$$+ random_{float}(farming / (2 * farming_{max}))]\}$$
$$* household_{count}$$ per day in kwh in an urban center

Budget Attribute in Power plants, is the estimate of how much of cost they need in order to full-fill the requirement of urban and rural centers fully.

$$budget = (coal - price/8) * energy - generated$$

Budget-for-coal Attribute in Organization, is the sum of all the budgets of power plants under them.

$$1\ Ton\ coal = 8\ MWh\ energy\ generated$$

$$coal - price = 2800\ Rs\ to\ 7600\ Rs\ /\ Ton$$

Energy Loss per unit length of wire is 1% of the energy generated. Hence the total loss in transmission will be 0.01 * total length of wire

Budget Distribution at the organization level , done by the government, is implemented in the ratio of their Budget-Demand. Organization will use the Budget allocated to generate the energy and then Energy distribution by organizations over power plants is done a/c to the ratio of the energy needs of the Power plants.

Distribution Centers will collect the energy from the connected power plants and distribute it to the further urban centers in the descending order of their posh attribute and similarly for rural centers, energy will be distributed in the descending order of their farming attribute.

5. Initialization

During the initialization the entities are setted-up on the simulation area based on the provided coordinates and the connection between them is established (pipe/wire).

Each Power Plant gets associated with an Organization and a connection between all the entities is established during the setup (t = 0).

The Respective Budget is assigned by the Government to the Organization alongside the coal prices provided through the slider.

Each of the Urban and Rural Centers are allotted random populations and ‘posh’ or ‘farming’ variables respectively denoting the activities requiring energy.

6. Input data

The count of Rural and Urban centers and their respective population estimate, government-budget for electricity generation and recent coal-price are manually given to the code by the user through the slider.

Each of the 5 Power Plants are randomly connected with one of the 2 Distribution Centers. These distribution centers are in turn associated with an organization which will allot the budget.

All the entities are set-up in the simulation screen based on their respective provided coordinates.

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