Summary Description of the BOOM1 Model

By

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Abstract

This report describes the principal features of a computer model, BOOM1, designed to simulate the "boom town" impacts that may result from locating large energy facilities near small, isolated communities. Model outputs include population, permanent and mobile homes, public facilities and municipal debt, local property tax rate and state transfer payments, construction work force, construction productivity, and retail and service facilities. The model can be used to simulate the behaviour of these variables over a time span covering the pre-boom, construction, operation, and retirement phases of an energy project. The model runs may be interrupted in any year to simulate the effectiveness of assistance measures that have been proposed by national, state, local, and energy company officials. In these ways, the model can be used to help deal with boom-town problems and so minimize social and economic disruption from future energy construction projects.

Introduction

A crucial problem associated with the development of the vast energy resources of the American West is the adverse boom-town conditions that may result from locating large energy facilities near small, isolated communities. The construction of such plants will often lead to rapid increases in population and economic activity reminiscent of gold-rush boom towns in the nineteenth century. But unlike such boom towns, where people had little to lose and much to gain, energy boom towns in the twentieth century can be unpleasant and costly for nearly everyone involved.

Case studies of previous boom towns have indicated a wide range of problems associated with rapid, unmanaged growth. Schools become overcrowded and go to double sessions; health services do not keep up with population growth and neither do housing, shopping facilities and other private services. Newcomers are not integrated into the community; crime and mental illness increase; and the general quality of life is degraded. Construction turnover is consequently high causing a loss of productivity and cost overruns that may run as high as several hundred million dollars for a large energy facility.

Figure 1 graphically illustrates the magnitude of these problems. In this graph, a 1500-MW plant is located near a hypothetical agricultural town with a pre-boom population of 8000. Construction of the plant is initiated in 1975 and is largely completed by 1981. The curves show no change during the pre-boom years 1970-1975. The amount of housing, public facilities, and retail and services facilities, for example, is just sufficient to meet the needs of the town. The town may be said to be in equilibrium: no growth or shrinkage is needed in any sector to bring all of the town's sectors into balance with one another.

The equilibrium is upset, however, during the boom years 1975-1978. Construction workers immigrate in large numbers to work on the power plant. Company planners expected a peak work force of 1500 workers, but declines in productivity because of the general adverse conditions in the community cause contractors to hire many more workers to complete construction on schedule. In the third year of construction, for example, almost 3000 workers are on the payroll. Although the immigration of so many construction workers causes rapid increases in population, little permanent housing is developed because construction workers prefer the convenience of mobile homes.

Town officials make a considerable effort to serve the needs of the larger population by doubling the local property tax rate; however, the increase in both local property tax and state transfer payments is too little and too late to prevent a substantial decline in the adequacy of public facilities dueing the boom period. Retail and service facilities also fail to keep pace with the growth in population and income since private investors are reluctant to cater to the temporary business of the construction worker families.
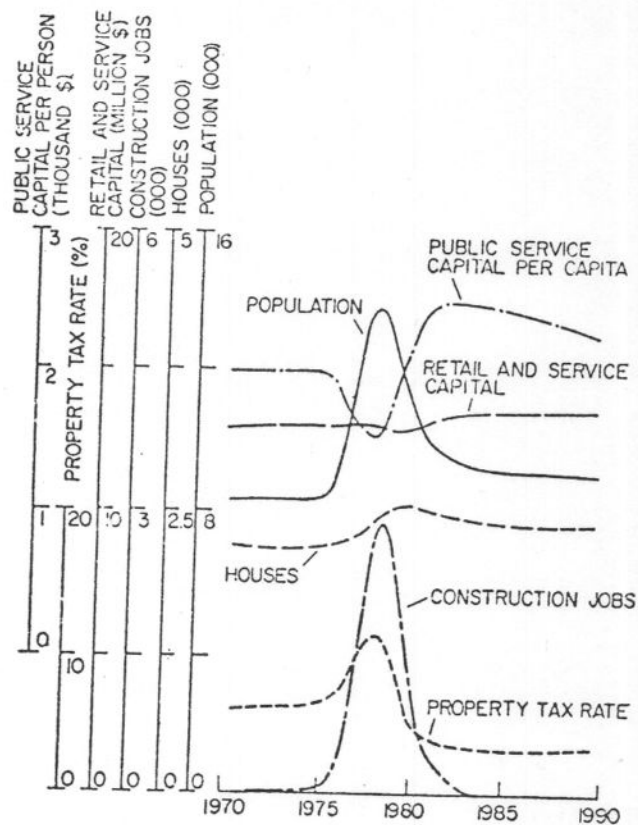
Fig. 1. Business as usual simulation results of the BOOM1 model.

The severity of these problems can change rapidly from year to year. During the boom years 1975-1978, local officials may face sharply rising population, shortage of public facilities, limitations on their ability to issue new debt, and the need to raise local taxes. However, during the bust years of 1978 to 1982, the exodus of large numbers of construction workers causes a rapid decline in the number of mobile homes and people, and a growing surplus of public facilities. Figure 1 thus indicates that the adverse socioeconomic effects of locating a large power plant near a small community are concentrated largely in the five to six year construction period. By the time construction is completed, the impacted community may well enjoy a surplus of public and private facilities. This surplus, combined with the increase in assessed valuation that occurs with the completion of power-plant construction, allows the town to reduce the property tax rate to a value well below the pre-boom level.

Several impacts do not vanish once the construction work force leaves town, however. Poor construction worker productivity, for example, can force up the capital cost of the power plant by several hundred million dollars. Similarly, poor productivity can cause cost overruns in the construction of public facilities. Local taxpayers and distant electricity consumers will have to pay for these overruns long after the boom is over. Moreover, rapid growth during the boom period can lead to scattered land-use patterns that are not easily changed once the construction families leave town.

The BOOM1 Model

During the past year, a multidisciplinary team of scientists from the Los Alamos Scientific Laboratory and the Battelle Pacific Northwest Laboratory has been organized to investigate the impacts of electric power production in the West. The team is developing a computer-based methodology for analysis of the regional impacts of alternative plans for electricity generation. A portion of the project is devoted to the construction of a computer simulation model designed to simulate the socioeconomic impact of locating large power plants near small, isolated communities.

A preliminary version of the model, entitled BOOM1, has been constructed and used to generate the curves shown in Fig. 1. The model can be used to generate the "business as usual" situation of Fig. 1 in which no special assistance is provided to the community. Alternatively, the simulation run can be interrupted in any particular year to change a specific policy parameter such as the bond limit or the amount of front-end money available. Used in this way, BOOM1 can simulate the timing as well as the magnitude of proposed boom-town policies. The principal features which make BOOM1 a useful tool for policy analysis are described in the following section.

Principal Features of the Model

1. Dynamic Representation

As the curves in Fig. 1 show, BOOM1 simulates the evolution of the town through time. In other words, BOOM1 is a dynamic model. It shows not only the conditions at the beginning and at the end of the boom, but also how the town gets from the beginning to the end. BOOM1 can thus simulate the timing of boom town developments, and it is the timing of events which can be particularly exasperating for town officials. The ability of the town to issue new debt, for example, is often severely limited just when the town is most in need of extra financing. A few years later, the restriction on selling new bonds may vanish as the power plant comes on line and is counted as part of the local tax base. By this time, however, town officials, facing a surplus of public facilities, are not interested in issuing new debt.

Since it is dynamic, the behaviour of the model may be interrupted at any time during the simulation to change a parameter value. This feature allows the model to be used to test the timing as well as the magnitude of alternative boom town policies.

2. Whole-System Representation

All models are simplifications of reality. Some models simplify reality by concentrating on a small corner of the total system and performing highly detailed calculations. A model of boom town conditions might, for example, focus on a single impact of power plant construction such as the increase in public expenses. The calculation of public expenses might make numerous distinctions; it could distinguish between costs for water and sewer services, for elementary and secondary education, for various health services, for library and parks, for fire and police protection, and so on.

BOOM1 is not such a model. BOOM1 uses a different method of simplifying reality. BOOM1 is a whole-system (holistic) model in which the emphasis is on interrelationships among the different sectors of the town. Specifically, BOOM1 is organized into the following five sectors:

    a)   housing

    b)   public construction and municipal financing

    c)   retail and services

    d)   power plant

    e)   migration

The calculations within each of the sectors, however, are not as detailed as are the calculations that might appear in a model with a more narrow focus. The housing sector, for example, simulates only the number of mobile homes and permanent homes. It does not distinguish between single units and multiple units, between old and new homes, or between company housing and private housing. Similarly, BOOM1's municipal financing sector simulates the sale and repayment of only one kind of debt. It does not distinguish between short-term and long-term debt, or between general obligation bonds, revenue bonds, and special-assessment district bonds.

Why simulate the whole system at the expense of the detail within each sector? Why not concentrate on achieving a detailed representation of an individual sector of the town? The holistic approach has been chosen because of the large number of interconnections between the sectors in a boom town. The following description illustrates just a few of these interconnections:

a) Municipal financing is connected to assessed valuation, and
b) assessed valuation is connected to housing.
c) Housing is connected to population, and
d) population is connected to jobs.
e) Jobs are connected to worker productivity, and
f) productivity is connected to construction worker turnover.
g) Turnover is connected to the general attractiveness of the town, and the
h) general attractiveness is connected to the adequacy of public services, and to close the circle of interconnections,
i) public services are connected to municipal financing.

Thus, the purpose of the BOOM1 model is to help the decision-maker understand how the sectors of a town "fit together", not to understand the highly detailed behaviour of an individual sector acting in isolation from the rest of the town.

3. Soft Relationships

The behaviour of boom towns is likely to be crucially affected by relationships and interdependencies that are difficult to quantify in a model. The relationship between the attractiveness of the town and the ability of the construction contractor to retain skilled workers is an example of one such "soft" relationship. In their case study of Rock Springs, Wyoming, Gilmore and Duff observed a substantial decline in worker productivity which they ascribed to a degraded quality of life.[1] But quantifying this significant relationship is made difficult by a shortage of data.

As energy development in the western states proceeds and as more case studies are performed, more data will become available. The new data can be used to improve the parameter estimates of the model. If a model is to be useful to decision-makers who are selecting boom-town policies now, however, it must make use of the information that is currently available.

4. Vicious Circles

Management of boom-town conditions is made difficult by the presence of several vicious circles that act to make conditions worse and worse once a town fails to keep pace with growth. One such vicious circle that involves the soft relationship between the quality of life and construction-worker productivity has been described as follows:

> The Rock Springs case study describes how the boom degraded quality of life in the community. The effect a degraded quality of life may have on productivity and turnover was experienced by Bechtel Corporation in their construction of the Jim Bridger plant in Rock Springs. During the spring of 1974, productivity of construction workers at the plant dropped well below expectations. Since the contractor was on a tight schedule, the loss in productivity had to be made up by hiring more construction workers. The additional population created an even greater strain on provision of local services, and caused further decline in the quality of life. Productivity then dropped even more.[2]

The causal-influence diagram (Fig. 2) shows the way in which variables in the BOOM1 model are interconnected to form the vicious circle described above. The notation shows model variables interconnected by lines of causal influence. The signs at the end of each arrow[*] represent the polarity of effect. A positive sign indicates that the two linked variables change in the same direction, while a negative sign indicates that the variables change in opposite directions. An increase in the number of units under construction, for example, leads to an increased number of construction workers (positive polarity). An increase in the productivity of construction workers, on the other hand, leads to a decrease in the number of workers required to complete the construction project (negative polarity). The positive sign in the middle of the loop notes that the closed chain of causal influences forms a positive feedback loop - another name for a vicious circle.

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[*] The arrows in Fig. 2 only show the interconnections directly involved in the positive feedback loop. Many additional arrows would be needed to portray all the interrelationships included in the BOOM1 model.
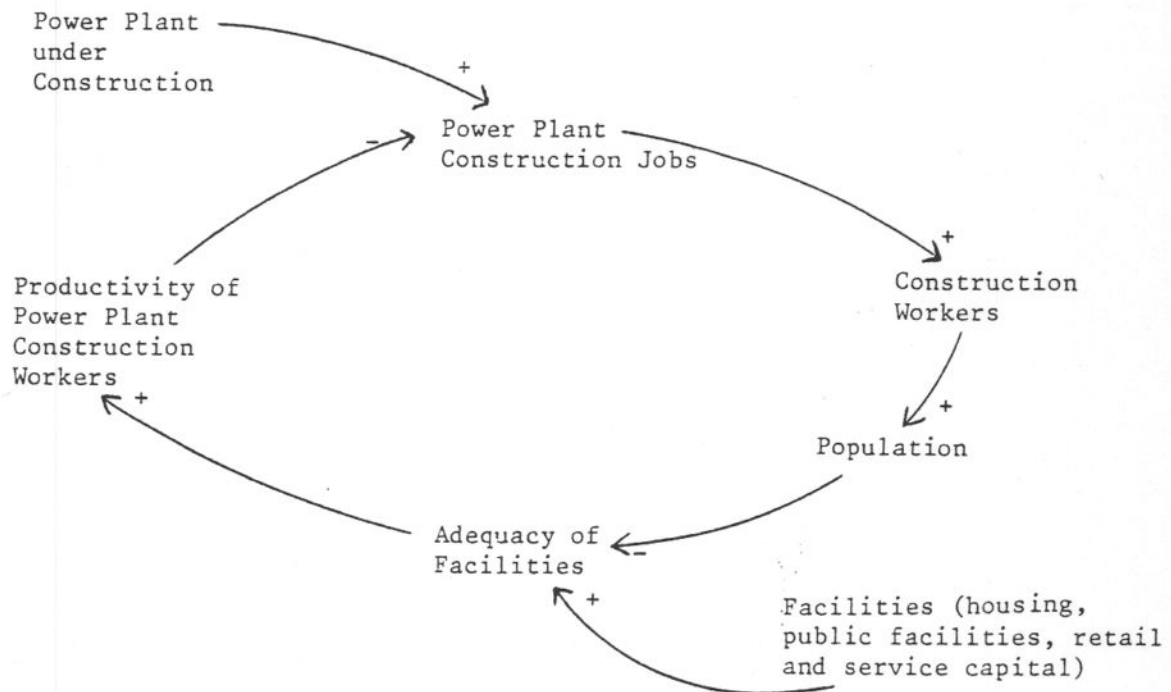
Fig. 2. Interconnection of BOOM1 variables to form a vicious circle

Another vicious circle represented in the BOOM1 model involves the inflation in the cost of public construction that can occur in towns experiencing adverse boom-town conditions. Inflated costs reduce the number of public facilities that can be financed and cause the town to cut back on the construction of needed facilities. The increased shortage of public facilities reduces the quality of life and leads to higher turnover and lower productivity. The decline in productivity, in turn, causes even more inflation in the cost of public construction.

5. Simulation of the Poor Response of Towns Under Rapid Growth

In summarising the results of seven case studies of communities affected by large construction projects,[3] researchers from the Denver Research Institute concluded that:

> The case studies revealed extreme situations. In Sweetwater county (Wyoming) and Kenai (Alaska), the quality of life was degraded compared to pre-boom conditions. Schools and housing were inadequate. In other cases, particularly Tullahoma (Oklahoma) and Idaho Falls (Idaho), the quality of life appears to have been enhanced. The differences are due, in large measure, to the rate of growth and the number of construction employees.

> The more rapid the growth rate, the more likely an area was to suffer a decrease in the quality of life. Growth rates more than 10 percent annually are hard to accommodate; rates of 15-20 percent have led to near chaos in unmanaged rural growth situations. Public and private services simply do not keep pace, and masses of newcomers are not integrated into relatively small communities.

It appears, therefore, that a town's ability to accommodate growth can break down if the town is put under the stress of an annual growth rate exceeding 10-15%. The behaviour of BOOM1 has been examined by varying the size of the power plant to determine if the model exhibits such a breakdown. Eight simulation runs have been performed to test the model's response under different rates of growth. The eight points in Figure 3 show the results of the simulations. These points are located along two axes:

(1) the horizontal axis represents the expected population growth rate during the boom period and indicates the degree of stress on the town;

(2) the vertical axis represents the maximum value of the boom town index which shows the severity of conditions at the peak of the boom*.

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*   The boom town index is simply a weighted sum of three shortages (permanent housing, retail and service facilities, and public services) and the fraction of the housing stock that is mobile homes. The third point on the solid curve in Figure 3, for example, shows a boom town index of 30 per cent. This represents the adverse conditions at the peak of the boom shown in Figure 1. The reader may think of the value of 30 per cent as representing boom town conditions slightly more severe than the conditions at the peak of the boom in Rock Springs, Wyoming.
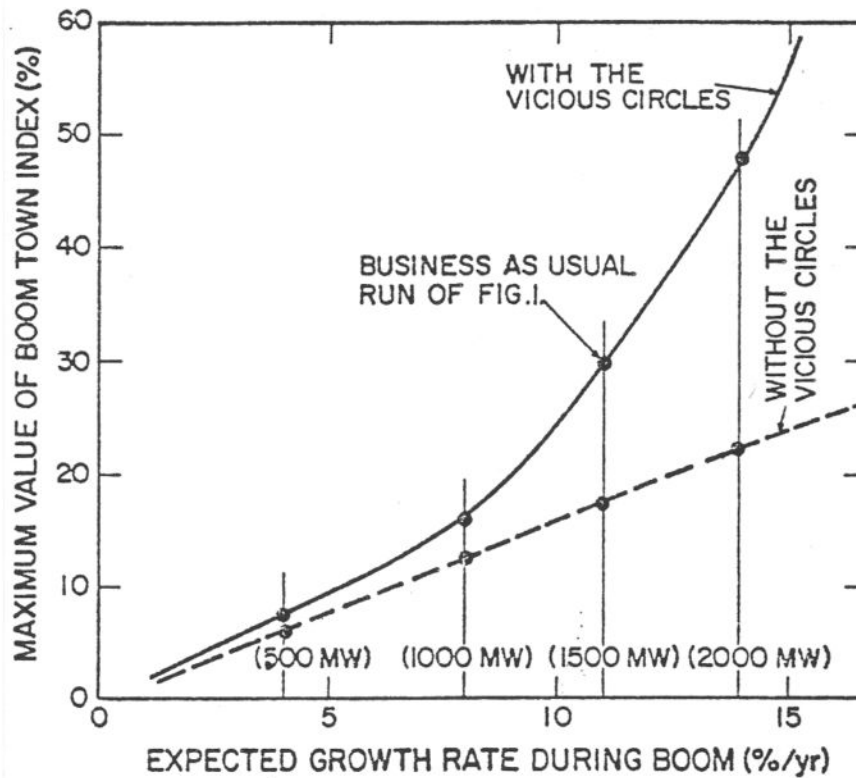
Fig. 3.   Results of eight simulation runs showing the poor response of the model under rapid growth.

As the size of the power plant used in each simulation increases, the model
is stressed by a larger and larger rate of growth. When put under higher stress,
the model exhibits increasingly severe conditions as measured by the boom town index.
As the growth rate exceeds 10 per cent, the solid curve in Figure 3 starts to increase
more and more rapidly, indicating a breakdown in the ability of the town to
accommodate growth. A comparison of the solid and dashed curves in Figure 3 indicates
that the vicious circles in BOOM1 are responsible for the model's tendency to
exhibit the breakdown under rapid growth.

6. Simulation of Cutbacks in Public Construction

The municipal financing sector of BOOM1 simulates the sale and repayment of
debt needed to help finance the construction of facilities. During the boom period
of many simulations, the level of outstanding debt grows very rapidly. Unfortunately,
the town's bonding capacity does not show any significant growth until portions of
the power plant are completed and can be added to the town's tax base. When the
rapidly growing debt draws near the bonding capacity, the ability of the financing
sector to issue new debt is reduced. Whenever the town cannot raise sufficient funds
(either from current revenues or from the sale of new debt), it has no choice but to
cut back on the construction of new facilities. This particular feature of BOOM1
(which is not present in many local impact models*) allows the model to simulate
directly the effectiveness of loan guarantee programs designed to remove the
restrictions on a town's ability to issue new debt.

7. Documentation Available

A computer model must be more than a "black box" capable of generating reasonable
curves if a decision maker is to judge for himself whether the model makes sense.
The details of BOOM1 are documented in a technical report entitled <u>User's Guide to the</u>
<u>BOOM1 Model</u>.[4] In addition to showing the individual equations and parameter estimates,[**]
the <u>User's Guide</u> provides the following information needed to judge BOOM1's usefulness:

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* Many models simply compare total revenues with toal expenses and make note of
whatever deficits or surpluses occur. The construction of public facilities,
however, is not affected by any deficits that may occur.

** Many potential model users ask "How can I get the model itself?". The list of
equations shown in the <u>User's Guide</u> <u>is</u> the model, and since it is a short list,
one need only obtain a copy of the <u>User's Guide</u> to have obtained the model itself.

a) a list of factors <u>not</u> included in the model,

b) causal influence diagrams of vicious circles,

c) flow diagrams of each of the five sectors,

d) numerous plots of model variables,

e) results of tests showing the sensitivity of the model to alternate estimates of parameters,

f) results of illustrative policy simulations showing the effectiveness of front end money, public loan guarantees, and guaranteed loans to the retail and services investor.

g) a list of simple parameter changes used in the policy runs.

Applications

BOOM1 can be used to assist national, state, local, and energy company officials who are concerned with boom-town problems. National planners, for example, are debating the merits of the administration's Federal Energy Development Impact Assistance Fund's provisions to provide direct grants of front-end money as well as loan guarantees to localities facing rapid development. The effectiveness of these measures has been tested with BOOM1.[5] BOOM1 could also be used to simulate the impact of special loans whose initial interest payments may be deferred until after the energy facility comes on line and is counted as part of the local tax base.

Industry leaders have a strong self-interest in avoiding adverse boom-town conditions which can lead to large increases in the cost of construction. BOOM1 can be used to test several of the options open to energy companies, including:

a) prepayment of taxes

b) "impact payments" to the local government

c) guarantees for home mortgages of employees,

d) establishing open and trustworthy (bonded?) channels of communication with local officials and

e) adopting a longer construction interval over which to build the energy facility.

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A model of state revenues and expenses, titled STATE1, is being constructed at the Battelle Pacific Northwest Laboratories to be used in conjunction with BOOM1 to test the effectiveness of statewide efforts to deal with boom-town problems. The state of Wyoming, for instance, is considering a statewide community development corporation to provide assistance to local communities. In the initial application, STATE1 is to be parameterized for the state of Wyoming, and BOOM1 for each of the potential boom towns in Wyoming. The combination of models could be used to simulate the effectiveness of the Wyoming Community Development Corporation.

BOOM1 can also be used to help local officials deal with the problems of rapid growth. The model can show the usefulness of obtaining prepayment of taxes or impact payments*, for example. BOOM1 could also be used to simulate the impact of alternative tax and fee structures involving different mixtures of:

a) property tax,

b) sales and use tax,

c) entry and permit fees,

d) employee head tax.

The model may be used to help local officials decide how much industrial activity should be allowed within their jurisdiction. New construction projects that would push the annual growth rate past 15 per cent, for example, could overstress a town to such an extent that efforts to provide front-end money and loan guarantees are ineffective. A town might be better off in exercising plant-site control authority to prohibit the simultaneous construction of too many industrial facilities.

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* Puget Sound Power and Light Company agreed to provide "impact payments" to schools and law enforcement agencies in Skagit County, Washington, as a condition for obtaining a rezone permit for construction of a nuclear power plant.[6]

References

1. John S. Gilmore and Mary K. Duff, _A Growth Management Case Study: Sweetwater County, Wyoming_ (Univ. of Denver Research Inst., Denver, CO, December, 1974) p. 4. See also John Gilmore and Mary Duff, _Boom Town Management_ (Westview Press, Inc., Flatiron Industrial Park, Boulder, CO, November, 1975)

2. Univ. of Denver Research Inst., _The Social, Economic, and Land Use Impacts of a Fort Union Coal Processing Complex_, final report to the United States Energy Research and Development Administration, Div. of Fossil Fuels (August 1975), pp. 101-102.

3. Ibid, pp. 4-5

4. Andrew Ford, _User's Guide to the BOOM1 Model_, Los Alamos Scientific Laboratory report LA-6396-MS (to be issued).

5. Ibid., pp. 44-45

6. David Myhra, "One Nuke Gets a Warm Welcome," _Planning_ (September 1975), p. 13.