Application of LINGO in Environment System Optimization Design

Bao-you LIU* and Pei-wen ZHANG

Key Laboratory of Pollution Prevention and Control in Hebei Province, College of Environmental Science and Engineering, Hebei University of Science and Technology, Shijiazhuang Hebei 050018, China

*Corresponding author

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Abstract. In order to save resources and protect environment, it is necessary to systematically optimize the typical environmental problems. In this paper, waste water treatment optimization problems, air pollution control problems and solid waste disposal problems were selected as typical examples, to illustrate the LINGO environmental system optimization process of the application process. The results show that LINGO has the characteristics of practicability, simple solution and easy understanding. It can be used as an effective tool to optimize the design of environmental problems. LINGO solution results can be used as a reference for the relevant environmental design department to carry out the actual case design.

Introduction

What Is Environmental System Optimization?

Environmental system optimization is to choose the most reasonable one from all possible options to achieve the optimal goal of science. Optimization should be considered from a holistic and partial perspective. We usually know the philosophy of the barrel principle, the shortest wooden decision bucket capacity. The whole is made up of parts. How to achieve total maximum function and effect is to optimize the direct connotation.

Why Environmental System Optimization

With the continuous economic development, the demand for resources gradually increased. At the same time due to population growth and people's increasing quality of life standards, the consumption rate of various resources has continued to increase. The human resources can be used and its limited, the demand seems to be unlimited, the human face of fresh water, forests, mineral resources, energy shortages, sustainable development faces severe challenges. How to use the minimum resource consumption to get the maximum output is an important development problem to be solved.

It should also be noted that environmental issues have been identified as the major constraints to the continued advancement of human society. As resources development technology imbalance lead to resource destruction and waste is very serious, the ecological environment is deteriorating. Environmental pollution, natural disasters occur frequently. How to regulate the relationship between economic development and pollution control, with the least funds to achieve maximum environmental benefits is also an important issue.

The Scope of Application of Environmental System Optimization

Environmental system optimization technology in scientific experiments, engineering design, environmental planning and other issues in the application, making limited resources and provisions of the constraints, to achieve economic development and environmental protection the best results. For example, the air pollution system simulation and planning and control, water pollution system simulation optimization and control, solid waste transport and disposal, ecological environment system planning and management and rational allocation of resources.

In the analysis of the problem to consider: the construction of sewage treatment plants, landfill...
design, to consider how to select the parameters to ensure that since the meet requirements, but also reduce costs? In the process of resource and energy allocation, how to meet the requirements of various aspects of the program, but also a good income? In the production process, how the rational allocation of raw materials and equipment in order to make product quality improvement, cost reduction, and the amount of waste generated at least? In environmental planning, how to carry out various industries, and how to decide the rational distribution of enterprises is necessary to make the best environmental and economic benefits?

Environmental System Optimization Steps

**Analyze the System to Identify The Problem.** The environmental system analysis is carried out. Through the basic data, environmental quality and impact assessment of pollution sources, the problems and targets of pollution control are clarified, and various options and the mutual restraints and links of the various elements are put forward to systematically analyze and synthesize. Mainly understand the composition of the system and the relationship between the various subsystems, the main parameters and variables, to solve the main problems and to achieve the purpose.

**Define the System or Problem.** The process of optimization model establishment includes the determination of initial conditions, the determination of boundary conditions using the appropriate model, the natural entity into the optimization model, the establishment of objective function, and parameter estimation model error test and sensitivity analysis. It can be used to establish linear, nonlinear single-objective mulch-objective optimization of a variety of models.

**To Find The Most Solutions.** A variety of optimization methods can be used to solve the process of optimization model, and a linear and nonlinear single objective mulch-objective integer programming dynamic programming method can be used. For some simple models, the optimal solution can be obtained directly through the graphical method, and for the more complex model, you must use computer software to solve. Common include: matlab, spss, excel, lingo and so on.

**Decision-making of Best Solution or Program.** Combined with the actual regional, decision-making, from the optimal solution to find the best solution. The establishment of the optimal model is the most important and difficult step in the process of system analysis. It is necessary to describe the interrelationship among the elements and elements of the entity system through appropriate screening and using appropriate mathematical equations. An optimization model is usually composed of objective functions and constraints.

Objective function
Max (min) \( Z = F (x_1, x_2, x_3, ..., x_n) \)

Restrictions
\( G_n \ (x_1, x_2, x_3, ... x_n) \leq, =, \geq b_1; \ G_2 \ (x_1, x_2, x_3, ... x_n) \leq, =, \geq b_m \)

The state vector \( X \ (x_1, x_2, x_3, ... x_n) \) contains one of your decision choices, and the objective function is constrained by m constraints. The solution that satisfies the constraint is called a feasible solution. The solution of all feasible solutions that can make \( Z \) get the maximum or minimum value is called the optimal solution.

Application of LINGO in Environmental System Optimization

In this paper, waste water treatment optimization problems, air pollution control problems and solid waste disposal problems as an example, to illustrate the environmental system optimization process of application.

**Waste Water Treatment Optimization Problem (Nonlinear Programming Problem)**

Problem Description: Each kg of metal produced 0.3 kg of waste, the waste discharge concentration with the waste water 2kg / m³, part of the waste water treatment, discharged into the nearby rivers. The Government controls the total amount of waste to 10 kg / d. The maximum production capacity of the plant is 5500 kg / d, the cost is $ 13 / kg, the production cost is $ 9 / kg, the waste water treatment facility has a waste water treatment capacity of 700 m³ / d, the treatment cost is $ 2 / m³, the waste water treatment efficiency and the pollutant load \((\times 100m^3 \ / \ d)\), and the treatment
efficiency is $\eta = 1 - 0.06Q$. An optimization model is established to solve the problem, and $Q$ is the waste water treatment quantity.

Solution: Let $X$ be the metal production, the unit is 100kg, $y$ is the amount of waste produced by the metal, unit is 100kg, $Z$ is the total income value. According to the proposal, the objective function is:

$$\text{Max} \ Z = 400X - 100y$$

Restrictions

$$0.3X - y + 0.03y^2 \leq 10; \ X \leq 50; \ Y \leq 14; \ 0.3X - y \geq 0; \ X \geq 0, \ y \geq 0$$

Each constraint represents: daily allowable emissions limits for waste; daily production limits for metal products; waste water treatment capacity for waste water treatment facilities; daily waste treatment capacity greater than output; product output and waste disposal capacity is not a negative value.

This is a nonlinear programming model, we can consider using lingo11.0 solution. The Lingo program is

$$\text{Max} \ 400X1 - 100X2$$

ST

$$0.3X1 - X2 + 0.03X2^2 \leq 10$$

$$X1 \leq 50$$

$$X2 \leq 14$$

$$0.3X1 - X2 \geq 0$$

Lingo solution results, the results show that the optimal profit to 19,500 US dollars, this time need to produce the production of 5,000 tons, the amount of waste required to deal with 500 tons.

Control of Air Pollutant Emissions (Linear Programming Problem)

Problem Description: There are three point sources of total suspended particulate matter (TSP) in a district, two of which are coal-fired power plants and the other is cement plants, which discharges 95 kg of total suspended particulates for every 1 ton of coal burned, Each plant burns 1 ton of coal to discharge 85kg of total suspended particulates. The coal power of the two power plants is 400000t/a and 300000t/a, the output of cement plant is 250000t/a. At present, the three total suspended particulate emissions Source No control measures. Now, the removal efficiency and cost of the control method that each point source can select is shown in Table 1 below. The objective of this issue is to reduce total emissions of total suspended particulates from the cement plant and the two power plants by 80 percent at minimum cost. Relative to the individual enterprises to achieve compliance control cut, save much money?

| Point source | Control method | Removal rate | No removal efficiency (%) | Cost (Yuan/t) | Coal consumption (t/a) | TSP Emission (kg/t) | Total emissions (kg/t) |
|--------------|----------------|--------------|---------------------------|--------------|------------------------|---------------------|------------------------|
| power plant1 | Partition       | 59           | 41                        | 1            | 400 000                | 95                  | 38000000               |
|              | spray           | 94           | 6                         | 2            |                        |                     |                        |
|              | Static electricity | 97   | 3                         | 2.8          |                        |                     |                        |
| power plant2 | Partition       | 59           | 41                        | 1.4          | 300 000                | 95                  | 28500000               |
|              | spray           | 94           | 6                         | 2.2          |                        |                     |                        |
|              | Static electricity | 97   | 3                         | 3            |                        |                     |                        |
| Cement plant | Partition       | 59           | 41                        | 1.1          | 250 00                 | 85                  | 21250000               |
|              | Multistage      | 74           | 26                        | 1.2          |                        |                     |                        |
|              | Long cone       | 84           | 16                        | 1.5          |                        |                     |                        |
|              | spray           | 94           | 6                         | 3            |                        |                     |                        |
The total emissions are now 67,750,000 kg/a, and the total allowable emissions should be 17,550,000 kg/a, since a reduction of 80% in total emissions is required.

I: the source of pollution, 1 is the power plant 1, 2 is the power plant 2, 3 is the cement plant 3, j is the control method, and i is the source of the pollution. 0 means no control, 1 means diaphragm sedimentation tank, 2 means Multi-stage dust collector, 3 means long cone dust collector, 4 means spray scrubber, 5 means electrostatic dust collector;

According to the meaning of the title, the establishment of the following mathematical model of linear programming:

Min Z = X11 + 2X14 + 2.8X15 + 1.4X21 + 2.2X24 + 3X25 + 1.1X31 + 1.2X32 + 1.5X33 + 3X34

S.T.
X10 + X11 + X14 + X15 = 400000
X20 + X21 + X24 + X25 = 300000
X30 + X31 + X32 + X33 + X34 = 250000
95X10 + 39X11 + 5.7X14 + 2.9X15 + 95X20 + 39X21 + 5.7X24 + 2.9X25 + 85X30 + 34.9X31 + 22.1X32 + 13.6X33 + 5.1X34 <= 17550000
Xij >= 0

Convert to lingo program

Min X11 + 2X14 + 2.8X15 + 1.4X21 + 2.2X24 + 3X25 + 1.1X31 + 1.2X32 + 1.5X33 + 3X34
ST
X10 + X11 + X14 + X15 = 400000
X20 + X21 + X24 + X25 = 300000
X30 + X31 + X32 + X33 + X34 = 250000
95X10 + 39X11 + 5.7X14 + 2.9X15 + 95X20 + 39X21 + 5.7X24 + 2.9X25 + 85X30 + 34.9X31 + 22.1X32 + 13.6X33 + 5.1X34 <= 17550000

The results show that power plant 1 is treated by partition method 241291.3, sprayed method 158708.7, power plant 2 treated by spray method 300000.0, cement plant treated by multi-stage precipitator 250000.0, the total cost is 1518709 yuan. If you consider individual enterprises to achieve compliance control reduction, then change the last line of constraints:

95X10 + 39X11 + 5.7X14 + 2.9X15 <= 7600000
95X20 + 39X21 + 5.7X24 + 2.9X25 <= 5700000
85X30 + 34.9X31 + 22.1X32 + 13.6X33 + 5.1X34 <= 4250000

Then run lingo11.0 again, the results are: power plant 1 by partition method 159759.8, using spray method 240240.2, power plant 2 using spray method 255319.1, the cement plant using multi-stage precipitator method 100000.0, long cone dust collector Processing 150000.0, at this time the total cost of a minimum of 1546942 yuan. Consolidated governance, compared to individual plant governance, can save 1.86% of the cost.

Solid Waste Disposal (0-1 Mixed Integer Programming Problem)

Problem Description: There are two cities to build a regional solid waste disposal system. There are 40,000 people in the city, the amount of solid waste is 700t/week; city 2 has 65000 people, solid waste is 1200t/week. There are three possible disposal sites for the three options shown in Table 2. The transport costs are known to be US $0.5/(t*km) to determine the optimal disposal of solid waste Program so that the entire system costs most?

| Site | Method         | Distance from the city 1(km) | Distance from the city 2(km) | Fixed cost ($/week) | Variable cost ($/t) | Processing capacity (t/week) |
|------|----------------|------------------------------|------------------------------|--------------------|---------------------|-------------------------------|
| 1    | Incineration   | 15                           | 10                           | 3850               | 12                  | 1000                          |
| 2    | Discharge the sea | 5                           | 15                           | 1150               | 16                  | 500                           |
| 3    | Buried         | 30                           | 25                           | 1920               | 6                   | 1300                          |

(J = 1-3, j = 1 for incineration, j = 2 for sea discharge, and j = 3 for burial), where x is the number of municipalities (i = 1 to 2) Garbage volume, yi = 1, said to adopt the first i method, = 0 otherwise
This is a 0-1 mixed integer programming problem, the LINGO program
Min 19.5X11 + 18.5X12 + 21X13 + 17X21 + 23.5X22 + 18.5X23 + 3850y1 + 1150y2 + 1920y3
ST
X11 + X21-1000 y1 <= 0
X12 + X22-500 y2 <= 0
X13 + X23-1300y3 <= 0
X11 + X12 + X13 = 700
X21 + X22 + X23 = 1200
END
INT y1
INT y2
INT y3
X12 = 0; X21 = 800, X22 = 0; X23 = 400. The results of the solution Y1 = Y2 = Y3 = 1, X11 = 200; X12 = 500;
The first method is to pay a fixed cost of US $ 6,920, followed by 200 tons for the city 1 and 500 tons for the city 2 by incineration method, and the burial method Processing 400 tons, this time the total cost of a minimum of 41070 US dollars. In order to verify whether the results of this problem is unique, we re-operation lingo, and make X11 = 0, at this time the results of the operation: Y1 = Y2 = Y3 = 1, X11 = 0; X12 = 500; X13 = , X22 = 0; X23 = 200. The minimum fee is still 41070.

Conclusions
This paper selects several examples of typical environmental system optimization problems, using lingo software to solve, and gives the process of mathematical modeling and lingo program to verify the effectiveness of the software, usability and efficiency characteristics, Can be used as an effective tool to solve environmental problems. The result of the solution has a strong guiding significance for finding the best solution to the practical problem.

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