A Review of Current Electric Power Network Expansion Models

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Abstract

Electric power transmission expansion planning (TEP), which involves identifying the areas where the existing transmission infrastructure is inadequate, determining the optimal locations and routes for new transmission lines and substations, and evaluating each option in detail. TEP is important for ensuring the reliable and cost-effective delivery of electricity to consumers, and it requires consideration of technical, economic, environmental, and social factors. In this paper, we briefly compare different TEP models, while addressing the advantages and disadvantages of each approach.

Introduction

Electric power transmission expansion planning (TEP) is the process of determining the most efficient and cost-effective way to expand the transmission system to meet the increasing demand for electricity [1-4]. TEP involves identifying the areas where the existing transmission infrastructure is inadequate and determining the optimal locations and routes for new transmission lines and substations.

The TEP process typically involves several stages. The first stage is to identify the current and projected electricity demand in the region. This information is used to determine the need for additional transmission capacity. The second stage involves identifying potential transmission routes and locations for new substations based on a range of factors, including land use, environmental impacts, cost, and reliability [5]. Once potential transmission routes and substation locations have been identified, the third stage involves evaluating each option in more detail. This includes assessing the technical feasibility, cost, environmental impact, and social acceptability of each option. This evaluation process helps to narrow down the list of potential transmission routes and substation locations to those that are most feasible and cost-effective. The final stage of the TEP process involves selecting the best option and developing a plan for implementing the new transmission infrastructure. This includes securing the necessary permits and approvals, designing the transmission lines and substations, and constructing and commissioning the new infrastructure.

TEP is a critical process for ensuring the reliable and cost-effective delivery of electricity to consumers. It requires careful consideration of a range of technical, economic, environmental, and social factors to determine the optimal approach to expanding the transmission system.

Review of Current TEP Models

There are various TEP models used by power system planners and researchers to plan and analyze the expansion of the electric power transmission system [6, 7]. Some of the current TEP models include:

- Linear Programming (LP) - LP is a mathematical optimization technique used to identify the optimal transmission expansion plan based on a set of constraints and objectives.
- Mixed Integer Linear Programming (MILP) - MILP is an extension of LP that allows for binary decision variables, which enables more complex decision-making [8, 9].
- Nonlinear Programming (NLP) - NLP is used when the transmission expansion problem involves non-linear relationships between the decision variables and the objective function [10].
- Dynamic Programming (DP) - DP is a mathematical optimization technique that considers the time-varying behavior of the power system to determine the optimal transmission expansion plan [11].
- Heuristic and meta-heuristic methods - These methods include algorithms such as genetic algorithms, simulated annealing, and ant colony optimization, which are used to find good solutions to complex TEP problems in a reasonable amount of time [11, 12].

Each TEP model has its advantages and disadvantages, and the choice of model depends on the specific needs and constraints of the power system planning problem at hand. Some of the its advantages and disadvantages are as follows:

1. Linear Programming (LP)

Advantages: LP is fast, efficient, and can handle large-scale problems. It is simple to implement and solve, and results are easy to interpret.

Disadvantages: LP cannot handle non-linear relationships between variables, assumes that the objective function and constraints are linear and static, and may not provide the best solution for complex problems.

2. Mixed Integer Linear Programming (MILP)

Advantages: MILP can handle binary decision variables, allowing for more complex decision-making. It is more flexible than LP and can handle large-scale problems [2, 13-15].

Disadvantages: MILP is more computationally complex than LP, may not find the optimal solution for complex problems, and results can be difficult to interpret [16].

3. Nonlinear Programming (NLP)

Advantages: NLP can handle non-linear relationships between variables, is more flexible than LP, and can handle complex problems.

Disadvantages: NLP is more computationally complex than LP, may not find the optimal solution for complex problems, and results can be difficult to interpret [14, 17].

4. Dynamic Programming (DP)

Advantages: DP can handle time-varying behavior of the power system, can handle complex problems, and results can be easily interpreted [11, 18, 19].

Disadvantages: DP can be computationally intensive, assumes complete knowledge of future system states, and may not find the optimal solution for complex problems.

5. Heuristic and meta-heuristic methods

Advantages: Heuristic and meta-heuristic methods can handle complex problems, do not require complete knowledge of the system, and can find good solutions in a reasonable amount of time.

Disadvantages: Heuristic and meta-heuristic methods may not find the optimal solution, results can be difficult to interpret, and may require extensive tuning of parameters to achieve good results.

It is important to evaluate the advantages and disadvantages of each TEP model carefully to select the best one for the specific power system planning problem at hand [20].

Summary and Conclusion

Electric power transmission expansion planning (TEP) is a critical process that involves determining the most cost-effective way to expand the transmission network to meet the growing demand for electricity while ensuring reliability and stability. TEP models are mathematical models that help power system planners make informed decisions about how to expand the transmission network by optimizing various factors, such as the cost of expansion, the reliability of the system, and the overall performance of the power grid.

There are several TEP models available, each with its own advantages and disadvantages. Linear Programming (LP) is a commonly used TEP model that is fast, efficient, and can handle large-scale problems. However, it cannot handle non-linear relationships between variables and may not provide the best solution for complex problems. On the other hand, Mixed Integer Linear Programming (MILP) is more flexible than LP and can handle binary decision variables, but it is more computationally complex and may not find the optimal solution for complex problems.

Nonlinear Programming (NLP) is another TEP model that can handle non-linear relationships between variables and is more flexible than LP. However, like MILP, it is more computationally complex and may not find the optimal solution for complex problems. Dynamic Programming (DP) is a TEP model that can handle time-varying behavior of the power system and can handle complex problems. However, it can be computationally intensive and assumes complete knowledge of future system states. Finally, heuristic and meta-heuristic methods are TEP models that can handle complex problems, do not require complete knowledge of the system, and can find good solutions in a reasonable amount of time. However, they may not find the optimal solution, and results can be difficult to interpret.

Overall, the choice of TEP model depends on the specific needs and constraints of the power system planning problem at hand, and a careful evaluation of the advantages and disadvantages of each model should be made to select the one that is best suited for the problem being solved.

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