# Determining the Planning Period of a Distribution Substation Based on Acceptable Errors

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***Abstract*—The distribution substation planning is faced with numerous uncertainties so that the planning result can only be a "rough outline," and the problem of determining the planning period arises. On the basis of the assessment of uncertainties in distribution planning, a specific approach to determine the planning period of a distribution substation based on acceptable errors is proposed, indicating that the load forecast error is the key factor to affect the planning period. In order to provide a clearer understanding of this paper's primary objective, the proposed approach is applied to determining the planning period of a power supply radius optimization (PSRO) model in distribution substation planning. Finally, an example is illustrated which validates the suggested approach of this paper.**

***Index Terms*—Acceptable error, distribution substation planning, load forecast error, planning period, power supply radius optimization.**

## I. INTRODUCTION

DURING the distribution substation planning stage, there are various uncertainties in planning, no matter if it is for short term planning, mid-long term planning or for rolling planning, which results in the planning scheme often being very different from the practical network. Thus, the distribution planning is based on principle, and these principles need to be demonstrated in a technological and economical way and also need to include some optimization. Generally speaking, the planning principles can be a "rough outline," rather than refined, which is a specific embodiment affected by the various uncertainties. Therefore, the existing distribution planning principles still have some ambiguity, which make them incomplete for the requirements of the smart grid planning system.

On the other hand, the principle of planning is such an important consideration that many electric utilities in China (including State Grid Corporation of China) [1], [2] have formulated distribution planning guidelines. And these guidelines need to be demonstrated using technology-economical evaluation methods, so that they can be regarded as the "principles" of distribution planning.

As aforementioned, for both distribution network structure planning and distribution substation planning, the main task is to evaluate the distribution network performance based on the forecasted information. And the mathematical models of planning including the different types of optimization models of which most of the early models in literature are deterministic models aiming to obtain the optimal economy subject to security and reliability constraints [3]–[5] while a great many models considering uncertainties have blossomed in recent years such as stochastic models and robust models [6]–[12]. After the optimization models are solved by means of Benders decomposition [13], [14] or various artificial intelligence algorithms [15]–[18], etc., the optimal solutions can be used as the principles for the implementation of planning schemes.

However, a common question in engineering practice is how to determine the planning period for the planning of the network frame and substations. And this involves at least two different aspects: 1) The determination of the planning period should consider the errors caused by uncertainties and the need to be coordinated with planning contents such as selection of the voltage level and power supply mode. 2) The investment and operational cost and benefit makes a significant difference for the planning period as it reflects the economy of the planning process.

From the perspective of system level, distribution network planning usually contains the planning for sub-transmission, distribution substation, feeder systems and so on. The typical planning period is shown in Table I [19].

TABLE I
TYPICAL DISTRIBUTION NETWORK PLANNING PERIOD

| System Level | Planning Period (year) | |
|---|---|---|
| | Short-term | Long-term |
| Sub-transmission | 6 | 20 |
| Distribution substation | 6 | 20 |
| Feeder system | 6 | 20 |
| Primary three phase feeders | 4 | 12 |
| Laterals and small feeder segments | 1 | 4 |
| Service transformers and secondary | 0.5 | 2 |

The planning period illustrated in Table I is determined according to the planning guidelines or engineering experience in conventional distribution network planning which is usually inaccurate. And an unreasonable planning period may not be coordinated with other planning contents such as the selection of the voltage level. Specifically, too short a period will reduce

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the necessity of distribution planning, while if the period is excessively long it may cause unacceptable errors.

Considering there are few discussions on determining the planning period in the literature, the main contributions of this paper include: 1) A specific approach to determine the planning period of distribution substations based on acceptable error is proposed. 2) On the basis of evaluation of the uncertainties in distribution planning, with the load forecast error being the main influence on determination of the planning period compared with other errors.

This paper is organized as follows. Section II analyzes the uncertainties in the decision process of planning characterized by miscellaneous errors. Section III presents an estimation of the relative error for the economic function of the distribution substation planning. Section IV derives the planning period of general distribution substation planning based on acceptable errors. In Section V, the approach to determine the planning period of a distribution substation centered on a power supply radius optimization model is proposed. Section VI provides an example analysis. Finally, Section VII provides the conclusion.

## II. Uncertainties in the Decision Process of Planning

### A. Description of the Decision Process of Planning

Distribution substation planning is a process of making a decision as well as an optimization problem from the mathematical point of view, and it can be described as the following general model:

$$C = \min f(x) \\ \text{s.t.} \begin{cases} h(x) \geq P^{\mathrm{D}} \\ g(x) \geq 0 \end{cases} \tag{1}$$

where $x$ is the decision variable, and it can be the voltage level, power supply radius or the capacity of substations and so on; $f(x)$ is the objective function, and it denotes the investment cost and the operational cost of the distribution substation; $h(x)$ represents the inequality constraints of the power and energy balance, and $P^{\mathrm{D}}$ represents the predicted load; $g(x)$ represents the constraints of the security and reliability. And it should be pointed out that configuration of the distribution network and load flow equations are neglected for simplicity in (1).

### B. Errors in the Decision Process of Planning

The distribution substation planning is always faced with numerous uncertainties, and most of the uncertainties lie in the load forecast error. And the uncertainty of the price of electricity or power equipment is also noteworthy [20]. In addition, there is some errors between the mathematical model of the planning and the practical system.

There exists inevitable errors for any load forecast method, and the root cause of the error lies in different kinds of uncertainties that the distribution planning process must face. A large number of calculations show it is normal that there is some error between the forecast result and the actual value, but the error should not be too large. Generally speaking, the error of the short term load forecast should be less than 3%, and the error of the mid-term forecast should be around 5%, while the long term forecast error should be around 15% [21]. Thus, the load forecast error is closely related to the planning period, because the longer the planning period is, the more uncertainties the distribution planning process is faced with.

With regard to the investment and operational cost or the electricity price, there is inherent errors. The error of investment and operational cost is typically due to the approximation adopted by the various methods, and the error in the electricity price is attributed to unknowns in the power market.

In addition, although there are various mathematical models for the distribution planning, there exists errors between all of the models and the actual physical system. And the error of the algorithms to solve the models lies in their calculation accuracy.

## III. Estimation of the Relative Error

The investment and operational cost functions of the distribution substation can vary with the planning contents [22]–[24], and they are usually expressed as polynomial functions in general. In this paper, for the sake of analysis, the cost functions are approximately described as the form of the following quadratic function:

$$f(x) = ax^2 + bx + c + \varepsilon_{\mathrm{f}} \tag{2}$$

where $a$, $b$, and $c$ are the parameters such as the equipment cost and the electricity price, and these parameters contain some errors; $\varepsilon_{\mathrm{f}}$ is the residual error between the quadratic function and $f(x)$, and it contains errors caused by the uncertainty of $a$, $b$, and $c$; if the error of the parameters $a$, $b$, and $c$ is not included, $\varepsilon_{\mathrm{f}}$ is the sum of the Taylor expansion terms of $f(x)$ which is higher than the second order.

In order to simplify the mathematical model, linearize the inequality constraints:

$$h(x) = dx + e + \varepsilon_{\mathrm{h}} \geq P^{\mathrm{D}} + \varepsilon_{\mathrm{p}} \tag{3}$$

$$g(x) = wx + q + \varepsilon_{\mathrm{g}} \geq 0 \tag{4}$$

where $\varepsilon_{\mathrm{h}}$, $\varepsilon_{\mathrm{g}}$, and $\varepsilon_{\mathrm{p}}$ respectively denotes the error of inequality constraints and load forecast; if the deviation of parameters is not considered, $\varepsilon_{\mathrm{h}}$ and $\varepsilon_{\mathrm{g}}$ are respectively the sum of the Taylor expansion terms of $h(x)$ and $g(x)$ which is higher than first order.

For the simplified planning model, the augmented Lagrange function is:

$$L = ax^2 + bx + c + \varepsilon_{\mathrm{f}} + \alpha(dx + e + \varepsilon_{\mathrm{h}} - P^{\mathrm{D}} - \varepsilon_{\mathrm{p}}) \\ + \beta(wx + q + \varepsilon_{\mathrm{g}}). \tag{5}$$

The Lagrange function can represent the economy of the whole decision process, so the error of the decision process of planning can be derived from the above equation:

$$\varepsilon = \varepsilon_{\mathrm{f}} + \alpha(\varepsilon_{\mathrm{h}} - \varepsilon_{\mathrm{p}}) + \beta\varepsilon_{\mathrm{g}}. \tag{6}$$

The relative error of cost functions can be expressed as:

$$\gamma = \frac{\varepsilon_{\mathrm{f}} + \alpha(\varepsilon_{\mathrm{h}} - \varepsilon_{\mathrm{p}}) + \beta\varepsilon_{\mathrm{g}}}{ax^2 + bx + c} \times 100\%. \tag{7}$$

When the linear inequality constraints (i.e. (3) and (4)) are effective, they can be converted to equality constraints, and the optimal model can be solved by means of the Lagrange multiplier method. For the augmented Lagrange function, i.e. (5), the Kuhn-Tucker conditions are:

$$\begin{cases} \dfrac{\partial L}{\partial x} = 2ax + b + \alpha d + \beta w = 0 \\ \dfrac{\partial L}{\partial \alpha} = dx + e + \varepsilon_{\mathrm{h}} = P^{\mathrm{D}} + \varepsilon_{\mathrm{p}} . \\ \dfrac{\partial L}{\partial \beta} = wx + q + \varepsilon_{\mathrm{g}} = 0 \end{cases} \tag{8}$$

And the solution is:

$$x^{(*)} = \arg\min f(x) \in \left\{ -\frac{b}{2a}, \frac{P^{\mathrm{D}} - e + (\varepsilon_{\mathrm{p}} - \varepsilon_{\mathrm{h}})}{d}, \frac{-(q + \varepsilon_{\mathrm{g}})}{w} \right\} \tag{9}$$

where the superscript $^{(*)}$ represents the optimal solution. And when the solution is $x^{(*)} = -\frac{b}{2a}$, we can get $\alpha^{(*)} = \beta^{(*)} = 0$; and in other situations, when $x^{(*)} = \frac{P^{\mathrm{D}} - e + (\varepsilon_{\mathrm{p}} - \varepsilon_{\mathrm{h}})}{d}$, we can get $\alpha^{(*)} = -\frac{2a(P^{\mathrm{D}} - e + \varepsilon_{\mathrm{p}} - \varepsilon_{\mathrm{h}}) + bd}{d^2}$, $\beta^{(*)} = 0$; and when $x^{(*)} = \frac{-(q + \varepsilon_{\mathrm{g}})}{w}$, we can obtain $\beta^{(*)} = \frac{2a(q + \varepsilon_{\mathrm{g}}) - bw}{w^2}$, $\alpha^{(*)} = 0$. Substitute the above optimal solution into (7), and we can obtain the value of the relative error.

## IV. Planning Period of Distribution Substation

### A. Acceptable Error

In the practical projects, the level of acceptable errors needs to be considered. For example, the error of the project investment estimation in China should be less than 30% during the planning stage [25], and that is:

$$\gamma = \frac{\varepsilon_{\mathrm{f}} + \alpha^{(*)}(\varepsilon_{\mathrm{h}} - \varepsilon_{\mathrm{p}}) + \beta^{(*)}\varepsilon_{\mathrm{g}}}{ax^{(*)2} + bx^{(*)} + c} \times 100\% \le \gamma_0 \tag{10}$$

where $\gamma_0$ represents the level of acceptable error, and it expresses the feasibility of project investment. If the error of the investment estimation of a project is too large, the feasibility of the project implementation is relatively poor. Therefore, the level of acceptable error is the key factor to determine the feasibility of a project.

### B. Planning Period

As above, after the functions $f(x)$, $h(x)$, and $g(x)$ are expanded in Taylor's series and they are made quadratic and linear respectively, the errors $\varepsilon_{\mathrm{f}}, \varepsilon_{\mathrm{h}}, \varepsilon_{\mathrm{g}}$ depend on $(x - x_0)$. The errors can be expressed in terms of the Lagrange remainder:

$$\begin{cases} \varepsilon_{\mathrm{f}} = \dfrac{f'''(\xi)}{6}(x - x_0)^3 \\ \varepsilon_{\mathrm{h}} = \dfrac{h''(\xi)}{2}(x - x_0)^2 \\ \varepsilon_{\mathrm{g}} = \dfrac{g''(\xi)}{2}(x - x_0)^2 \end{cases} \tag{11}$$

where $x_0 \le \xi \le x$. And when $x \to x_0$, the errors $\varepsilon_{\mathrm{f}}$, $\varepsilon_{\mathrm{h}}$, and $\varepsilon_{\mathrm{g}}$ can be considered as infinitesimal of a higher order than $(x - x_0)^n$. And since the condition $x \to x_0$ is always adopted, the errors $\varepsilon_{\mathrm{f}}$, $\varepsilon_{\mathrm{h}}$, and $\varepsilon_{\mathrm{g}}$ are ignored here, resulting in

$$\varepsilon = \varepsilon_{\mathrm{f}} + \alpha\left(\varepsilon_{\mathrm{h}} - \varepsilon_{\mathrm{p}}\right) + \beta\varepsilon_{\mathrm{g}} = -\alpha\varepsilon_{\mathrm{p}}. \tag{12}$$

Hence, compared with other kinds of errors, the load forecast error $\varepsilon_{\mathrm{p}}$ needs to be analyzed to determine the planning period according to (10).

Ignore the errors caused by the quadratic and linear form, and we can derive from (10):

$$2a\varepsilon_{\mathrm{p}}^2 + (2a(P^{\mathrm{D}} - e) + bd)\varepsilon_{\mathrm{p}} - \gamma_0(ax^{(*)2} + bx^{(*)} + c)d^2 = 0. \tag{13}$$

For convenience, let

$$v = 2a(P^{\mathrm{D}} - e) + bd. \tag{14}$$

Solve (13) in terms of $\varepsilon_{\mathrm{p}}$ being the unknown variable:

$$\varepsilon_{\mathrm{p}} = \left| \frac{-v \pm \sqrt{v^2 + 8a\gamma_0\left(ax^{(*)2} + bx^{(*)} + c\right)d^2}}{4a} \right| . \tag{15}$$

For the sign "±," the load forecast error $\varepsilon_{\mathrm{p}}$ with smaller absolute value is generally chosen as the final result.

Given that the desired value of the load forecast error is figured out in accordance with (15), the planning period can be determined provided the error characteristics of the load prediction methods are known. Actually, the load growth prediction methods can be classified into two types called analytical and global [26]. The global methods used in distribution substation planning include square function, exponential function, logistic function, etc. And the relationship between the prediction error and time of these methods can be obtained by applying the trend extrapolation method to the load forecast error.

Assuming the load forecast error has been expressed as the function of the planning period for a certain load forecast method:

$$\varepsilon_{\mathrm{p}} = u(t). \tag{16}$$

Therefore, the planning period of the distribution substation determined based on acceptable error can be calculated out in accordance with (16).

## V. Determining the Planning Period of a Power Supply Radius Optimization Model

The discussions from Section II to Section IV are based on general distribution substation planning aiming to determine the corresponding planning period. In order to provide a clearer understanding of this paper's primary objective, the general distribution substation planning model (i.e. formula (1)) is centered on a power supply radius optimization (PSRO) model which has been proposed by the authors in [27].

Distribution substation planning includes the planning for the number of main transformers, the capacity of main transformers and the power supply radius and so on. And the PSRO model is as follows when the number and the capacity of transformers are confirmed.

### A. Objective Function

The PSRO model contains six minimum objective functions involving the investment and operational annual cost for the substations.

*1) Investment Cost of the Substation*

$$C_1^{\mathrm{b}} = a_{\mathrm{b}0} + (a_{\mathrm{b}} + b_{\mathrm{b}}\Delta S)\, M \tag{17}$$

where $a_{\mathrm{b}0}$ is the fixed cost connected with the substation location, $a_{\mathrm{b}}$ is the fixed cost of each transformer, $b_{\mathrm{b}}$ is the cost coefficient connected with the capacity of the transformers and the higher the capacity is the larger the coefficient becomes, $\Delta S$ is the capacity of each main transformer, $M$ is the number of main transformers in each substation.

*2) Investment Cost of the Incoming Line*

$$C_1^{\mathrm{H}} = \left(a_{\mathrm{l}}^{\mathrm{H}} + 2b_{\mathrm{l}}^{\mathrm{H}} x\right) M \tag{18}$$

where $a_{\mathrm{l}}^{\mathrm{H}}$ is the fixed cost of each incoming line related to line corridors and intervals, $b_{\mathrm{l}}^{\mathrm{H}}$ is the investment cost per unit length of each incoming line, $x$ is the power supply radius of each substation.

*3) Investment Cost of the Outgoing Line*

$$C_1^{\mathrm{L}} = \left(a_{\mathrm{l}}^{\mathrm{L}} + b_{\mathrm{l}}^{\mathrm{L}} x\right) MN \tag{19}$$

where the parameters $a_{\mathrm{l}}^{\mathrm{L}}$ and $b_{\mathrm{l}}^{\mathrm{L}}$ are similar to the incoming line, and $N$ is the number of circuits of each outgoing line.

*4) Operational Annual Cost of the Transformer*

$$C_2^{\mathrm{b}} = \omega M \left( \frac{\Delta P_{\mathrm{d}} \pi^2 x^4 \sigma^2 \tau}{M^2 \Delta S^2 \cos^2 \varphi_{\mathrm{b}}} + \Delta P_0 T \right) \tag{20}$$

where $\omega$ is the electricity price, $\Delta P_{\mathrm{d}}$ is the load loss of each transformer, $\sigma$ is the average load density, $\tau$ is the maximum load equivalent hour, $\cos\varphi_{\mathrm{b}}$ is the power factor of the transformer, $\Delta P_0$ is the no-load loss of each transformer, and $T$ is the annual hours (8760 h).

*5) Operational Annual Cost of the Incoming Line*

$$C_2^{\mathrm{H}} = \frac{2\omega\pi^2 x^5 \sigma^2 r^{\mathrm{H}} \tau}{M \left(U_{\mathrm{N}}^{\mathrm{H}} \cos\varphi_{\mathrm{l}}^{\mathrm{H}}\right)^2} \tag{21}$$

where $r^{\mathrm{H}}$ is the equivalent resistance per unit length of each incoming line, $U_{\mathrm{N}}^{\mathrm{H}}$ is the voltage level of the incoming line, $\cos\varphi_{\mathrm{l}}^{\mathrm{H}}$ is the power factor of the incoming line.

*6) Operational Annual Cost of the Outgoing Line*

$$C_2^{\mathrm{L}} = \frac{\omega\pi^2 x^5 \sigma^2 r^{\mathrm{L}} \tau}{MN \left(U_{\mathrm{N}}^{\mathrm{L}} \cos\varphi_{\mathrm{l}}^{\mathrm{L}}\right)^2} \tag{22}$$

where $r^{\mathrm{L}}$, $U_{\mathrm{N}}^{\mathrm{L}}$ and $\cos\varphi_{\mathrm{l}}^{\mathrm{L}}$ are similar to the incoming line, and the assumption $\cos\varphi_{\mathrm{l}}^{\mathrm{H}} = \cos\varphi_{\mathrm{l}}^{\mathrm{L}} = \cos\varphi_{\mathrm{l}}$ is usually adopted.

If the total area of the planning district is $A$, the number of distribution substations to be built is $A/(\pi x^2)$. And in consideration of the fixed assets depreciation rate $\lambda$, the final objective function of the PSRO model is:

$$C = \frac{A}{\pi x^2} \left[ \lambda \left( C_1^{\mathrm{b}} + C_1^{\mathrm{H}} + C_1^{\mathrm{L}} \right) + C_2^{\mathrm{b}} + C_2^{\mathrm{H}} + C_2^{\mathrm{L}} \right]. \tag{23}$$

### B. Inequality Constraint

The inequality constraint is mainly the constraint for the transformer capacity which should satisfy the $N-1$ principle:

$$\frac{\sigma\pi x^2}{(M-1)\cos\varphi_{\mathrm{b}}} \leq \Delta S \tag{24}$$

where the average load density $\sigma$ can be expressed as:

$$\sigma = \frac{P^{\mathrm{D}} + \varepsilon_{\mathrm{p}}}{A}. \tag{25}$$

Equation (25) indicates that the inequality constraint contains the predicted load and it can be converted into the form as inequality (3).

From the above, the planning period of the PSRO model composed of (23) and (24) in distribution substation planning can be determined immediately by means of the proposed approach from Section II to Section IV.

## VI. Example Analysis

Take an industrial district in Shanghai for example, and it covers an area of 16 km$^2$. The predicted load in this district is 624.5 MW. It is necessary to build some 35 kV distribution substations and to optimize the power supply radius of each substation. The purpose of this example analysis is to determine the period for planning these distribution substations.

For each substation, it contains 3 main transformers with the capacity of 31.5 MVA individually, and YJV22-1×630 cables with the resistance of 0.028 Ω/km are used as 35 kV incoming lines while YJV22-3×400 cables with the resistance of 0.047 Ω/km are chosen as 10 kV outgoing lines. The investment cost of the main electrical equipment is shown in Table II.

TABLE II
Investment Cost of Electrical Equipment for 35 kV Distribution Substations

| Electrical Equipment | Apparatus Type | Investment Cost |
|---|---|---|
| Main transformers | 3×31.5 MVA | \$24,000/MVA |
| 35 kV incoming cables | YJV22-1×630 | \$300,000/km |
| 10 kV outgoing cables | YJV22-3×400 | \$200,000/km |

And the loss of every transformer is respectively $\Delta P_{\mathrm{d}} = 145$ kW, $\Delta P_0 = 28$ kW. The power factor of the transformer and the lines is cos $\varphi_{\mathrm{b}} = \cos\varphi_{\mathrm{l}} = 0.95$. The circuits number of outgoing lines is $N = 5$. Other parameters include the maximum load equivalent hour $\tau = 6000$ h, the electricity price $\omega =$ \$0.13/kWh, and the fixed assets depreciation rate $\lambda = 2.5\%$.

According to the above parameters and Section V, the optimal model for power supply radius planning is:

$$\min f(x) = \min \left[ \frac{16}{\pi x^2} \left( 60.52x^5 + 63.3x^4 + 12x + 15.42 \right) \right]$$
$$\text{s.t.} \quad h(x) = \frac{304.81}{x^2} \geq P^{\mathrm{D}} + \varepsilon_{\mathrm{p}}.$$

In order to make the above model correspond to the expression forms in Section III, we need to deal with the objective function and inequality constraint respectively.

Since $f(x)$ is composed of different power functions, it can be converted into a quadratic function as (2) by means of curve fitting:

$$f(x) \approx 2035.5x^2 - 3261.38x + 2044.17 + \varepsilon_{\mathrm{f}}.$$

The comparison between the primitive objective function and the fitting objective function is shown in Fig. 1.

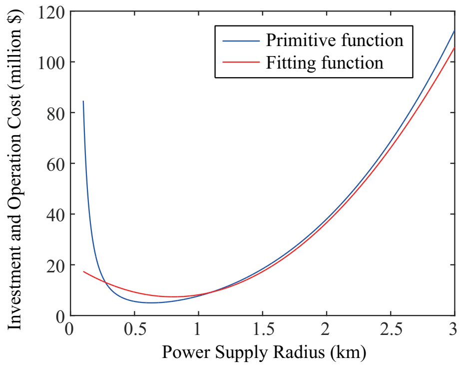


Fig. 1. Comparison between the primitive objective function and the fitting objective function.

In general, the power supply radius of each substation should be at least 0.2 km, i.e., the situation of $x < 0.2$ km does not need to be considered. Hence, the fitting function matches the primitive function very well in Fig. 1.

With regard to the inequality constraint, $h(x)$ can be expanded in Taylor's series at $x = 2$ in that 2 km is the typical power supply radius:

$$h(x) = -76.2x + 228.61 + \varepsilon_{\mathrm{h}}.$$

When the acceptable error of project investment estimation is set to be 15%, the load forecast error can be immediately calculated through (15):

$$\varepsilon_{\mathrm{p}} = 18.64\%.$$

In addition, the relationship between the load forecast error and the time by years for the adoptive prediction method is shown in Fig. 2.

In viewing Fig. 2, we can determine the planning period:

$$t = 17 \text{ years}.$$

And the result implies that if the planning period is set to be more than 17 years, the error of project investment estimation would exceed 15% which is not acceptable.

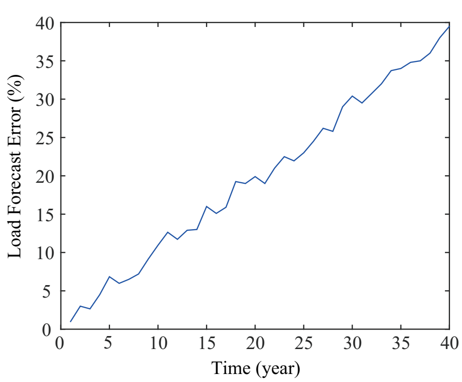


Fig. 2. Load forecast error over time.

## VII. Conclusion

Distribution substation planning is always faced with numerous uncertainties, and the determination of the planning period is closely related to these uncertainties. This paper analyzes the mathematical model of the decision process of distribution planning and takes the error of project investment estimation as an acceptable error to determine the planning period. The conclusions are as follows:

1) In conventional methods, the planning period is determined in terms of the guidelines of planning causing a rough result. While this paper proposes a specific approach to determine the planning period of a distribution substation based on acceptable errors.
2) Among the miscellaneous errors caused by uncertainties, the load forecast error is the main influence on determination of the planning period.
3) In order to improve the accuracy of the proposed approach, the error characteristics of the load prediction methods need to be studied through in-depth analysis.
4) In this paper, the proposed approach is applied to determine the planning period of the PSRO model. With respect to other optimization models in distribution substation planning or distribution network planning, because the decision variables usually contain some discrete variables and the state variables often include multidimensional vectors, the desired value of the load forecast error is no more a simple expression as (15), and in other words, the proposed approach needs further enhancement and enrichment.

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