Research on assessment method of cascading hazard to substation by earthquake damage

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Abstract. This authors of this article analyze the characteristics and influencing factors of cascading hazard to substation, try to provide classification standard for hazard level of damage to substation, introduce hazard index, and explanatory establish the method for rapid assessment of hazard level when substation suffers from earthquake damage considering earthquake damage, electricity load and voltage level as hazard factors. Then trial calculation of cascading hazard is carried out based on the data about damage to substations by Wenchuan Earthquake in 2008. The calculation result shows that this method has certain reliability and relatively strong operability, thus it can be used as reference for rapid assessment of cascading hazard situation of district electric power users caused by earthquake damage to substation and to determination of urgent and key targets of emergency rescue during earthquake.

1. Introduction
Cascading hazard due to earthquake damage to substation refers to impact and loss to national security, emergency rescue, post-disaster, social stability, economic development and people’s production and life and their living environment, caused by functional failure of substation, reduction of power supply load of power grid or power blackout within a district due to damage by earthquake.

There are many of cases of such hazard caused by earthquake. The relatively large losses suffered by manufacturers in Taichung Processing & Export Zone due to Taiwan Chi-Chi Earthquake in 1999 (Mr 7.3) were not directly caused by loss of workshop and equipment brought by the earthquake, but yield loss caused by power blackout and contract fines and reduction of foreign orders caused by delayed delivery. In addition, highly-precise and sterile environment in the high-tech workshops of Hsinchu Science Park was damaged due to lack of electric power supply for a long time, thus production could not be resumed within a short period of time. It can be seen that power blackout is fatal to high-tech industry[1]. After Wenchuan Earthquake happened in 2008, the reactor cooling system of Japan’s Fukushima Daiichi Nuclear Plant lost electric power supply due to earthquake tsunami, causing serious nuclear leakage. Consequently, hundreds of people suffered from serious nuclear radiation and radioactive contaminants spread within Japan and even larger area through air and sea water, causing considerable damage to the ecological environment of Japan and long-term influence on marine biological and ecological system and even the health of human beings as well[3].
The severity of the above cascading hazard makes people realize that social and economic losses, environmental damage and personnel casualties and injury and other cascading hazard situation that may be caused by power blackout should also be assessed besides direct physical damage and functional failure during the assessment of post-disaster situation of substation. At present, research on post-earthquake disaster situation of lifeline system is mainly focused on such aspects as the destruction of every subsystem, interdependence and interaction of these subsystem, and economic loss caused by functional disruption. Li Jie (1991) put forward the concept of composite lifeline systems and studied the interaction among lifeline systems through simulation of dynamic process[4]; Tang Aiping studied the characteristics of earthquake damage to lifeline system after earthquake, hazard and influence on emergency response[5]; Guo Endong once studied rapid assessment of losses of lifeline system caused by earthquake damage[6]. Shinozuka linked physical damage model and economic loss evaluation model of electric power system with geographic information system (GIS)[7]; Wen Ruizhi and Yao Baohua studied the coupling effect among lifelines system and its influence[8][9]. Takao Adachi made systematic analysis of the interdependence among lifeline systems and divided it into four categories, respectively physical, geographical, and logical interdependence[10]; Kanoknart Leelardcharoen established the interdependent and response model of electric power system and communication system after the occurrence of a devastating earthquake by the method of probability quantizing, and put forward the method of considering interdependence among systems when making vulnerability analysis of single lifeline system[11]. Applied Technical Committee (ATC) of the United States studied direct and indirect economic losses caused by function failure of lifeline system by the method of expert questionnaire as early as 1991[12].

To sum up, the previous research was focused on such aspects as earthquake damage and economic loss, but there’s few research on the form, factor and degree of cascading hazard by earthquake damage and corresponding assessment index and other aspects. However, after an earthquake happens, it is necessary to assess the severity of hazard to substation after damage occurred so as to determine urgent and key targets that require rescue and preservation and send rescue force satisfying rescue requirements. Therefore, this article carried out preliminary exploration of issues related to cascading hazard to substation by earthquake damage and established a framework for rapid assessment of cascading hazard level for providing technical support for meeting the governmental need of grasping the disaster situation in disaster-stricken area and formulating disaster relief programs in the first time after the occurrence of an earthquake.

2. Cascading Hazard of Functional Failure of Substation

Hazard to substation by earthquake includes not just economic losses caused by physical damage to the facilities within the substation, but more importantly, functional failure of the substation leading to cascading hazard to district users due to power blackout. Once the function of substation fails, all users of downstream service area will suffer from power blackout, which means cascading hazards can impact the entire scope of power blackout. The main cascading hazards are as follows:

(1) Resulting in functional disaster spreading of other lifeline systems. The functional status of electric power system as an important power support for other lifeline subsystem will significantly affect the function of other subsystems even if other subsystems have no physical damage themselves. For example, power blackout after the occurrence of Loma Prieta Earthquake in 1989 led to cutting off of large-scale water supply and decline of the capability of water drainage system, traffic congestion of highway system due to failure of signal lamp, reduction of number of stops at stations by urban subway due to shortage of electric power, the decrease of communication capacity in some areas caused by damage to electric power[13].

(2) Restricting the efficiency of earthquake rescue, disaster relief and reconstruction work seriously. The emergency response experience accumulated during Wenchuan Earthquake (2008) and other earthquakes shows that lack of the support of electric power can make emergency command and dispatch, rescue and treatment of the wounded, allocation of disaster relief materials, pacification and resettlement of disaster-stricken victims, emergency rehabilitation of destructed infrastructure very difficult, and even result in that part of the work cannot be continued, thus delaying rescue and further exacerbating the disaster of earthquake. During the work of recovery and reconstruction, large cities
with developed economy and culture and large population have larger demand of electric power for restoring people’s normal life as well as production and construction, therefore the impact of lack of electric power supply is more serious.

(3) Significant impact on society, people, politics and economy. Long-time and large-scale power blackout will not only cause the disorder of social life and production but also cause personnel casualties and injury to the electric load of underground mines, operation room of hospitals, lift well of high-rise buildings that require ventilation, and even may cause social unrest. For example, after the occurrence of Tangshan Earthquake in 1976, Chi-Chi Earthquake in 1999 as well as Loma Prieta Earthquake in 1989, there were various kinds of illegal and undisciplined behaviours such as spreading rumors, price gouging, robbery and theft, which aggravated public panic and endangered social stability. Disruption of power supply will also result in varying degrees of economic losses. For example, sudden power blackout may cause damage to electric equipment, a large number of scrapped products, and the disruption of continuous production process of key enterprises in the national economy which takes a long time to be recovered, etc.

(4) Causing secondary disasters, damaging human survivable environment. There have been many records of poisoning, fire and explosion, and environmental pollution and other hazards occurring in power blackout area and its surroundings after earthquakes such as Hanshin Earthquake in 1995 and East Japan Earthquake in 2011, etc. sudden blackout of electric power due to earthquake can also cause the shutdown of sewage treatment plant, tailing pond and solid waste disposal facilities, therefore sewage was discharged directly and tailing dreg, solid waste and medical waste not treated timely, resulting in pollution of soil, rivers, reservoirs, etc.

3. Main Influencing Factors of Cascading Hazard Degree

The degree of cascading hazard is determined comprehensively by function status of the substation itself as well as the influence on the function of downstream users. After analysis, influencing factors that can be summarized include the degree of earthquake damage to substation, voltage level and highest load level of electric power users and emergency and recovery capability of substation, anti-seismic engineering capability, emergency defense capability and political status of electric power users; in addition, economic development, population distribution and geographical environment and other factors within the substation area can also affect the degree of hazard, but the most important ones are the following three factors.

(1) The degree of earthquake damage to substation. If there’s no earthquake damage to the substation, then there’s no cascading hazard. If earthquake damage is severer, the power loss of transmission and transformation is higher, the scope impacted by power blackout wider and repair time longer in general. Although some important electric power users may have dual power supply or their own power supply, but this can only deal with power blackout for a short period of time, the cascading hazard brought by the overlaying of such sudden power blackout and power blackout for a long time is inevitably more serious. Therefore, the degree of earthquake damage to substation basically determines the degree of hazard.

(2) Substation voltage level (SV). Although substations of the same voltage level may have different status in the electric power system, but in general, if SV is higher, then the substation is more important in the system and the impact of its power blackout on the system is greater. The important level of substation is determined by voltage level firstly for further determination of anti-seismic design of different levels in anti-seismic design codes for power facilities in China. Hub substation occupies central status in the power grid system. Currently, its voltage level is 500kv and above, 330kv and 220kv, and has ultra-high voltage DC transmission line, etc. Power blackout of the whole substation of this kind is likely to cause splitting or paralysis of the system. Intermediate substation is generally located at the interface of high and ultra-high voltage main loop line or trunk line of the system. Its voltage level is generally 220kv and 330kv and power blackout of the whole substation will cause the splitting of power grid within an area and affect power supply within the entire area. District substation mainly supplies power to its district. Its voltage level is generally 110kv and 220kv and power blackout of the whole substation will cause the power blackout within its power supply district. Terminal substation is located at the terminal of electric power transmission line and supplies
power to users directly. Its voltage level is mainly 110kv and 35kv, and power blackout of the whole substation will only cause power blackout to terminal users within the district [14]. In addition, the current power supply range of 10kvis 10km, 20-50km for 35kv, 30-100km for 66kv, 50-150km for 110kv, 100-300km for 220kv, 200-600km for 330kv, and 150-850km for 500kv [15]. Therefore, the voltage level of substation determines power supply range directly which further determines the range of impact after power blackout.

### Table 1. Electric power load classification and blackout hazards

| Load Level | Standard Definition | Load Example | Blackout Hazard |
|------------|----------------------|--------------|-----------------|
| Load 1 (LD₁) | It shall be classified as LD₁ in case of compliance with one of the following circumstances: 1. when disruption of power supply can cause personal casualty and injury. 2. when disruption of power supply will cause significant losses in terms of politics and economy. 3. when disruption of power supply can affect the normal work of power consumption units that has great political and economic significance. 4. when there’s in LD₂ such load as may cause poisoning, explosion, fire and other conditions if power supply is disrupted, or load in particularly important places power supply to which is not allowed to be disrupted, and these load shall be regarded as particularly important load. | Important electric power loads in party and government organizations, important transportation hubs, important communication hubs, large stadiums, shopping malls, public places often used for international activities with a large number of people, steelmaking furnace of steelmaking plant, underground mines involved by high-risk enterprises, important urban public service industries such as schools and hospitals and other power consumption units. Disruption of power supply will cause damage to important equipment, scrapping of large number of products produced with important raw materials, and disruption of continuous production process of key enterprises in the national economy which takes a long time to be recovered. | Personal injury, significant economic loss, significant political influence, environment disruption, disorder of social order, and dysfunction of other lifeline systems |
| Load 2 (LD₂) | It shall be classified as LD₂ in case of compliance with one of the following circumstances: 1. when disruption of power supply will cause relatively significant losses in terms of politics and economy. 2. when disruption of power supply can affect the normal work of important power consumption units. | Important electric power load in transportation hubs, communication hubs and other power consumption units, and the disruption of power supply will cause disorder of large theaters, large shopping malls and other important public places where a relatively large number of people gather. Such electric power loads as factories, large towns and rural irrigation stations, and loss of electric power supply will cause damage to main equipment, scrapping of large number of products, disruption of continuous production process which takes a long time to be recovered, and significant reduction of production by key enterprises. | Relatively large economic loss, relatively great political influence, social disorder, and dysfunction of other lifeline systems |
| Load 3 (LD₃) | Those loads cannot be classified into LD₁ and LD₂ should be LD₃. Such loads as factory-affiliated workshops, small towns, power consumption by rural residents. | | Inconvenience to the life of residents and likely to cause a certain degree of social disorder |
(3) Load level of electric power user. As per Design Code For Power Supply And Distribution System (GB50052-95)[16], the load level of electric power users can be classified into three kinds in accordance with the degree of effect caused by sudden disruption of power supply, respectively Load 1 (LD1), Load 2 (LD2) and Load 3 (LD3), from high to low. Detailed definitions and hazard of power blackout are shown in table 1.

It can be seen from table 1 that if LDj is higher, then security and stability requirements of power supply is higher and cascading hazard during sudden and long-time power blackout is more serious. In addition, LDj can also indirectly reflect economic development condition, political impact on national level, population distribution status and other factors of power grid service area. Therefore, the highest load level of electric power users (LDj, j=1,2, 3) within the district is adopted by this article to represent the most important electric load and potential object suffering from maximum hazard during power blackout among downstream users within the district of the substation. For example, if the power supply of two substations with the same voltage level and damage degree, one responsible for electric power supply to steelmaking furnaces of steelmaking plants of LD1 and the other one responsible for electric power supply to ordinary residents of LD3, are cut off for one hour after the occurrence of earthquake, it’s obvious that cascading hazard to the former one is more serious than that to the latter one because steelmaking furnaces are scrapped after power blackout for thirty minutes, thus the former one is the key target of emergency rescue determined after rapid assessment.

4. Hazard Level and Hazard Index of Substation

4.1. Classification of Hazard Level

In order to evaluate the degree of hazard due to power failure of the substation, hazard must be classified firstly. There’s few domestic or abroad research in this aspect so far. In order to express the degree of hazard, hazard status is divided into four levels, namely, particularly severe hazard (level I), severe hazard (level II), moderate hazard (level III) and slight hazard (level IV). The status description of these level considers several aspects comprehensively, i.e. the length of influence time by hazard, influence on the function of other lifeline subsystems, influence on economic loss, political stability and social order and loss degree of ecological environment and public life and property, as shown in table 2.

| Hazard Level                  | Description of Hazard Status                                                                                                                                                                                                 |
|------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Level I (particularly severe hazard) | Power supply function is lost completely. Long-time and large-scale power blackout can cause functional disaster spreading of other lifeline systems, particularly adverse effect on emergency rescue work during earthquake rescue and disaster relief, personnel casualty and injury, destruction of ecological environment within a wide range, extraordinarily serious economic losses, and affect political stability and social order extremely seriously. |
| Level II (severe hazard)      | It takes a few days to for power supply function to be resumed. Large-scale power blackout can cause functional disaster spreading of other lifeline systems, a few personnel casualties and injuries and influence on surrounding environment, serious economic losses, serious restriction on earthquake relief work, and significant impact on political stability and social order. |
| Level III (moderate hazard)   | Power supply function is affected to certain degree. Power blackout may occur in some areas and usually can be resumed within a few days. It can cause functional disaster spreading of other relevant lifeline systems, certain influence on surrounding environment, moderate economic losses, unfavorable to the implementation of earthquake rescuer and disaster relief work and have certain impact on social stability. |
| Level IV (slight hazard)      | Power supply function is not affected or short-term power blackout may occur in some areas. May cause minor personnel injury, a few users, minor economic losses and other minor cascading hazards.                                                                                   |
4.2. Hazard Index

In order to express the degree of hazard to substation by earthquake damage quantitatively, this article introduces hazard index (HI) and expresses hazard index quantitatively through mathematical expression of hazard influencing factor. As mentioned in the third section, there are many factors that influence the degree of hazard, but it can be measured by two indexes, i.e. the degree of earthquake damage to the substation and the importance degree of the substation. These two indexes belong to level 2 quantitative indexes. Among them, the importance of substation can be expressed by level 2 indexes of several factors.

4.2.1. Quantification of the Degree of Earthquake Damage

There was method for classifying functional failure of substation into four levels mainly according to power loss and resumption time in 1980s [17]. The national standard Classification of Earthquake Damage to Lifeline Project(GB/T24336-2009) specifies the principles and methods of classifying earthquake damage to lifeline projects including electric power facilities, and provides the standard for classifying earthquake damage to substation into five levels[18]for investigation into earthquake damage on site, assessment of loss due to earthquake, assessment of earthquake intensity, prediction of earthquake damage and engineering restoration, etc. Some scholars have established the FI-EDS[19] method for rapid assessment of earthquake damage to substation based on anti-seismic fortification intensity and statistics of earthquake damage after analysis of the characteristics and mode of earthquake damage and functional failure of substation in different intensity areas based on statistics of damage situation, shutdown situation and resumption time of substations within various intensity areas of Wenchuan Earthquake, and proposed earthquake damage index of substation $D_i$ considering the kind and number of damaged substation equipment as assessment index of the degree of damage to substation. This article utilizes $D_i$ as quantitative index for expressing earthquake damage to substation.

4.2.2. Importance Degree of Substation

The importance of substation depends on the status of substation in the system and power load level within substation district.

As discussed in the third section, if substation voltage level SV is higher, then it’s more important is in the system, so voltage level of the substation can be regarded as a quantitative index of the importance of substation by defining the system status coefficient (SP) of substation. Corresponding experience reference value of SP and SV is shown in table 3.

| Voltage Level (SV) | System Status Coefficient (SP) |
|-------------------|--------------------------------|
| lower than 60kv   | 0.30                           |
| 110kv-220kv       | 0.60                           |
| 330kv-500kv       | 0.85                           |
| higher than 500kv | 1.00                           |

As discussed in the third section of this article, electric power load can be classified into $LD_1$, $LD_2$ and $LD_3$ according to reliability requirement of electric power load and the degree of political, economic and other damage and influence caused by disruption of power supply, as shown in table 1. The hazards to various electric power loads by loss of power supply is shown in below figure 1.
The meaning of symbols in figure 1: C1- personal casualty and injury; C2- economic loss; C3- political impact; C4- environmental damage; C5- inconvenience to life of residents and social disorder to a certain degree; C6- dysfunction of other lifeline systems.

According to the hazard situation of the above various electric power loads caused by loss of power supply, the proposed value of load coefficient of three load levels by quantification method is proposed to be as follows: $LD_1 = 0.85; LD_2 = 0.6; LD_3 = 0.3$.

The importance of substation can be expressed by important coefficient $\eta$. The larger importance coefficient is, the more important substation is. The valuing method of importance is shown in formula (1).

$$\eta = \max \{ SP, LD \} \quad (1)$$

In formula (1), $\eta$ stands for substation importance coefficient, $SP$ for substation status coefficient and $LD$ for the highest load level, the highest among the load levels of electric power users ($LD_j, j=1, 2, 3$) within the district, standing for the most important electric load and potential object suffering from maximum hazard during power blackout. The formula (1) shows that the values of $SP$ and $LD$ exert important influence on the degree of earthquake damage. Importance degree shall be the larger value of $SP$ and $LD$, which means that the higher the status of substation in power transmission system is, the more important it is. When its status in power transmission system is relatively low, the importance degree of substation can still be very high if there’s important user load.

4.2.3. Calculation Method of Hazard Index

For the substation with a certain importance factor, when earthquake damage increases, functional failure situation is more serious and the degree of cascading hazard to substation also increases; on the other hand, if earthquake damage is relatively slight or there’s no earthquake damage at all, then cascading hazard to substation is relatively slight or there’s no cascading hazard at all. Similarly, for the substation suffering from certain earthquake damage, if the substation is more important, then cascading hazard to it is more serious. Therefore, cascading hazard index of earthquake to substation can be expressed quantitatively by the mathematical relationship of quantitative index of the degree of earthquake damage to substation (earthquake damage index) and quantitative index of the importance degree of substation (importance index), and the two indexes have synergistic effect. Therefore, cascading hazard of the substation can be expressed by formula (2):

$$HI = D_i \times \eta \quad (2)$$

In the formula (2), $HI$ is cascading hazard index of earthquake to substation, $HI \in [0, 1]$; $D_i$ is earthquake damage index to substation[19]; and $\eta$ is importance degree coefficient of the substation.

A relatively reasonable corresponding relationship between value range of substation hazard index and cascading hazard level is determined as shown in table 4 according to the trial calculation value of hazard index in the formula (2) and in combination with the classification of cascading hazard as shown in table 1.

| Hazard Level          | Value Range of Hazard Index ($HI$) |
|----------------------|-----------------------------------|
| Level I (particularly severe hazard) | $0.6 < HI \leq 1.0$ |
| Level II (severe hazard)        | $0.3 < HI \leq 0.6$ |
| Level III (moderate hazard)     | $0.2 < HI \leq 0.3$ |
| Level IV (slight hazard)        | $HI \leq 0.2$ |

Distribution diagram of the levels of different hazards to substation with the two parameters $D_i$ and $\eta$ taken as horizontal and vertical coordinate respectively as shown in figure 2 can be drawn according to formula (2) and table 3. After earthquake damage index and importance coefficient of the substation are determined, the level of cascading hazard to the substation by earthquake damage can be seen from figure 2 easily and visually.
5. **Rapid Assessment Flow of Cascading Hazard**

Rapid assessment of cascading hazard refers to the assessment of the hazards that have occurred or may occur but not necessarily, made immediately after the occurrence of earthquake and within the “black box” period of earthquake damage information according to basic information that is limited but has significant influence on assessment targets. This assessment is based on the principle of judging hazards within the period of emergency response to earthquake as simple and rapid as possible. Assessment flow of the level of cascading hazard to substation based on three basic hazard factors that can be obtained easily, i.e. $D_i$, $SP$ and $LD$, is shown in figure 3.

In the flow chart, the method for determining earthquake damage index of the substation $D_i$ has already been discussed in detail in the literature [19]. In addition, system status coefficient $SP$ and load level coefficient $LD$ of the substation usually cannot be obtained at the same time during the determination of importance coefficient. When only one of them is clear, single-condition coefficient can also be used for judgment. In general, voltage level is easier to be obtained when carrying out work on emergency response site in case of earthquake.

![Flowchart](image)

**Figure 3. Rapid assessment flow of hazard**
6. Trial Calculation of the Degree of Cascading Hazard to Substation

Wenchuan Earthquake caused a lot of damages to the substation of state grid within Sichuan Province. Among them, the earthquake resulted in the shutdown of one 500kv substation, thirteen 220kv substations, two 220kv user stations and sixty-eight 110kv substations, voltage loss by 123 35kv substations and lose of load during earthquake up to 3,978,000KW. The earthquake mainly affected the power supply of Aba Prefecture, Chengdu City, Deyang City, Mianyang City, Guangyuan City and Bazhong City and resulted in power blackout in Mianzhu County in Deyang, Beichuan County, Jiangyou City, Santai County, Santai County and An County in Mianyang, Qingchuan County, Cangxi County, Wangcang County and Jiange County in Guangyuan City, Wenchuan County, Songpan County, Li County, Ruoergai County in Aba Prefecture, etc. Power supply for 4,050,700 users in total was affected. Large-scale power blackout led to the suspension or partial suspension of the production by several production enterprises, affected social and economic order seriously and caused huge direct and indirect economic losses due to earthquake damage [2].

| Substation Name       | Earthquake Damage Index | Earthquake Damage Level | System Status Coefficient | Load Coefficient | Important Coefficient | Hazard Index | Hazard Level |
|-----------------------|-------------------------|-------------------------|----------------------------|------------------|------------------------|--------------|--------------|
| 500kv Longwang Station | 0.20                    | LevelII                 | 0.85                       | 0.85             | 0.85                   | 0.17         | LevelIV      |
| 500kv Tanjiawan Station | 0.45                    | LevelIII                | 0.85                       | 0.60             | 0.85                   | 0.38         | LevelIII     |
| 220kv Yunxi Station   | 0.45                    | LevelIII                | 0.60                       | 0.60             | 0.60                   | 0.27         | LevelIII     |
| 220kv Xinshi Station  | 0.70                    | LevelIV                 | 0.60                       | 0.60             | 0.60                   | 0.42         | LevelIII     |
| 220kv Bohe Station    | 0.20                    | LevelII                 | 0.60                       | 0.85             | 0.85                   | 0.17         | LevelIV      |
| 110kv Tianyu Station  | 0.45                    | LevelIII                | 0.60                       | 0.60             | 0.60                   | 0.27         | LevelIII     |
| 110kv Chuanxindian Station | 1.0                    | Level V                 | 0.60                       | 0.60             | 0.60                   | 0.60         | LevelV       |
| 110kv Xiilukou Station | 0.70                    | LevelIV                 | 0.60                       | 0.30             | 0.60                   | 0.42         | LevelIII     |
| 35kv Zundao Station   | 1.0                     | Level V                 | 0.3                        | 0.30             | 0.30                   | 0.30         | LevelIII     |

Table 5 shows hazard assessment results of substations suffering from typical earthquake damage by application of the established evaluation method. The assessment results show the following aspect. (1) For substation whose earthquake damage level is high but importance level is low, the level of cascading hazard is also low such as 35kv Zundao Station. It was damaged seriously and needed to be rebuilt, but cascading hazard to it was not severe because it was located at the terminal of power grid and its status in the system was low. (2) For substation whose earthquake damage level is low but importance level is low, the level of cascading hazard to it is also low, such as 220kv Bohe Station and 500kv Longwang Station. Both of them are hub substation within their district, their importance in the system is very high and there’s power consumption load of level 1 within their district, but cascading hazard to them is slight due to slight earthquake damage to the substations themselves. (3) For substations whose earthquake damage level and importance degree are relatively high, the degree of cascading hazard to them is also relatively high, such as 110kv Chuanxindian Station. This station is
located in Shifang City, one of the top ten counties and cities in Sichuan Province, and there’re loads of level 2 within the substation district. After the occurrence of earthquake, power facilities were damaged relatively seriously and had to be reconstructed in other places, thus the degree of hazard is particularly high.

7. Conclusion
All previous devastating earthquake disasters have repeatedly shown that cascading hazard caused by earthquake damage often vary significantly due to different importance degrees of substation, but it is also quite complex, thus it’s necessary to carry out in-depth research. The method for rapid assessment of cascading hazards is proposed by this article, aiming at providing scientific reference for deployment of post-earthquake emergency work for electric power system, control strategy of secondary disaster and the distribution of disaster relief materials.

The occurrence of cascading hazard is determined comprehensively by two aspects, i.e. importance of the substation’s function and the substation’s functioning situation. Two main influencing factors from various hazard influencing factors, i.e. the degree of earthquake damage and importance (expressed by voltage level and load level), are summarized and a preliminary hazard assessment framework is established in this article.

It should be pointed out that there is not a lot of research on the assessment of cascading hazard to substation in China and abroad. The author of this article only makes preliminary exploration and attempt in terms of technical method, and there are still many problems that need to be further studied. For example, the quantitatively indexes of influencing degree by influencing factors of cascading hazard should also include emergency response and recovery capability of the substation, emergency response and defense ability to power blackout and political status of electric power users, and economic development, population distribution, geographical environment within substation district and many other factors which can also affect the severity of hazard. Index quantification of these factors still needs to be studied further; classification of hazard level is only described vaguely and empirically and requires detailed quantitative study of indexes.

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