Risk-based transmission transfer capability evaluation

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Generally, Available Transfer Capability (ATC) is calculated based on the severest case with some safety margin reserved for any uncertainty in the near future. However, without considering the probabilistic nature of the power system, it becomes a question whether ATC is reasonable in practice or not. This paper proposes a probabilistic approach to cope with this problem. By the probabilistic method, a characteristic of the transfer capability can be obtained through its Probability Density Function (PDF). Transmission Reliability Margin (TRM) is the component of ATC that accounts for uncertainties and safety margins. In this paper, an analytic framework for TRM calculation using transfer capability sensitivity formulas and a probabilistic characterization of the various uncertainties are suggested. The objective of this research is to provide realistic information on the actual ability of the network that may be an alternative choice for system operators. The advantages of the proposed methods are illustrated by applications to a modified IEEE 118-bus system.

إن القدرة المتاح نقلها بين الشبكات (ATC) تعتمد عامة في حسابها على دراسة الحالات الحرجة للمنظومة آخذين في الإعتبار بعض دواعي أمن التشغيل لأية إحتمالات غير متوقعة في المستقبل القريب، وبدون إعتبار غيمية أداء منظومة القوى يصبح هناك سؤال هام هو أن مفهوم ATC هام أم لا. هذا البحث يعرض طريقة تعتمد على نظرية الاحتمالات لتقدير ATC للمنظومات عن طريق حساب دالة كثافة الاحتمالات. إن اعتمادية المنظومة TRM هو جزء أساسي وهام في حساب ATC والذي يحمل في طياته عوامل الأمان من الإحتمالات الحرجة الغير متوقعة. هذا البحث يقدم إطارا تحليليا لحساب TRM مستخدما في ذلك معادلات تجريبية لحساسية مقدرة النقل وطريقة الاحتمالات. والغرض من البحث في مجمله هو تمثيل وتحليل الشبكات الكهربية حتى يتمكن القائمون على تشغيلها من دراسة وحسن التصرف إزاء أية كوارث. وقد وضحت مزايا هذه الطرق بتطبيقها على منظومة IEEE القياسية المعدلة ذات ١١٨ عقدة.

Keywords: Power system reliability, Planning and operation, Total transfer capability, Transmission reliability margin, Risk analysis

1. Introduction

In a present open access transmission system, accurate and flexible information is needed to provide non-discriminatory access from all participants. Available Transfer Capability (ATC) is one key parameter that indicates an ability of power systems to reliably increase a transferred power between two zones or two points. According to [1], ATC depends on several parameters, i.e. Total Transfer Capability (TTC), Transmission Reliability Margin (TRM), sum of Existing Transmission Commitments (ETC) and Capacity Benefit Margin (CBM). Mathematically, ATC is defined as TTC minus base flow, TRM and CBM. Although TRM and CBM are important parts of ATC, they can be considered independent from TTC evaluation [1].

Currently, the ATC used in almost all utilities around the world is based on a deterministic method [2-4]. With appropriate system conditions assumed, many sets of transfer capabilities are calculated based on N-1 contingencies [5]. The worst case or minimum value of transfer capability in conjunction with some safety margin to handle uncertainties in the near future is defined as the ATC. In general, this method seems appropriate and efficient in managing usage of the transmission system.

However, because it fails to consider the probabilistic nature of the power system, the obtained ATC may be too conservative and therefore lead to a costly and inefficient use of a system resource. This paper proposes a probabilistic approach to evaluate TTC to cope with this problem. By using the probabilistic method, a Probability Density Function (PDF) or distribution of the related TTC is obtained [1]. This proposed information provides an alternative choice for Transmission Providers

(TPs) to allow them to flexibly choose an appropriate TTC, and then ATC, under their criteria to match with a real time economic signal. This paper is organized in the following sequence. In section 2, the probabilistic nature of TTC calculation is discussed. In section 3, a reference of algorithm for TTC calculation used in this paper is given. The risk analysis concept for considering an appropriate TTC is proposed. Then, applications of the proposed probabilistic method to a modified IEEE 118-bus system are presented in section 4. Section 5, suggests a probabilistic method to quantify TRM. Then, applications to a modified IEEE 118-bus system are presented in section 6. Finally, conclusions are provided in section 7.

2. Probabilistic nature of TTC calculation

In TTC calculation, generally, the maximum Transfer Capability (MTC) of Many scenarios will be evaluated due to the N-1 contingencies. The minimum one of these candidates is set to be the TTC of a specified path. However, this technique may not be appropriate in some practical systems. One reason is that a probability of an occurrence of the worst case may be very small and may not occur in any specified lead-time. This results in the too conservative and inefficient use of network resources. The other reason, in contrast to the first one, is that in a system that contains a large number of equipment, the N-1 contingencies may not be enough to cover all possible scenarios occurring in the near future. For example, assume that one power system has 1000 transmission lines and each line has 0.1% unavailability [5]. The probabilities in cases of no-line outage, one-line outage and two-line outage are shown respectively as follows:

No-line outage: $^{1000}C_0\times(0.999)^{1000}\times(0.001)^0=$ 0.3677

One-line outage: $^{1000}C_1\times(0.999)^{999}\times(0.001)^1=$ 0.3681

Two-line outage: $^{1000}C_2\times(0.999)^{998}\times(0.001)^2=$ 0.1840

From the above example, the N-1 criterion covers only 73.58% of the overall possible events which may not be enough. Therefore, situations with more than one equipment outage, (N-2, N-3 or more criteria) are also significant and cannot be neglected. For these purposes, many researches using a probabilistic approach based on Monte Carlo simulation have been proposed [6,7]. In this simulation method many network conditions are sampled. Then, the MTC is calculated for each scenario. However, because of time consuming limitations, Monte Carlo simulation is not adopted in this paper. Rather, a state selection method [5] is used. An appropriate contingency level defined as the numeric amount of equipment that fails or is in the outage state at the same time used in this method depends on characteristics of each system. Nevertheless, N-2 contingencies criterion is used in this paper. The reason for this choice is that generally TTC is calculated for a short lead time, more than N-2 contingencies might rarely occur.

A probabilistic approach to TTC proposed in this paper starts from identification of all scenarios comprising their system condition and probability obtained from N-2 contingencies. Then, at each scenario, the MTC is calculated. After performing this task for all contingencies, the obtained data containing maximum transfer values and their related probability is used to form a probability distribution. This distribution is used to describe a probabilistic nature of TTC for the specified path and is a vital tool used in considering the appropriate TTC proposed in this paper. A detailed explanation of the utilization of probabilistic TTC is discussed in the next section.

3. TTC evaluation and risk analysis

TTC is the maximum amount of power for a given set of system conditions that can be transferred from one location known as a source to another location known as a sink without any violations of system constraints. A method used in this research for calculating TTC is divided into two steps, Prediction and Calculation. Prediction uses a linear estimation concept to identify an active constraint that limits the transferred power. Calculation uses the information from the prediction step to augment that active constraint into the power flow equation to calculate an accurate

TTC. Details methodology of these two concepts can be found in [8].

3.1. Probability density function of MTC

As it is stated earlier, considering only cases based on N-1 contingency may not be enough. Consequently, rather N-1, this paper will also consider contingency cases obtained from N-2 criteria. All cases considered here are only the contingencies related to the unavailability of transmission line. The unavailability of generators should not be taken into account for the purpose of TTC calculation. This is because TTC is defined based on a particular base-case. However, any occurrence of contingencies concerning generator will cause the generations and demand to be re-dispatched. As a result, the base-case condition will be changed. The effect of these system conditions changes should be handled by an introduction of TRM, not by TTC.

A concept of the proposed probabilistic approach can be described using the following example. Assume that the maximum transferred power of a transaction from bus 1 to bus 3, of a small power system shown in

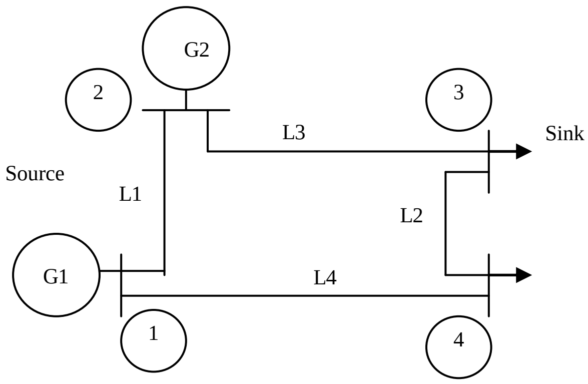

Fig. 1. Model power system.

Fig. 1, is considered. From a statistical record, transmission lines are assumed to have 9%, 7%, 5% and 3% unavailability, respectively. From these values, the probability for each event can be evaluated by the following formula [5]:

$$P(X) = \prod_{j \in \text{Outage}} FOR_j \times \prod_{k \in \text{Available}} (1 - FOR_k)\,, \qquad (1)$$

where:
X is an interested event,
j is a set of outage elements, and
k is a set of available elements

The algorithm described in [5] is applied to all events related only to transmission line outage contingencies obtained from N-2 rule, the MTC and their event probability calculated using eq. (1) is shown in table 1. The keyword “Base Case” shown in the table means there is no outage element in that event. “L1” means only transmission line number 1 fails. “L1, L2” means both transmission lines fail in that event.

To construct the PDF used for describing their probabilistic nature, all data related to the MTC shown in table 1 is divided into multiple sections. Seven sections of equal width are used in this example. The probability of each section is evaluated by accumulating the probability of all events relating to that section. Then, each probability is normalized to yield a sum of unity, for this example, the numerical details of the PDF of the MTC are shown in table 2.

By the deterministic method, due to N-1 contingencies, the TTC will be set to 85 MW. However, from this example, this situation having approximately 2.41% probability hardly occurs. This is why the deterministic TTC obtained from the worst case among N-1

Table 1
MTC and their probability from N-2 rule

Event No.	Contingency	Probability	MTC (MW)	Event No.	Contingency	Probability	MTC (MW)
1	Base Case	0.779865	100	7	L1, L3	0.004059	93
2	L1	0.077130	102	8	L1, L4	0.002385	89
3	L2	0.058700	96	9	L2, L3	0.003089	93
4	L3	0.041046	94	10	L2, L4	0.001815	84
5	L4	0.024120	85	11	L3, L4	0.001269	83
6	L1, L2	0.005805	95				

Table 2
Probability density function of MTC

MTC(MW)*	83.00	86.17	89.33	92.50	95.67	98.83	102.00
Probability	0.003086	0.024137	0.002387	0.048229	0.064551	0.780425	0.077185

*Average point of an interval

contingencies is thought to be very conservative, and it provides motivation to consider increasing this value, TTC, beyond 85 MW. In addition, because the ATC also has some reserved margins, TRM and CBM, the TTC does not need to be that strict value.

3.2. Risk analysis

If the utilization of the TTC obtained from the deterministic method is inefficient, it becomes a question how much it should be used. This might be answered by considering risk analysis. The concept is that the higher value you use the greater risk you get. Consider the PDF from table 2. The sum of all probabilities is one. If any value of the maximum transfer value, TTC_j is considered, an associated risk of curtailment can be defined, a probability that the MTC is less than TTC_j, as follows:

$$\text{Risk of Curtailment } (TTC_j) = \sum_{x=-\infty}^{TTC_j} f(x)\Delta x\,, \quad (2)$$

where:
$f(x)$ is a PDF of the MTC, and
x is the amount of the MTC.

The easiest way to determine the optimal TTC is to define a prescribed risk level [9]. If one would accept a risk of 5%, then the TTC would be 92.26 MW. However, a more reasonable method should include a consideration of an optimum between benefit and risk in a monetary viewpoint [9]. Benefit and risk used in this analysis cannot be defined uniquely. They depend on the objective and structure of each power system. In this paper, only some examples of benefit and risk functions is given. Nevertheless, it should be noted that these functions can differ depending upon decisions of TPs.

1. Benefit function: This section proposes a wheeling benefit index which represents a merit when using transferred power x more than the deterministic TTC (x_o). For example, this index is an income corresponding to the average benefit power as shown below:

$$B(x)=g(x-x_o), \quad (3)$$

where, $g(z)$ is wheeling benefit function

2. Risk function: The risk when wheeling the power x more than the deterministic TTC can be evaluated from the concept of outage cost [10] and others. Because there are many possible outage conditions, the risk function can be defined as follow:

$$R(x) = \sum_{s=x_o}^{x} h(x,s)\,, \quad (4)$$

where:
$h(x,s)$ is monetary loss function, and
s is a dummy variable relating to the transferred power.

3. Determination of the appropriate TTC: To find an appropriate TTC, the total benefit function which is determined from benefit minus risk functions has to be maximized. At an optimal point, a derivative of this function will be zero that gives:

$$\frac{dB(x)}{dx} = \frac{dR(x)}{dx}\,. \quad (5)$$

Because $R(x)$, which has a discrete-PDF, is hard to differentiate, eq. (5) will be approximated with a numerical method to be eq. (6).

$$B(x_{n-1}+\Delta x)-B(x_{n-1})= R(x_{n-1}+\Delta x)-R(x_{n-1}). \quad (6)$$

Using eq. (6), the appropriate TTC will be evaluated by a search algorithm starting at the deterministic TTC. Then the transfer capability will be increased (may increase with the same step length as section width of PDF) and both the benefit and risk will be calculated. At the beginning, generally, an increment of benefit is greater than an increment of risk. At this time, the point - where both increments are equal - is intended to find. However, with a search algorithm, this is hard to be done. Therefore, the process will be continuously done until the point where the increase in benefit is not greater than the increase in risk is found. After that, an interpolation technique may be applied to find a more accurate solution.

4. Numerical example

In this section, the proposed probabilistic method is applied to the modified IEEE 118-bus system [11]. It is called a modified test system because probabilistic data related to transmission line failure and repair rates is assumed. The failure rate is assumed to have a value which is proportional to its line length and the repair rate is assumed to have a value depending upon its type. All contingencies that have to be taken into account for each interested path contain 172 cases from N-1 and 29, 313 cases from N-2 contingencies. Although TTC of this test system are calculated in numerous possible paths, only probabilistic TTC of one path is illustrated. The source and sink of this path are buses 69 and 51, respectively.

In this test system, the probability in the base case that all equipment is in service is about 0.1338. The probability of an event having one and two outage lines is 0.2572 and 0.4871 respectively. These probability results support the planners to consider more contingency cases than only in the N-1 rule. The TTC calculations for all 29,486 cases of this path are done with a method mentioned in section III. All calculations are conducted on a 1.6 GHz personal computer using a program developed on MatLab. The simulation time for all calculations is 33 minutes which is approximately 0.067 seconds each case.

The x_o obtained from considering only N-1 rule is 39.56 MW which is equivalent to an approximately 0.4719% in risk of curtailment. It can be seen that this risk value is very small. If the risk of 5% is accepted, then the TTC would be 45.04 MW. To evaluate the appropriate TTC by cost analysis, the benefit and risk functions are assumed as follows:

Wheeling benefit function:

$g(z)= 90z + 1500\ (e^{0.02z}-1)\ LE/hr$

Monetary loss function:

$h(x,s)=3000(x-s)+ 3.6\ (s^2-x_o^2)\ LE/hr$

From these assumed functions, the benefit and risk functions can be constructed as follows:

$$B(x)=90(x-x_o)+1500(e^{0.02\ (x-x_o)}-1)\ LE/hr,$$

$$R(x) = \sum_{s=x_o}^{x} [3000(x-s) + 3.6(s^2 - x_o^2)]\ LE/hr,$$

Table 3
Probability density function of MTC

MTC*		Probability	MTC*		Probability
Real power (MW)	Reactive power (MVar)		Real power (MW)	Reactive power (MVar)	
31.70	14.92	0.000013	43.37	20.41	0.000690
33.16	15.60	0.000306	44.10	20.75	0.000768
33.89	15.95	0.000185	44.83	21.10	0.007725
34.62	16.29	0.000299	45.56	21.44	0.006374
36.07	16.98	0.000111	46.29	21.78	0.019922
37.53	17.66	0.000307	47.02	22.13	0.184269
38.26	18.01	0.000041	47.75	22.47	0.718564
38.99	18.35	0.001337	48.48	22.81	0.007427
39.72	18.69	0.007949	49.21	23.16	0.017726
40.45	19.04	0.013475	49.94	23.50	0.000212
41.18	19.38	0.000455	50.67	23.84	0.000020
41.91	19.72	0.000418	51.40	24.19	0.000012
42.64	20.07	0.010879	52.86	24.88	0.000516

*Average point of an interval

Relationships among benefit, risk and total benefit as functions of TTC are shown in Fig. 2. It can be seen that, the benefit function increases linearly whereas, at the beginning, the risk is gradually increase. But when the transferred power exceeds 46.29 MW, it rapidly increases because the risk of curtailment becomes very high. Furthermore, the optimal TTC is not a point where the benefit equals to the risk but is the point that both increments are equal. At this point, 44.60 MW, the total benefit is at its maximum.

With the proposed algorithm described above, when the transferred power is 44.10 MW the increment of benefit and risk are 89.52 and 80.88 LE/hr respectively. And the increment of benefit begins to be less than that of risk when the transferred power is 44.83 MW. At this point the increments of benefit and risk are 89.88 and 93.9 LE/hr, respectively. With the interpolation technique, the appropriate TTC where benefit and risk are equal can be calculated using eq. (7), yielding the optimal TTC of 44.60 MW.

$$TTC = x_1 + \frac{(dB(x_1) - dR(x_1)) \times (x_2 - x_1)}{(dR(x_2) - dB(x_2)) + (dB(x_1) - dR(x_1))}. \quad (7)$$

5. TRM calculations

According to [1], “The determination of ATC must accommodate reasonable uncertainties in system conditions and provide operating flexibility to ensure the secure operation of the interconnected network”. There are two margins defined to allow for this uncertainty: The TRM is defined in [1] as “that amount of transmission capability necessary to ensure that the interconnected transmission network is secure under a reasonable range of uncertainties in system conditions”. The CBM ensures access to generation from interconnected systems to meet generation requirements. The CBM is calculated separately from the TRM. Since the uncertainty increases as conditions are predicted further into the future, the TRM will generally increase when it applies to times further into the future.

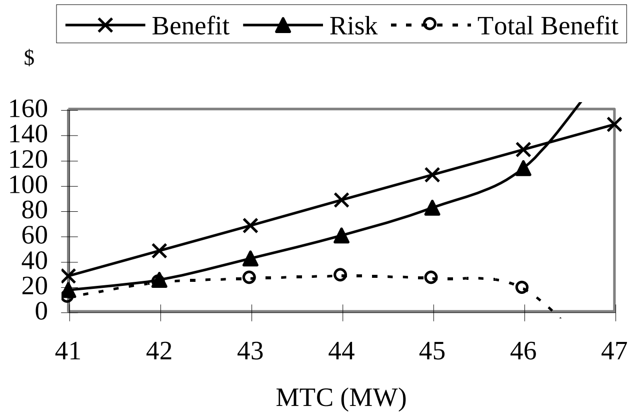

Fig. 2. Relations among benefit, risk and total benefit as the functions of TTC.

5.1. Parameters and their uncertainty

The ATC is computed from a base case constructed from system information available at a given time. There is some uncertainty or inaccuracy in this computation. There is additional uncertainty for future ATCs because the ATC computed at the base case does not reflect evolving system conditions or operating actions. These two classes of uncertainty are listed below:

1. Uncertainty in base case ATC:

- inaccurate or incorrect network parameters.
- effects neglected in the data.
- approximations in ATC computation.

2. Uncertainty due to evolving conditions

These uncertainties increase when longer time frames are considered.

- ambient temperature, humidity (contributes to loading) and weather.
- load changes not caused by temperature.
- changes in network parameters.
- change in dispatch.
- topology changes. This is often referred to as “contingencies”. The probabilities of these contingencies can be estimated.
- changes in scheduled transactions.

While some of these uncertainties may be quite hard to characterize a priori, it is important to note that it would be practical to collect empirical data on the changes in base cases as time progresses. Then standard deviations and means of the uncertain parameters corresponding to various time frames could be estimated.

It is also important to satisfy the statistical independence assumption when modeling the parameter uncertainty. For example, if the uncertainty of different loads has a common temperature component, then this temperature component should be a single parameter and the load variations should be modeled as a function of temperature.

The transfer capability is a function A of many parameters $p_1, p_2, \ldots, p_m$:

transfer capability = $A(p_1, p_2, \ldots, p_m)$. (8)

The parameters p_i are chosen to satisfy the following conditions:

- The uncertainty in the parameters p_i causes the uncertainty in ATC that is accounted for by the TRM.
- The uncertainty in the parameters is accounted for by regarding each parameter p_i as a random variable with known mean $\mu(p_i)$ and known standard deviation $\sigma(p_i)$.
- The parameters are statistically independent.

5.2. Transfer capability sensitivity

The uncertainty U in the ATC due to the uncertainty in all the parameters is:

$U = A(p_1, p_2, \ldots, p_m) - A(\mu(p_1), \mu(p_2), \ldots \mu(p_m))$. (9)

The mean value of the uncertainty is zero:

$\mu(U) = 0$. (10)

Approximating the changes in ATC linearly as in eq. (8) gives:

$$U = \sum_{i=1}^{m} \frac{\partial A}{\partial p_i}(p_i - \mu(p_i)) . \quad (11)$$

$\partial A / \partial p_i$ is the sensitivity of the transfer capability to the parameter p_i evaluated at the nominal transfer capability.

When the ATC is limited by voltage collapse, topology changes, voltage magnitude and/or thermal limits, the sensitivity can be computed using the formulas presented in ref. [12]. In each case a static, nonlinear power system model is used to evaluate the sensitivities. The computation of the sensitivity is very fast and the additional computational effort to compute the sensitivity for many parameters p_i is very small.

5.3. Formula for TRM

Since the parameters are assumed to be independent,

$$\sigma^2(U) = \sum_{i=1}^{m} \sigma^2\left(\frac{\partial A}{\partial p_i}(p_i - \mu(p_i))\right) , \quad (12)$$

$$= \sum_{i=1}^{m} \left(\frac{\partial A}{\partial p_i}\right)^2 \sigma^2(p_i) , \quad (13)$$

and the standard deviation of U is

$$\sigma(U) = \sqrt{\sum_{i=1}^{m} \left(\frac{\partial A}{\partial p_i}\right)^2 \sigma^2(p_i)} . \quad (14)$$

Under suitable conditions, the uncertainty U is approximately a normal random variable with mean zero and standard deviation given by eq. (14). This approximation gives a basis on which to define the TRM. The conditions described in the appendix are mild and require little knowledge of the distribution of the parameters.

If the defined TRM is large enough, it accounts for the uncertainty in U with rare exceptions. In other words:

Probability$\{U \le \text{TRM}\} = P$, (15)

where P is a given high probability. This can be achieved by choosing the TRM to be a certain number K of standard deviations of U:

TRM=$K\sigma(U)$. (16)

K is chosen so that the probability that the normal random variable of mean zero and standard deviation 1 is less than K is P. (That is, $P = \frac{1}{\sqrt{2\pi}}\int_{-\infty}^{K} e^{-t^2/2} dt$). It is straightforward to calculate K from P by consulting tables of the cumulative distribution function of a normal random variable. For example, if it is decided that the TRM should exceed U with P=95%, then K = 1.65. (Another way to state this result is that a normal random variable is less than 1.65 standard deviations greater than the mean 95% of the time). If it is decided that the TRM should exceed U with P=99%, then K = 2.33. Combining eqs. (14) and (16) yields a formula for TRM:

$$TRM = K\sqrt{\sum_{i=1}^{m}(\frac{\partial A}{\partial p_i})^2 \sigma^2(p_i)}\ . \quad (17)$$

In order to use formula (17), the following data must be available:

- A choice of uncertainty parameters p_1, p_2, …, p_m satisfying the above three conditions.
- The standard deviation $\sigma(p_i)$ of each parameter.
- Calculation of the sensitivity of the transfer capability to each parameter $\partial A / \partial p_i$

6. Simulation test results

This section shows by a preliminary example to test the TRM formula by comparing it with Monte Carlo simulations using the 118-bus system [11]. As shown in section 4, TTC from bus 69 to bus 51 is 44.60 MW. Suppose that the parameters listed in table 4 are added to the problem. The base case of the system assumes all parameters at their mean values. At the base system, the ATC(~TTC) is 44.6 MW. Sensitivity of ATC to these parameters can be calculated with no difficulty. Given a desired high probability P, TRM defined in eq. (15) is calculated using eq. (17). Table 5 lists TRMs with respect to different given Ps. In the Monte Carlo simulation, 100,000 samples are used.

Table 4
Parameter distributions

Parameter	Distribution
system loading p51	normal, μ=0.0, σ = 0.1
Bus 69 generation p69	normal, μ=15 MW, σ=0.748 MW
flow limit*	normal, μ=13.5 MW, σ=0.75 MW

*only TLs connected to source and sink buses.

Table 5
TRM calculated by formula and Monte Carlo

P	90%	95%	99%	99.5%
TRM formula (MW)	5.817	7.498	10.589	11.725
Monte Carlo (MW)	5.794	7.425	10.648	11.658

Table 5 shows that the performance of the TRM is the best formula, since it gives the same TRMs as Monte Carlo method but with least efforts.

7. Conclusion

This paper proposes a probabilistic approach to determine the appropriate TTC. A state selection with N-2 contingency level is used to generate considered events. In each event, the MTC, considering AC network and stability constraints, is computed. Then the probabilistic nature of TTC is formulated through probability density function. From this method, it is shown that the deterministic TTC which is calculated using the worst case of N-1 rule might be too conservative. It motivates planners to increase TTC beyond this value. Two proposed methods are considered to increase the TTC. One is to define a prescribed risk level and the other is to consider the optimum between benefit and risk.

This paper also suggests a defensible way to estimate TRM. The TRM formula requires estimation of the uncertainty in parameters, the evaluation of transfer capability sensitivities and specification of the degree of safety. The formula would be fast to evaluate for large systems (the transfer capability sensitivities are easy and quick to evaluate once the transfer capability is determined). The calculation provides one way to put a value on reducing parameter uncertainty in transfer capability calculations because a given reduction in uncertainty yields a calculable reduction in TRM, so, this can be related to the profit made in an increased transfer.

To show the advantages of the proposed methods, the application to a modified IEEE 118-bus system has been done. It has been concluded that the proposed methods are helpful for operator to trade off between benefit and risk in the new competitive environment.

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Received August 3, 2004
Accepted April 23, 2005