TTC & ATC – A brief overview

NERC document titled "*Available Transfer Capability Definitions and Determination*" (June 1996), [2] defines 'Transfer Capability' as the measure of the ability of interconnected electric systems to reliably move power from one area to another over all transmission lines (or paths) between those areas under specified system conditions. It is directional in nature and is highly dependent upon the generation, customer demand and transmission system conditions assumed during the time period analyzed.

Total Transfer Capability (TTC) is defined as the amount of electric power that can be transferred over the interconnected transmission network in a reliable manner while meeting all of a specific set of pre- and post-contingency system conditions.

Difference between transfer capability and transmission capacity

Transfer Capability is different from 'Transmission Capacity', which usually refers to the thermal limit or rating of a particular transmission element or component.
The capability to meet load (transfer capability) would however depend on several other factors such as spatial distribution and diversity of generation/load, network configuration (radial or meshed), availability of reactive compensation within that control area.
Thus, the individual transmission line capacities or ratings cannot be arithmetically added to determine the transfer capability of a transmission path or interface.

Available Transfer Capability (ATC) is a measure of the transfer capability remaining in the physical transmission network for further commercial activity over and above already committed uses. It is derived from the Total Transfer Capability (TTC) after discounting the reliability margins. Thus **ATC = TTC- Reliability Margins**
The reliability margins could be classified as Transmission Reliability Margin (TRM) and Capacity Benefit Margin (CBM). These have been explained in the subsequent sections.

Assessment of transfer capability

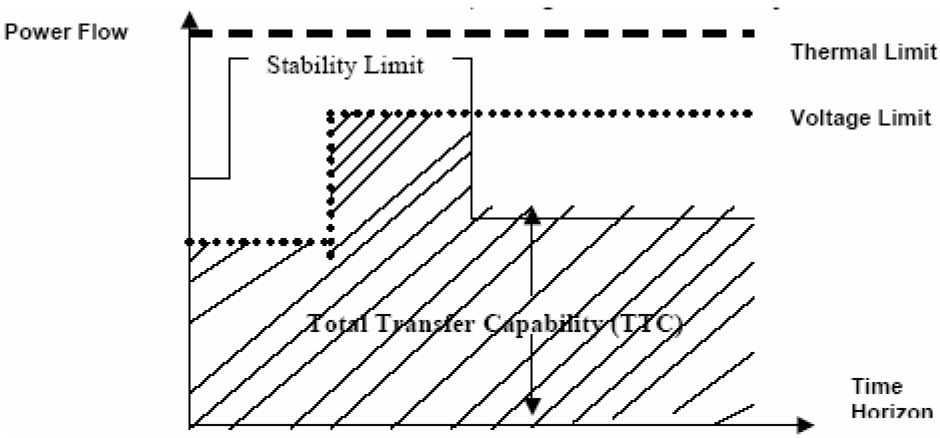
Due to the complexity involved, the assessment of transfer capability from one area to another in an interconnected system is carried out with the help of computer simulation studies. These studies are to be carried out for a particular scenario or snapshot, which is based on certain assumptions and forecasts. The factors, *inter alia* that are to be considered in these simulations are as below:

i. Planning criteria
ii. Forecasted demand- peak/off peak/transitions/four cardinal points.
iii. Generation despatch based on maintenance schedule for thermal and forecasted hydro generation during peak/off peak.
iv. System Configuration—new lines expected or existing lines under outage
v. Base Schedule Transfers mainly intra regional transactions known in advance
vi. Credible System contingencies

Limits to Transfer Capability

The ability of interconnected transmission network to reliably transfer power may be limited by the physical and electrical characteristics of the systems.
The limiting condition on some portions of the transmission network or flow gates can shift among thermal, voltage and stability limits as the network operating conditions

change over time. **TTC would be minimum of thermal limit, voltage Limit and stability Limit.**



Reliability Margins
Calculations of future transfer capabilities must consider the inherent uncertainties in projecting such system parameters over longer time periods. These include projections of system conditions, transmission system topology, projected customer demand and its distribution, generation despatch, location of future generators, future weather conditions, available transmission facilities and existing and future power transactions.
Margins in the form of **Transmission Reliability Margin** (TRM) and **Capacity Benefit Margin** (CBM) must be kept aside to provide operating flexibility in real time.

Transmission Reliability Margin (TRM)
NERC document on Transmission Capability Margins and their use in ATC determination defines TRM as the amount of transmission transfer capability necessary to provide a reasonable level of assurance that the interconnected transmission network will be secure. TRM accounts for the inherent uncertainty in system conditions and its associated effects on ATC calculations, and the need for operating flexibility to ensure reliable system operation as system conditions change.

Capacity Benefit Margin (CBM)
As per the 1996 NERC document, **Capacity Benefit Margin (CBM)** is defined as that amount of transmission transfer capability reserved by load serving entities to ensure access to generation from interconnected systems to meet generation reliability requirements. CBM is a more locally applied margin than TRM, which is more of a network margin.

The (n-1) criteria is applied while evaluating the first contingency transfer capability. However a considerable difference exists between what is a (n-1) contingency in planning horizon and a (n-1) contingency in operating horizon.

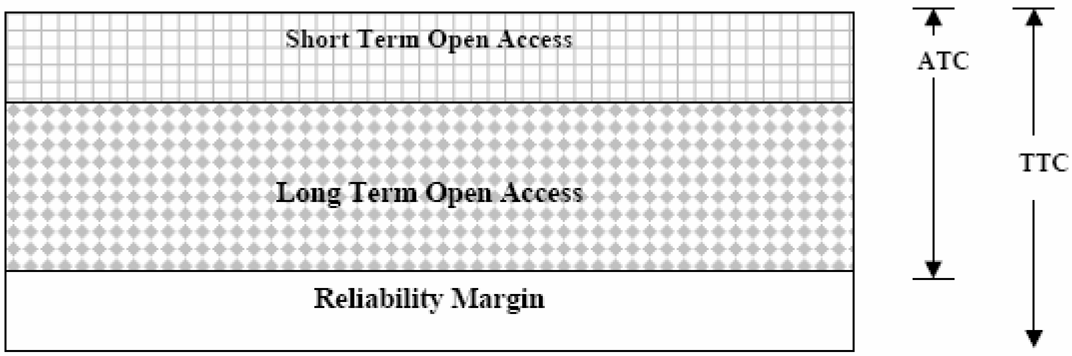
- A tower collapse or ‘lightning strike’ on a D/C tower would result in simultaneous loss of two elements.

- Non-availability or outage or non-operation of bus bar protection at a substation would result tripping of all the lines emanating from the substation at remote end in Zone-2.

- In a substation having breaker and a half switching scheme, outage of a combination of breakers could result in tripping of multiple for a fault on one line.

- Tripping of both the poles of an HVDC bipole system.

Therefore all such practical considerations call for an even higher reliability margin with consequent further reduction in ATC.



Transfer capability in the Indian context

Following synchronization of Northern grid with the Central grid (encompassing North-Eastern, Eastern and Western regions), a very large inter-connected system has evolved, in which, depending on the seasonal and diurnal variations of depatch pattern, certain transmission corridors or flow-gates, comprising a group of transmission elements, haul bulk power in a common direction. The total flow through each of these corridors must be restricted within a certain limit to avoid cascade tripping and consequent separation within the inter-connected system, under an N-1 contingency.
The subsequent commissioning of WR-NR synchronous link, leading to establishment of a “delta” connectivity “ER-NR-WR-ER”, has further contributed to the complexity of controlling the power flow in the inter-connected system. Any tripping of a critical element in one region directly affects the security of the network in the other two regions. The scheduling limits on inter-regional links are subject to over-riding constraints within each region depending on the flow through the relevant critical cross-section within each region. While such cross-sections within a region generally comprise of identified elements of the regional ISTS, the intra-state system too may be involved.

With individual state demands growing progressively, apart from studying and debating the base case and constraints at inter regional and then at intra regional ISTS under skewed scenario at all India level, a time has come to assess the transfer capability for intra-state systems also. Recently in Punjab, there was a voltage collapse near Bhatinda leading to loss of 700 MW generation when 220 kV voltage dipped below 140 kV, while the state was trying to meet its maximum agriculture load in-spite of warning from NRLDC. This happened when freq was around 49.5 Hz, with no constraints in inter regional or any 400 kV lines in any of the regions.

ATC & Open Access

In the present context of deregulated power market, more transactions are processed across different control areas as the power system gets more stressed with increasing loads. ATCs therefore need to be assessed with due prudence and are to be subjected to continuous review. ATC is available for both Long Term Open Access (LTOA) as well as Short Term Open Access (STOA, with the former having a higher priority. The priority of various STOA transactions can logically be viewed as follows–

Advance Reservations – Received within 19^{th} of a month, for implementation over a time frame of upto the next three months
First-come-first-serve – For applications received after 19^{th}, to be implemented within the month
Day-ahead reservations – For implementation on the next day
Same-day applications – For implementation on the same day only

A related aspect is that after synchronous operation of Northern grid, link wise Open Access approvals are gradually losing relevance. It needs to be appreciated that in the synchronous ER-NR-WR-NER grid, the flow on ER-NR corridor is dependent inter alia on ER-WR as well as WR-NR flow. Any change in WR-NR flow will have a bearing on the ER-NR flow as well. Therefore only the total import or total export capability of a region is more meaningful.

Consequences of not providing for a Reliability Margin in Indian context

The consequences of scheduling the interregional links at the full TTC level without any margin are as under:

1. Power shortages and compulsion to meet demand by most of the state utilities would result in more load being connected in the Northern and Western grid. This would lead to a drop in frequency, as there would not be commensurate increase in generation in Eastern region. The line loadings would also increase above the TTC levels and make the system insecure to even one element outage. A 1 Hz change in frequency could result in inter regional line loading changes of the order of 1000 MW.
2. Tight control at the interregional level (no UI) would be completely inconsistent with loose control at the inter state level (no limit on UI) and a floating frequency regime).
3. There would be frequent curtailments in real time, which would affect all the RLDCs/SLDCs in the country. The effect on a single transaction due to curtailment could be as low as 2 MW and the grid operators would be busy in rescheduling and catering to this ‘private’ need of stakeholders at a time when the larger ‘public’ issue of grid security is at stake. It also has the potential for creating disputes.
4. Unlike a safety net in the form of Under Frequency Relays (UFRs) available for low frequency, there is no safety net in the form of System Protection Schemes (SPS) to take care of cascade trippings and Under Voltage Relays to guard against voltage collapse.

Thus reliability margins are absolutely essential and are non negotiable for providing a reliable transmission services to all transmission system users under a broad range of potential system conditions. These margins are reserved by grid operators and made available for use by all the transmission users in real time.