# Local Network Exclusion

## Introduction

The purpose of this document is to provide the justification for the definitional exclusion of local networks (LN) from the definition of the Bulk Electric System (BES) as proposed in NERC Standards Development Project 2010-17. Presented herein are technical, logical, and practical considerations that provide such justification for exclusion of these facilities from the Bulk Electric System.

## Summary of Justification

The local network exclusion proposal is shown to be justified through the following facts:

1. In accordance with Commission Orders 743 and 743a on the matter of the revision of the Definition of the Bulk Electric System, the facilities used in the local distribution of electric energy are to be excluded;
2. The exclusion for local networks, as provided in the revised definition of the BES, ensures that a candidate for local network exclusion must satisfy all of the exclusion principles thus demonstrating that the candidate facilities are not performing a transmission function;
3. The limit on connected generation within the local network is consistent with the existing threshold above which a generating plant in aggregate becomes subject to owner and operator registration in the ERO Statement of Compliance Registry Criteria;
4. The voltage cap applied to the qualifications for a local network is established at 300 kV, which is consistent with the distinction being made between Extra High Voltage and High Voltage in the NERC Board of Trustees-approved Reliability Standard on transmission planning, TPL-001-2;
5. The power flow "shifts" that would occur on the elements of a local network are but a negligible fraction of that which distributes upon the BES elements for a given power transfer and is fully eclipsed by the Load in the local network; and
6. The interaction of the local network with the BES is similar in character to that of a radial facility.

## Description of Local Network

Local networks are defined in the draft BES Definition as:

*A group of contiguous transmission Elements operated at or above 100 kV but less than 300 kV that distribute power to Load rather than transfer bulk power across the interconnected system. LN's emanate from multiple points of connection at 100 kV or higher to improve the level of service to retail customer Load and not to accommodate bulk power transfer across the interconnected system. The LN is characterized by all of the following:*

a) *Limits on connected generation: The LN and its underlying Elements do not include generation resources identified in Inclusion I3 and do not have an aggregate capacity of non-retail generation greater than 75 MVA (gross nameplate rating) ;*
b) *Power flows only into the LN: The LN does not transfer energy originating outside the LN for delivery through the LN; and*
c) *Not part of a Flowgate or transfer path: The LN does not contain a monitored Facility of a permanent Flowgate in the Eastern Interconnection, a major transfer path within the Western Interconnection, or a comparable monitored Facility in the ERCOT or Quebec Interconnections, and is not a monitored Facility included in an Interconnection Reliability Operating Limit (IROL).*

Local networks are present to provide local electrical distribution service and are not planned, designed, nor operated to benefit or support the balance of the interconnected electrical transmission network. Their purpose is to provide local distribution service, not to provide transfer capacity for the interconnected electric transmission network. Their design and operation is such that at the point of connection with the interconnected electric transmission network, their effect on that network is similar to that of a radial facility, particularly in that flow always moves in a direction that is from the BES into the facility. Any distribution of parallel flows into the local network from the BES, as governed by the fundamentals of parallel electric circuits, is negligible, and, more importantly, is overcome by the Load served by the local network, thereby ensuring that the net actual power flow direction will always be into the local network at all interface points. The presence of a local network is not for the operability of the interconnected electric transmission network; neither will the local network's separation or retirement diminish the reliability of the interconnected electric transmission network.

## Commission Determination on Exclusion of Local Distribution – Relation to Local Network

In Order 743a, the Commission made it clear that facilities that are used in the local distribution of electric energy will be excluded from the Bulk Electric System. Such clarification was provided in both paragraphs 22 and 25 of the Order. The Commission agreed with certain commenters that facilities used in the local distribution of energy should be excluded from the revised Bulk Electric System definition.

In response to this facet of the Order, in developing the BES definition, the SDT has followed this guidance. Exclusion E3 was specifically designed to capture for exclusion those high voltage non-radial facilities being used for the local distribution of energy.

The exclusion characteristics in items a, b, and c above are further explained in the next section. These exclusion principles serve to ensure that facilities excluded under the local network exclusion (E3) are not necessary for the reliable operation of the interconnected electric transmission network and are instead used in the local distribution of energy.

## Exclusion Principles

Of key importance is that Exclusion E3 in the draft BES definition requires the facilities of a candidate network to meet all of the characteristics listed in the exclusion. The SDT adopted this approach to ensure that none of the characteristics typical of interconnected electric transmission networks, or necessary for the operation of the interconnected electric transmission system, would be permissible in those facilities that are qualified for Exclusion E3. In the discussion below, it is shown that these characteristics successfully prevent exclusion of facilities necessary for operating an interconnected electric transmission network, and allow only facilities that are not necessary for such operation to be excluded from the BES.

A. *First Exclusion Principle: Limits on Connected Generation*

> *Limits on connected generation: The LN and its underlying Elements do not include generation resources identified in Inclusion I3, and do not have an aggregate capacity of non-retail generation greater than 75 MVA (gross nameplate rating);*

This characteristic places restrictions on the type and size of generation resources that can be connected within the candidate facility. By placing this generation restriction on the local network, it is ensured that that the candidate facility will not under any circumstance act as a host to generation that exceeds the existing aggregate generation threshold in the ERO Statement of Compliance Registry Criteria (SCRC) and that the candidate facility will not contain Blackstart Resources. The SDT submits that this characteristic minimizes the contribution and influence the local network may have over the neighboring Elements of the BES by limiting both the magnitude and the function of the connected generation. The threshold of 75 MVA was chosen in a manner to provide consistency with the criteria applied in the ERO's SCRC regarding the registration for entities owning and operating generation plants in aggregate.

B. *Second Exclusion Principle: Power Flow and Function*

> *Power flows only into the LN: The LN does not transfer energy originating outside the LN for delivery through the LN;*

This characteristic ensures that the real power flow direction at all connection points to the BES is into the candidate local network, thereby ensuring that the candidate facilities behave in a manner that is radial in character. Further, the local network is restricted as to its use; i.e., it cannot be used for "wheel" transactions, or the transfer of energy originating outside the local network for delivery through the local network. By restricting the flow direction to be exclusively into the network at its connection points to the BES and precluding the network from providing transmission wheeling service, this exclusion characteristic further ensures that the local network is providing only a distribution service, and is not contributing to, nor is necessary for, the reliable operation of the interconnected electric transmission network. Regarding the location of the connection points to the BES, Exclusion E3 specifies that local networks "emanate from multiple points of connection at 100 kV or higher…" These points of emanation, where the local network begins and the BES ends, are established on a case-by-

case basis, but will necessarily be the points, below 300 kV, at which all of the qualifying exclusion principles are satisfied. As an example, see Appendix 1 to this document, which provides, among other things, a single line diagram depicting a local network and its interface with the BES.

C. *Third Exclusion Principle: Flowgates and Transfer Paths*

> *Not part of a Flowgate or transfer path: The LN does not contain a monitored Facility of a permanent Flowgate in the Eastern Interconnection, a major transfer path within the Western Interconnection, or a comparable monitored Facility in the ERCOT or the Quebec Interconnections, and is not a monitored Facility included in an Interconnection Reliability Operating Limit (IROL).*

This characteristic further ensures that the candidate local network facilities do not contain nor comprise facilities of well-established flowgates and transfer paths throughout the Interconnections of North America. These transfer paths are customarily used to provide bulk power transfers within the Interconnections, and therefore, the function and purpose of any candidate facilities included in or among such paths extends beyond the distribution function. A number of interchange coordination Reliability Standards apply to these transfer paths and flowgates. The SDT feels that such facilities are necessary for the reliable operation of an interconnected electric transmission network and would not be excluded from the definition of the BES.

## The Use of a 300 kV Cap is Appropriate for Local Network Exclusion

The selection of a 300 kV cap for the applicability of an exclusion for a local network was based upon recent NERC Standards Development work in Project 2006-02 "Assess Transmission Future Needs and Develop Transmission Plans." As conveyed in its work product, TPL-001-2, the Project 2006-02 SDT sets a voltage level of 300 kV to differentiate Extra High Voltage (EHV) facilities from High Voltage facilities acting as a threshold to distinguish between expected system performance criteria.[1] The Project 2010-17 SDT seeks to establish consistency in the limitations placed on the exclusion applicability for local network facilities, and has therefore adopted this 300 kV level to ensure that EHV facilities, which under the TPL-001-2 Standard are held to a higher standard of performance, are not subject to this exclusion.

## There is Minimal Effect to Flow in the Local Network due to BES Power Transfer

Similar to the character of a radial facility, and in order to qualify for exclusion from the BES under Exclusion E3.b,a local network must only have power flow into the network at all connection points to the BES. As demonstrated below, while this flow at the connection points is always into the local

[1] Per footnote #3 in TPL-001-2, "Bulk Electric System (BES) level references include extra-high voltage (EHV) Facilities defined as greater than 300 kV and high voltage (HV) Facilities defined as the 300 kV and lower voltage Systems. The designation of EHV and HV is used to distinguish between stated performance criteria allowances for interruption of Firm Transmission Service and Non-Consequential Load Loss."

network, the magnitude of the flow at these connection points will exhibit very slight shifts as bulk power transactions are implemented on neighboring BES facilities. This occurs because local network facilities are electrically parallel to Elements comprising the BES, and hence, the local network will experience a small effect due to changes in power angle across the parallel network as BES dispatch and flow patterns change. However, such flow shift is shown to be minimal, and the resultant power flow at all BES interface points is dominated by the superimposed load flow serving the distribution Load connected within the local network. Again, Exclusion E3.b ensures that flow shall always be from the BES into the local network in order to qualify for exclusion.

In order to provide a realistic example of the electrical interaction between a typical local network and the BES, an electric system in the western United States was examined from a power transfer distribution factor (PTDF) perspective. In a PTDF analysis, the branch elements of an electrical network are examined on the basis of the percentage split of a given power flow as it propagates through the network. In the simplest example of two identical lines operated at the same voltage, arranged in parallel between a given sending bus and receiving bus, the total power transfer will divide equally among the two parallel line elements, and hence, each element would be found to have a 50% PTDF. In a more complicated network, the line elements will carry a portion of the total flow in a manner that is inversely proportional to their impedance; i.e., the lower the impedance of the network branch, the higher portion of the flow that will distribute along that branch.

The electric system in question is depicted in Appendix 1. The station name identifiers and the network topology (but not electrical connectivity) have been changed to respect the confidentiality of the information. In the represented system, a bulk power transfer was simulated, with a point of receipt (injection) at BES bus T9 and a point of delivery at the other end of the system at BES bus T10. With this simulated power transfer, power flow analysis tools were used to determine the distribution of this simulated transfer as it propagates across the various parallel branches of the network. As depicted in Appendix 1, the facilities that are presumed to be excluded via the local network exclusion (E3) are shown to carry negligible flow, with the largest PTDF at a mere 0.23% of the total transfer. Note that a PTDF analysis shows only the *incremental* shift in power flow and does not imply that this 0.23% actually flows in and then back out of the network. The power flow results demonstrate that the flow measured at the interface points of the BES continues to flow into the local network, and is essentially unchanged, as it is only shifted in magnitude by a mere 0.23% of the modeled transaction amount.

In addition to the PTDF analysis, another analysis of Line Outage Distribution Factors (LODF), examines the re-distribution of flow that occurs on parallel elements after a subject element is removed from service. For example, if a BES element is carrying 500 MW, and is taken out of service, LODF describes how that flow re-distributes among all parallel paths in a given network. LODF factors are measured in percent of the pre-outage flow on the outaged element. Conducting this analysis on the example network and modeling the worst case outage, which is the loss of the line element between BES buses T9 and T10, shows that the net shift in flow for the local network is 4.0% of the pre-outage flow, and the largest shift in flow on any of the individual local network elements is 2.7%. The flow direction at the interface points between the local network and the BES continues to be into the local network.

This degree of flow shift on the local network facilities is *de minimus*, and neither diminishes or improves the reliability of the parallel BES facilities. From both a PTDF and an LODF analysis perspective, the local network exhibits qualities equivalent to radial facilities in that the power flow emanates from the point of BES connection in one direction – the only difference being that in the case of the local network, in order to provide source reliability to the distribution Load, more than one connection is provided to the BES.

# Appendix 1
## Local Network Technical Justification
## Power Transfer Distribution Factor Analysis

This appendix provides Power Transfer Distribution Factor (PTDF) and Line Outage Distribution Factor (LODF) analyses and assessments using a relevant power flow case used in actual operating studies in the Western Interconnection to assess reliable Operating Transfer Capability on a rated path in the Western Electricity Coordinating Council ("WECC"). The electrical system representation is accurate; however, the bus names and topology have been graphically rearranged to address any Critical Energy Infrastructure Information ("CEII") concerns.

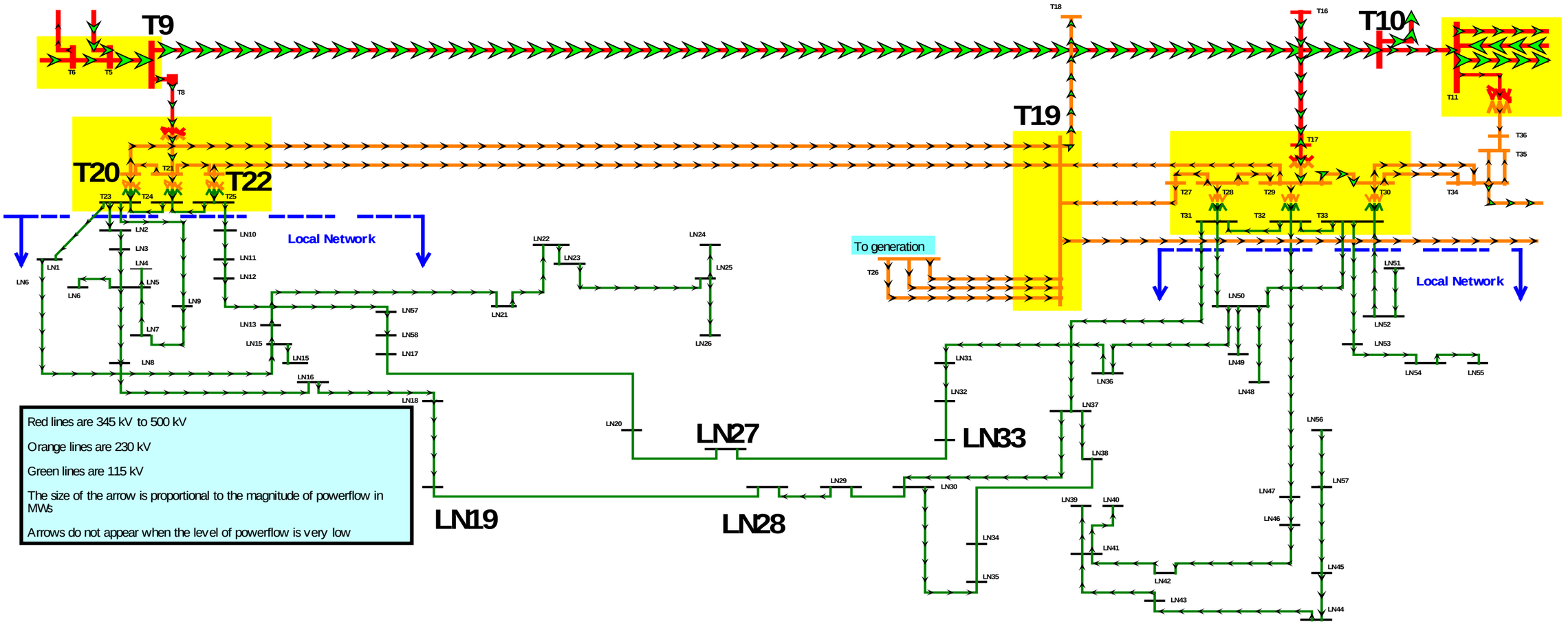
Although linear analyses, such as these, are relatively independent of actual power transfer levels, the modeled system conditions represented peak load demand and high power transfer conditions. The PTDF analyzes the injection of power from BES electrical bus T9 and delivering it to BES bus T10, which is consistent with the use of the BES transfer path. Based on the PTDF assessment, 92% of the power flow is transferred over the 500 kV line that directly connects BES buses T9 and T10. The remaining flow appears on the underlying 230 kV lines and adjacent 345 kV and 500 kV lines. The largest PTDF on any local network is 0.23 percent.

The LODF analysis considers the "worst-case" outage of the strongest (lowest impedance) transmission element, the line between BES buses T9 and T10. The LODF values that are computed represent the percentage of the pre-outage T9-T10 flow that re-distributes on each of the remaining branches. The analysis shows that the net shift in flow for the local network is 4.0% of the pre-outage flow, and the largest shift in flow on any of the individual local network elements is 2.7%. The 2.7% shift occurs on the local network branch between buses LN19 and LN28, and a 1.3% shift occurs on the branch between LN27 and LN33. The flow direction at the interface points between the local network and the BES continues to be into the local network.

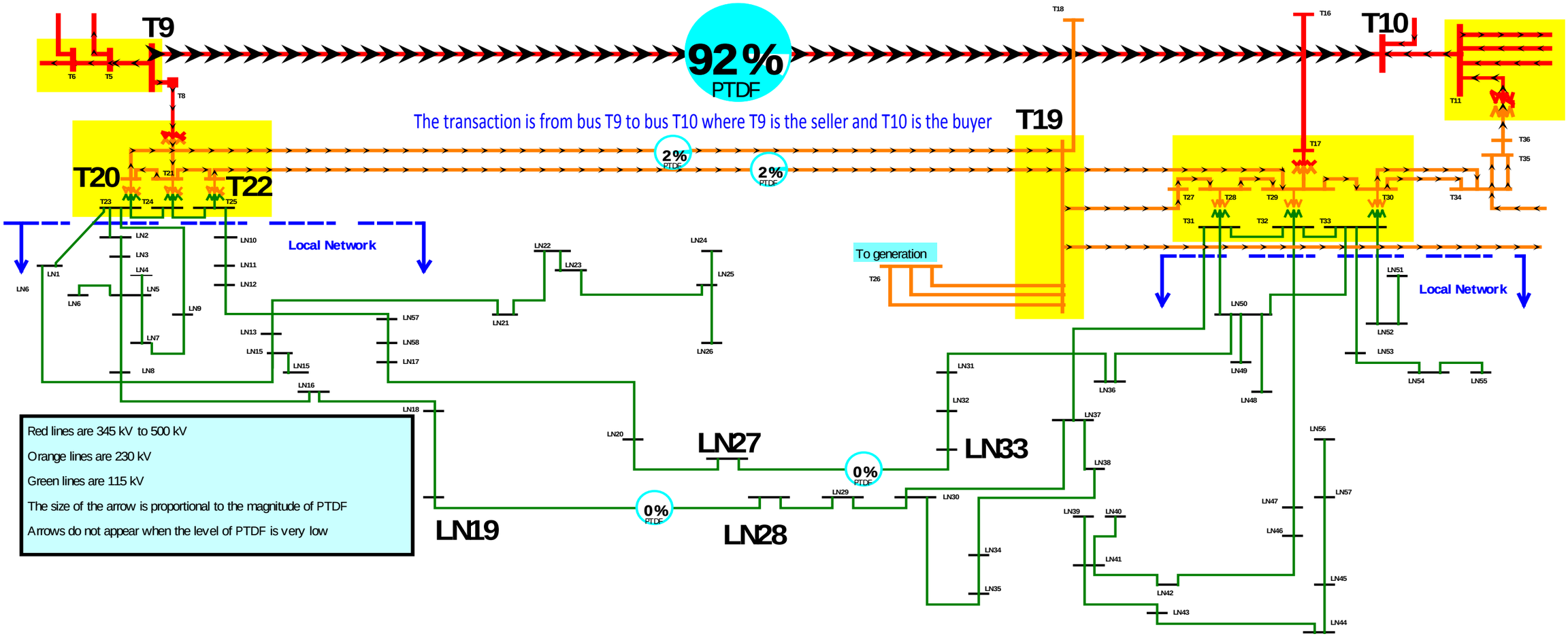
Below are three single line diagrams, which depict the 1) powerflow, 2) percentage distribution of flows for the PTDF analysis, and 3) the percent of flow distribution for the LODF analysis. In these diagrams, the local network elements are indicated by a green line color, and the local network station buses are indicated with an "LN" designation, for example, "LN23".

Following the single line diagrams are two tables: Table 1 - a tabulation of the PTDF values for the network, and Table 2 - depicting the LODF values for the T9-T10 line outage case.

# The Powerflow Single Line



# The Power Transfer Distribution Factors (“PTDF”) Single Line



**The Line Outage Distribution Factors ("LODF") Single Line identifying the revised PTDF values of the transmission line from T9 to T10 is opened**

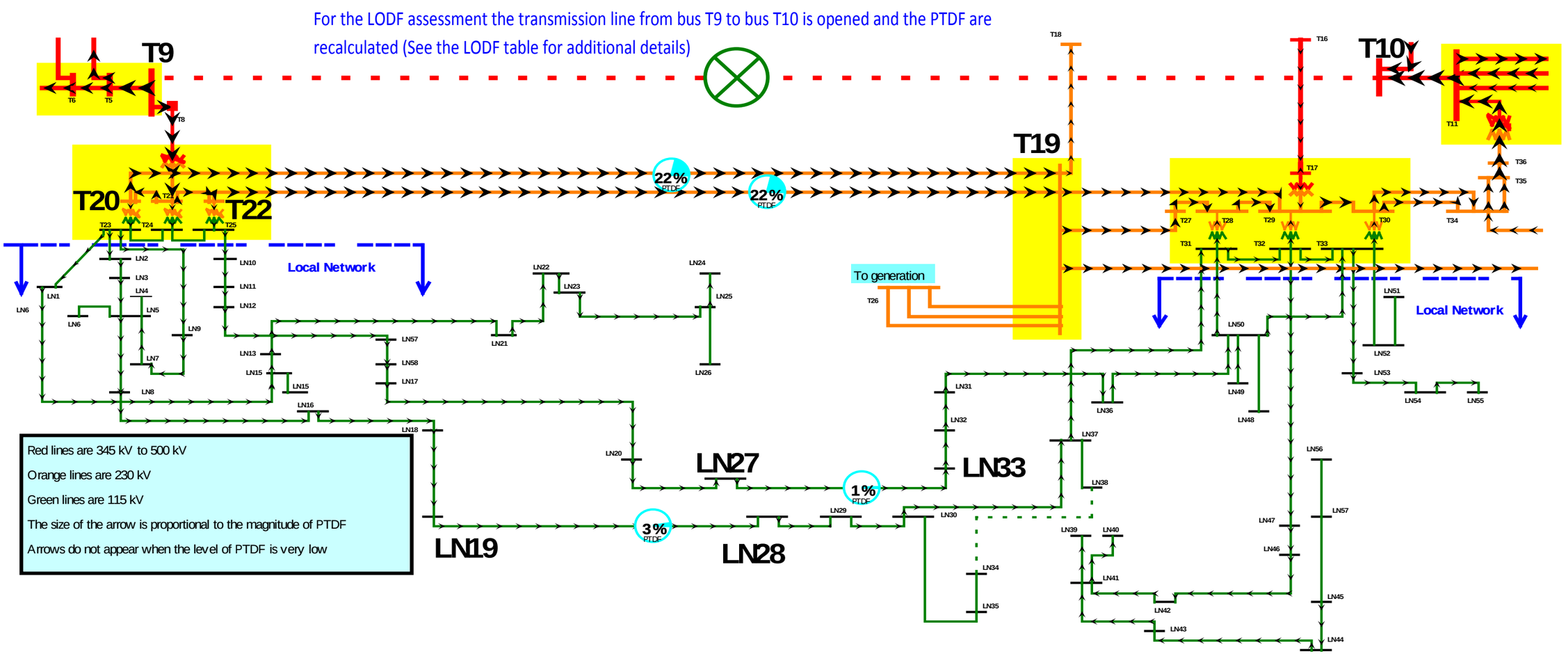


**Table 1 - Power Flow Transfer Distribution Factor Results**

| Line PTDF Records | | | | |
|---|---|---|---|---|
| From Name | To Name | % PTDF From | % PTDF To | Nom kV (Max) |
| T10 | T9 | -91.61 | 91.61 | 500 |
| T10 | T11 | -5.4 | 5.4 | 500 |
| T5 | T9 | -4.77 | 4.77 | 500 |
| T11 | T36 | -4.13 | 4.13 | 230 |
| T36 | T35 | -3.08 | 3.08 | 230 |
| T12 | T11 | -2.4 | 2.4 | 500 |
| T19 | T20 | -1.84 | 1.84 | 230 |
| T19 | T22 | -1.81 | 1.81 | 230 |
| T22 | T21 | -1.74 | 1.74 | 230 |
| T34 | T30 | -1.3 | 1.3 | 230 |
| T34 | T30 | -1.29 | 1.29 | 230 |
| T41 | T40 | -0.57 | 0.57 | 230 |
| T40 | T39 | -0.55 | 0.55 | 230 |
| T37 | T38 | -0.49 | 0.49 | 230 |
| LN16 | LN8 | -0.23 | 0.23 | 115 |
| LN28 | LN19 | -0.23 | 0.23 | 115 |
| LN19 | LN18 | -0.23 | 0.23 | 115 |
| T30 | T33 | -0.11 | 0.11 | 115 |
| LN50 | LN36 | -0.11 | 0.11 | 115 |
| LN32 | LN33 | -0.11 | 0.11 | 115 |
| LN31 | LN32 | -0.11 | 0.11 | 115 |
| LN20 | LN17 | -0.11 | 0.11 | 115 |
| LN12 | LN11 | -0.11 | 0.11 | 115 |
| LN11 | LN10 | -0.11 | 0.11 | 115 |
| LN3 | LN2 | -0.1 | 0.1 | 115 |
| T29 | T32 | -0.09 | 0.09 | 115 |
| T29 | T17 | -0.09 | 0.09 | 230 |
| LN30 | LN29 | -0.09 | 0.09 | 115 |
| LN9 | T23 | -0.08 | 0.08 | 115 |
| LN5 | LN7 | -0.08 | 0.08 | 115 |
| T28 | T31 | -0.07 | 0.07 | 115 |
| T32 | T31 | -0.07 | 0.07 | 115 |
| LN50 | LN49 | -0.07 | 0.07 | 115 |
| LN53 | T33 | -0.06 | 0.06 | 115 |
| LN55 | LN54 | -0.06 | 0.06 | 115 |
| LN41 | LN43 | -0.06 | 0.06 | 115 |
| T33 | T32 | -0.05 | 0.05 | 115 |
| LN39 | LN41 | -0.05 | 0.05 | 115 |
| T42 | T39 | -0.04 | 0.04 | 230 |
| LN47 | T32 | -0.04 | 0.04 | 115 |
| LN1 | T23 | -0.04 | 0.04 | 115 |
| LN41 | LN42 | -0.04 | 0.04 | 115 |
| LN25 | LN23 | -0.04 | 0.04 | 115 |

| Line PTDF Records | | | | |
|---|---|---|---|---|
| From Name | To Name | % PTDF From | % PTDF To | Nom kV (Max) |
| LN22 | LN21 | -0.04 | 0.04 | 115 |
| LN13 | LN15 | -0.04 | 0.04 | 115 |
| LN15 | LN1 | -0.04 | 0.04 | 115 |
| LN45 | LN57 | -0.03 | 0.03 | 115 |
| LN57 | LN56 | -0.03 | 0.03 | 115 |
| LN50 | LN48 | -0.03 | 0.03 | 115 |
| T1 | T2 | 0 | 0 | 500 |
| LN51 | LN52 | 0 | 0 | 115 |
| T33 | LN52 | 0 | 0 | 115 |
| LN4 | LN5 | 0 | 0 | 115 |
| LN6 | LN5 | 0 | 0 | 115 |
| LN38 | LN37 | 0 | 0 | 115 |
| LN30 | LN35 | 0 | 0 | 115 |
| LN35 | LN34 | 0 | 0 | 115 |
| LN38 | LN34 | 0 | 0 | 115 |
| LN24 | LN27 | 0 | 0 | 115 |
| LN26 | LN25 | 0 | 0 | 115 |
| T25 | LN23 | 0 | 0 | 115 |
| LN26 | LN20 | 0 | 0 | 115 |
| LN14 | LN15 | 0 | 0 | 115 |
| LN22 | LN11 | 0 | 0 | 115 |
| LN17 | LN10 | 0 | 0 | 115 |
| LN23 | LN10 | 0 | 0 | 115 |
| T25 | T24 | 0.01 | -0.01 | 115 |
| T24 | T23 | 0.02 | -0.02 | 115 |
| T6 | T4 | 0.03 | -0.03 | 500 |
| T19 | T26 | 0.03 | -0.03 | 230 |
| T19 | T26 | 0.03 | -0.03 | 230 |
| T19 | T26 | 0.03 | -0.03 | 230 |
| LN47 | LN46 | 0.04 | -0.04 | 115 |
| LN46 | LN42 | 0.04 | -0.04 | 115 |
| LN25 | LN24 | 0.04 | -0.04 | 115 |
| LN22 | LN23 | 0.04 | -0.04 | 115 |
| LN13 | LN21 | 0.04 | -0.04 | 115 |
| LN53 | LN54 | 0.06 | -0.06 | 115 |
| LN45 | LN44 | 0.06 | -0.06 | 115 |
| LN44 | LN43 | 0.06 | -0.06 | 115 |
| LN41 | LN40 | 0.06 | -0.06 | 115 |
| LN9 | LN7 | 0.08 | -0.08 | 115 |
| LN37 | T31 | 0.09 | -0.09 | 115 |
| T16 | T17 | 0.09 | -0.09 | 345 |
| LN30 | LN37 | 0.09 | -0.09 | 115 |
| T20 | T23 | 0.1 | -0.1 | 115 |
| LN3 | LN5 | 0.1 | -0.1 | 115 |
| T24 | LN2 | 0.1 | -0.1 | 115 |

| Line PTDF Records | | | | |
|---|---|---|---|---|
| From Name | To Name | % PTDF From | % PTDF To | Nom kV (Max) |
| LN50 | T31 | 0.11 | -0.11 | 115 |
| T22 | T25 | 0.11 | -0.11 | 115 |
| LN57 | LN58 | 0.11 | -0.11 | 115 |
| LN12 | LN57 | 0.11 | -0.11 | 115 |
| LN31 | LN36 | 0.11 | -0.11 | 115 |
| LN27 | LN33 | 0.11 | -0.11 | 115 |
| LN20 | LN27 | 0.11 | -0.11 | 115 |
| LN58 | LN17 | 0.11 | -0.11 | 115 |
| T25 | LN10 | 0.11 | -0.11 | 115 |
| LN50 | T33 | 0.12 | -0.12 | 115 |
| T21 | T24 | 0.12 | -0.12 | 115 |
| T19 | T18 | 0.13 | -0.13 | 230 |
| LN5 | LN8 | 0.23 | -0.23 | 115 |
| LN28 | LN29 | 0.23 | -0.23 | 115 |
| LN16 | LN18 | 0.23 | -0.23 | 115 |
| T2 | T7 | 0.3 | -0.3 | 500 |
| T2 | T7 | 0.34 | -0.34 | 500 |
| T37 | T34 | 0.49 | -0.49 | 230 |
| T13 | T12 | 0.59 | -0.59 | 500 |
| T14 | T11 | 0.71 | -0.71 | 500 |
| T38 | T39 | 0.78 | -0.78 | 230 |
| T27 | T28 | 0.94 | -0.94 | 230 |
| T28 | T29 | 1.1 | -1.1 | 230 |
| T4 | T3 | 1.15 | -1.15 | 500 |
| T19 | T29 | 1.21 | -1.21 | 230 |
| T19 | T27 | 1.22 | -1.22 | 230 |
| T19 | T38 | 1.26 | -1.26 | 230 |
| T1 | T7 | 1.28 | -1.28 | 500 |
| T4 | T1 | 1.28 | -1.28 | 500 |
| T34 | T35 | 1.54 | -1.54 | 230 |
| T34 | T35 | 1.54 | -1.54 | 230 |
| T21 | T20 | 1.77 | -1.77 | 230 |
| T6 | T2 | 2.34 | -2.34 | 500 |
| T5 | T6 | 2.37 | -2.37 | 500 |
| T5 | T4 | 2.4 | -2.4 | 500 |
| T29 | T30 | 2.48 | -2.48 | 230 |
| T15 | T11 | 2.97 | -2.97 | 500 |
| T12 | T10 | 3 | -3 | 500 |
| T9 | T8 | 3.62 | -3.62 | 500 |
| T8 | T21 | 3.62 | -3.62 | 230 |

**Table 2 - Line Outage Distribution Factor Results (Outage of T9-T10)**

| Line LODF Records | | | | | | |
|---|---|---|---|---|---|---|
| From Name | To Name | % LODF | MW From | MW To | CTG MW From | CTG MW To |
| T10 | T9 | -100 | -1482.1 | 1483.7 | 0 | 1.6 |
| T9 | T8 | -43.2 | 217.9 | -217.8 | 857.5 | -857.4 |
| T8 | T21 | -43.2 | 217.8 | -217.5 | 857.4 | -857.1 |
| T12 | T10 | -35.7 | -937.2 | 937.2 | -408.3 | 408.3 |
| T15 | T11 | -35.4 | 1632.1 | -1596.9 | 2156.2 | -2120.9 |
| T29 | T30 | -29.5 | 404.1 | -404.1 | 841.8 | -841.8 |
| T5 | T4 | -28.6 | -835.5 | 835.5 | -411.4 | 411.4 |
| T5 | T6 | -28.2 | -873.5 | 873.5 | -455.2 | 455.2 |
| T6 | T2 | -27.8 | -911.5 | 912.6 | -499 | 500.1 |
| T21 | T20 | -21 | 69 | -69 | 380.8 | -380.8 |
| T34 | T35 | -18.3 | 29.2 | -29.1 | 300.9 | -300.9 |
| T34 | T35 | -18.3 | 29.2 | -29.1 | 300.9 | -300.9 |
| T4 | T1 | -15.3 | -1783.5 | 1802.5 | -1557.4 | 1576.4 |
| T1 | T7 | -15.3 | -1802.5 | 1802.5 | -1576.4 | 1576.4 |
| T19 | T38 | -15 | 107.3 | -107 | 330.4 | -330 |
| T19 | T27 | -14.5 | -53.1 | 53.2 | 162.3 | -162.2 |
| T19 | T29 | -14.4 | -50.9 | 51 | 162.8 | -162.7 |
| T4 | T3 | -13.8 | 986 | -985 | 1189.8 | -1188.9 |
| T28 | T29 | -13.1 | 155.8 | -155.8 | 349.4 | -349.4 |
| T27 | T28 | -11.2 | -154.7 | 154.7 | 11.3 | -11.3 |
| T38 | T39 | -9.2 | 326.8 | -319.7 | 463.7 | -456.6 |
| T14 | T11 | -8.4 | -1656.8 | 1684.2 | -1532.1 | 1559.6 |
| T13 | T12 | -7.1 | -1308.7 | 1329.4 | -1204.2 | 1224.8 |
| T37 | T34 | -5.8 | -219.8 | 220.1 | -133.7 | 133.9 |
| T2 | T7 | -4.1 | -826.9 | 833.1 | -766.2 | 772.4 |
| T2 | T7 | -3.5 | -714.3 | 719.6 | -661.9 | 667.2 |
| LN5 | LN8 | -2.7 | 21.8 | -21.8 | 62.3 | -62.3 |
| LN16 | LN18 | -2.7 | 21.1 | -21.1 | 61.6 | -61.6 |
| LN28 | LN29 | -2.7 | -8.4 | 8.5 | 32.1 | -32.1 |
| T19 | T18 | -1.5 | 203.2 | -202.5 | 225.6 | -224.8 |
| T22 | T25 | -1.4 | 83.1 | -83 | 103.2 | -103.1 |
| T21 | T24 | -1.4 | 78.4 | -78.3 | 99.1 | -99 |
| LN50 | T33 | -1.4 | -38.6 | 38.7 | -18.2 | 18.3 |
| T25 | LN10 | -1.3 | 35.7 | -35.7 | 54.4 | -54.4 |
| LN12 | LN57 | -1.3 | 22.3 | -22.3 | 41 | -41 |
| LN57 | LN58 | -1.3 | 12.4 | -12.4 | 31.1 | -31.1 |
| LN58 | LN17 | -1.3 | 0.1 | -0.1 | 18.8 | -18.8 |
| LN20 | LN27 | -1.3 | 0.1 | -0.1 | 18.8 | -18.8 |
| LN27 | LN33 | -1.3 | 0.1 | -0.1 | 18.8 | -18.8 |
| LN31 | LN36 | -1.3 | -20.3 | 20.3 | -1.6 | 1.6 |
| LN50 | T31 | -1.3 | -36.7 | 36.7 | -16.7 | 16.8 |
| T24 | LN2 | -1.2 | 80.3 | -80.2 | 98.3 | -98.2 |
| T20 | T23 | -1.2 | 77.4 | -77.2 | 95.8 | -95.7 |

| | | | | | | |
|---|---|---|---|---|---|---|
| LN3 | LN5 | -1.2 | 53.6 | -53.5 | 71.6 | -71.5 |
| T16 | T17 | -1 | 449.4 | -436.5 | 464.6 | -451.7 |
| **Line LODF Records** | | | | | | |
| From Name | To Name | % LODF | MW From | MW To | CTG MW From | CTG MW To |
| LN9 | LN7 | -1 | 48.7 | -48.6 | 63.3 | -63.3 |
| LN30 | LN37 | -1 | -39.1 | 39.1 | -24 | 24 |
| LN37 | T31 | -1 | -48.3 | 48.4 | -33.2 | 33.3 |
| LN45 | LN44 | -0.7 | 70.8 | -70.8 | 81.3 | -81.3 |
| LN44 | LN43 | -0.7 | 67.7 | -67.6 | 78.2 | -78.1 |
| LN53 | LN54 | -0.7 | 59.5 | -59.5 | 69.6 | -69.5 |
| LN41 | LN40 | -0.7 | 53.2 | -53.1 | 63.1 | -63 |
| LN46 | LN42 | -0.5 | 55.6 | -55.6 | 63.5 | -63.5 |
| LN47 | LN46 | -0.5 | 55.8 | -55.6 | 63.7 | -63.5 |
| LN13 | LN21 | -0.5 | 47.9 | -47.9 | 55.7 | -55.7 |
| LN22 | LN23 | -0.5 | 24.6 | -24.6 | 32.5 | -32.5 |
| LN25 | LN24 | -0.5 | 14.4 | -14.4 | 22.2 | -22.2 |
| T6 | T4 | -0.4 | 38 | -38 | 43.8 | -43.8 |
| T24 | T23 | -0.3 | 45.3 | -45.3 | 49.4 | -49.4 |
| T19 | T26 | -0.3 | -152.9 | 157.7 | -148.1 | 153 |
| T19 | T26 | -0.3 | -152.9 | 157.7 | -148.1 | 153 |
| T19 | T26 | -0.3 | -152.9 | 157.7 | -148.1 | 153 |
| T25 | T24 | -0.1 | 47.3 | -47.3 | 48.7 | -48.7 |
| LN51 | LN52 | 0 | 30.6 | -30.5 | 30.6 | -30.5 |
| LN30 | LN35 | 0 | 24.4 | -24.4 | 24.4 | -24.4 |
| LN17 | LN10 | 0 | 0 | 0 | 0 | 0 |
| LN23 | LN10 | 0 | 0 | 0 | 0 | 0 |
| LN22 | LN11 | 0 | 0 | 0 | 0 | 0 |
| LN26 | LN20 | 0 | 0 | 0 | 0 | 0 |
| T25 | LN23 | 0 | 0 | 0 | 0 | 0 |
| LN24 | LN27 | 0 | 0 | 0 | 0 | 0 |
| LN35 | LN34 | 0 | 0 | 0 | 0 | 0 |
| LN38 | LN34 | 0 | 0 | 0 | 0 | 0 |
| T1 | T2 | 0 | 0 | 0 | 0 | 0 |
| LN38 | LN37 | 0 | -9.1 | 9.1 | -9.1 | 9.1 |
| LN26 | LN25 | 0 | -10.2 | 10.2 | -10.2 | 10.2 |
| LN14 | LN15 | 0 | -12.4 | 12.4 | -12.4 | 12.4 |
| T33 | LN52 | 0 | -22 | 22.1 | -22.1 | 22.1 |
| LN4 | LN5 | 0 | -22.4 | 22.4 | -22.4 | 22.4 |
| LN6 | LN5 | 0 | -33.9 | 33.9 | -33.9 | 33.9 |
| LN50 | LN48 | 0.3 | 29.9 | -29.9 | 25.4 | -25.3 |
| LN57 | LN56 | 0.3 | -17.2 | 17.3 | -21.7 | 21.7 |
| LN45 | LN57 | 0.3 | -37.6 | 37.6 | -42 | 42 |
| LN25 | LN23 | 0.5 | -24.6 | 24.6 | -32.4 | 32.5 |
| T42 | T39 | 0.5 | -28.5 | 30.5 | -35.9 | 37.9 |
| LN22 | LN21 | 0.5 | -38.1 | 38.1 | -45.9 | 46 |
| LN41 | LN42 | 0.5 | -48.9 | 48.9 | -56.8 | 56.8 |
| LN13 | LN15 | 0.5 | -51.6 | 51.6 | -59.4 | 59.4 |
| LN15 | LN1 | 0.5 | -64 | 64 | -71.8 | 71.9 |

| | | | | | | |
|---|---|---|---|---|---|---|
| LN1 | T23 | 0.5 | -64 | 64 | -71.9 | 71.9 |
| LN47 | T32 | 0.5 | -66.5 | 66.6 | -74.4 | 74.5 |
| T33 | T32 | 0.6 | 45.7 | -45.7 | 36.4 | -36.4 |
| LN39 | LN41 | 0.6 | -46.7 | 46.8 | -55.3 | 55.4 |
| **Line LODF Records** | | | | | | |
| From Name | To Name | % LODF | MW From | MW To | CTG MW From | CTG MW To |
| LN55 | LN54 | 0.7 | -50.6 | 50.7 | -60.7 | 60.7 |
| LN41 | LN43 | 0.7 | -58.7 | 58.8 | -69.2 | 69.3 |
| LN53 | T33 | 0.7 | -62.8 | 63 | -72.9 | 73 |
| T32 | T31 | 0.8 | 65.9 | -65.9 | 54.4 | -54.4 |
| T28 | T31 | 0.9 | 125.9 | -125.5 | 112.9 | -112.5 |
| LN50 | LN49 | 0.9 | 61.9 | -61.8 | 49.1 | -49 |
| T29 | T32 | 1 | 136.8 | -136.4 | 121.6 | -121.1 |
| LN30 | LN29 | 1 | -4.5 | 4.5 | -19.7 | 19.7 |
| LN5 | LN7 | 1 | -38.7 | 38.7 | -53.4 | 53.4 |
| LN9 | T23 | 1 | -58.4 | 58.5 | -73 | 73.2 |
| T29 | T17 | 1 | -436.1 | 436.5 | -451.3 | 451.7 |
| LN3 | LN2 | 1.2 | -61.9 | 62 | -79.9 | 80 |
| T30 | T33 | 1.3 | 125.6 | -125.3 | 105.9 | -105.7 |
| LN50 | LN36 | 1.3 | 29.7 | -29.7 | 11 | -11 |
| LN31 | LN32 | 1.3 | 11.2 | -11.2 | -7.5 | 7.5 |
| LN20 | LN17 | 1.3 | -0.1 | 0.1 | -18.8 | 18.8 |
| LN32 | LN33 | 1.3 | -0.1 | 0.1 | -18.8 | 18.8 |
| LN11 | LN10 | 1.3 | -35.7 | 35.7 | -54.4 | 54.4 |
| LN12 | LN11 | 1.3 | -35.6 | 35.7 | -54.3 | 54.4 |
| LN28 | LN19 | 2.7 | -2.1 | 2.1 | -42.6 | 42.6 |
| LN19 | LN18 | 2.7 | -12.6 | 12.6 | -53.1 | 53.1 |
| LN16 | LN8 | 2.7 | -21.7 | 21.8 | -62.3 | 62.3 |
| T37 | T38 | 5.8 | 219.8 | -219.8 | 133.7 | -133.7 |
| T40 | T39 | 6.6 | -221.1 | 222.8 | -318.7 | 320.4 |
| T41 | T40 | 6.8 | -308.2 | 309.9 | -408.2 | 409.9 |
| T34 | T30 | 15.4 | -138.7 | 138.7 | -366.6 | 366.7 |
| T34 | T30 | 15.5 | -139.7 | 139.7 | -369.2 | 369.2 |
| T22 | T21 | 20.7 | -70.2 | 70.2 | -377.3 | 377.3 |
| T19 | T22 | 21.5 | -90.4 | 90.7 | -409.8 | 410 |
| T19 | T20 | 21.9 | -91.6 | 91.9 | -416.3 | 416.6 |
| T12 | T11 | 28.6 | -392.2 | 392.2 | -816.5 | 816.5 |
| T36 | T35 | 36.7 | -58.2 | 58.2 | -601.7 | 601.7 |
| T11 | T36 | 49.2 | 65.3 | -64.8 | -663.5 | 664 |
| T5 | T9 | 56.8 | 1709 | -1701.6 | 866.6 | -859.1 |
| T10 | T11 | 64.3 | 544.9 | -544.9 | -408.3 | 408.3 |