# Use of PDTF's and ODTF's

## Powerworld PDTF and ODTF Sensitivity Functions

## Example – Path Utilization Tool (PUF Diagram)

# Topic of Discussion

- PDTF's – What are they?
- Demonstration of how they can be used to develop a useful tool.
- Development of Power Transfer Diagram (Excel Spreadsheet/Diagram)
- ODTF's – What are they?
  How are they different from PDTF's?

# PDTF's

- Power Transfer Distribution Factors (PTDF)
- PDTF is defined as the incremental impact on the transmission system of a transfer of power between two points in the power system
- PTDFs demonstrate a linear impact (i.e. is a linear sensitivity function)
- They provide what percent of the transfer appears on each transmission line in the power system

# PTDF Calculation

- PTDFs are calculated using the factored power flow Jacobian (Jacobian is a linearized matrix of partial derivatives of P and Q with respect to angle and voltage magnitude)

$$\Delta|\mathbf{V}| = [\mathbf{J}(\mathbf{V}^*)]^{-1} \Delta\mathbf{P}$$

$\Delta\mathbf{P}$ **-** Change in power injections associated with a power transfer

$\Delta|\mathbf{V}|$ **-** Change in system voltages, therefore flows on each transmission branch can be calculated

# Specifying Transfer for PDF Calculation

- Must specify a seller (source) and buyer (sink) for a power transfer

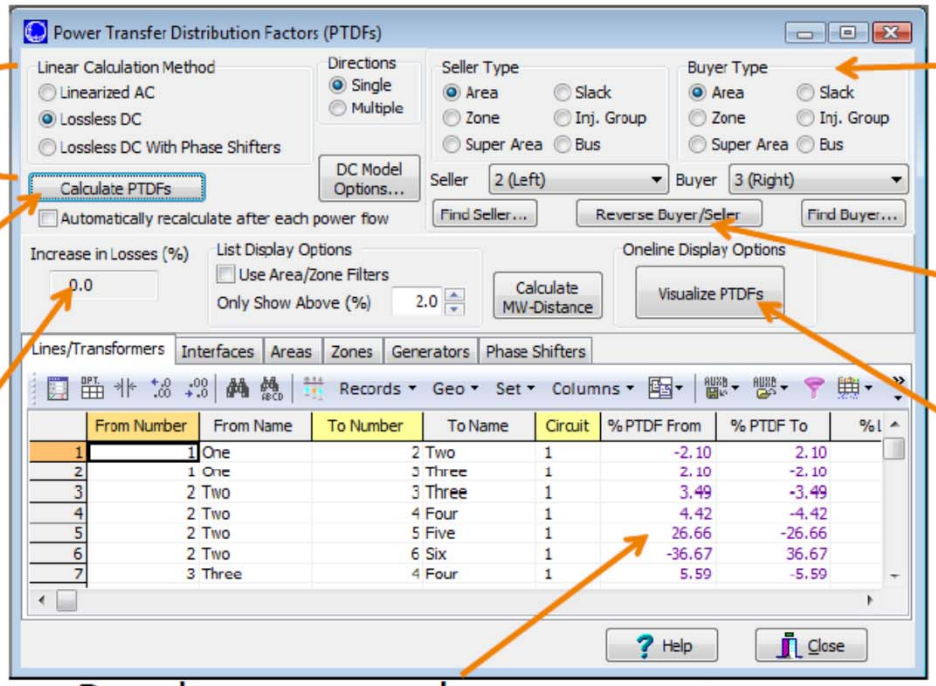
- Options for Seller and Buyer:
  - Area, Zone, or Super Area - Generators in region participate according to participation factors
  - Slack – Slack generator provides
  - Injection Group – Loads/Generators participate based on each element of the group
  - Bus – Power comes from/to this bus

# Calculation Method for PTDF

- Specify a Calculation Method
  - Linearized AC (includes losses)
  - Lossless DC – DC power flow (no losses)
  - Lossless DC with Phase Shifters – Modification of lossless DC that forces phase shifters to hold flow across them

# PTDF Display

- Choose **Tools** ribbon tab → **Sensitivities** → **Power Transfer Distribution Factors (PTDFs)**




Select Calculation Method

Select seller and buyer

Switches buyer and seller

Select to calculate the PTDFs

Visualize PTDFs on oneline. Available if only one oneline is open.

Percentage change in system losses

Results expressed as a percentage of the power transfer

# Example: Power Transfer Path Utilization Diagram (PUF Diagram)

- Develop an Excel Spreadsheet Diagram that provides a visual effect of power transfers across transfer paths in the NW from one area to another.

# Powerworld Files Used

- Installed Interface Groups to model transfer paths of interest
- Used the PTDF to do a linearized AC power transfer from bus (center of area of seller) to bus (center of area of buyer – common point)
- Used the superposition principle to allow determine from any one bus to another

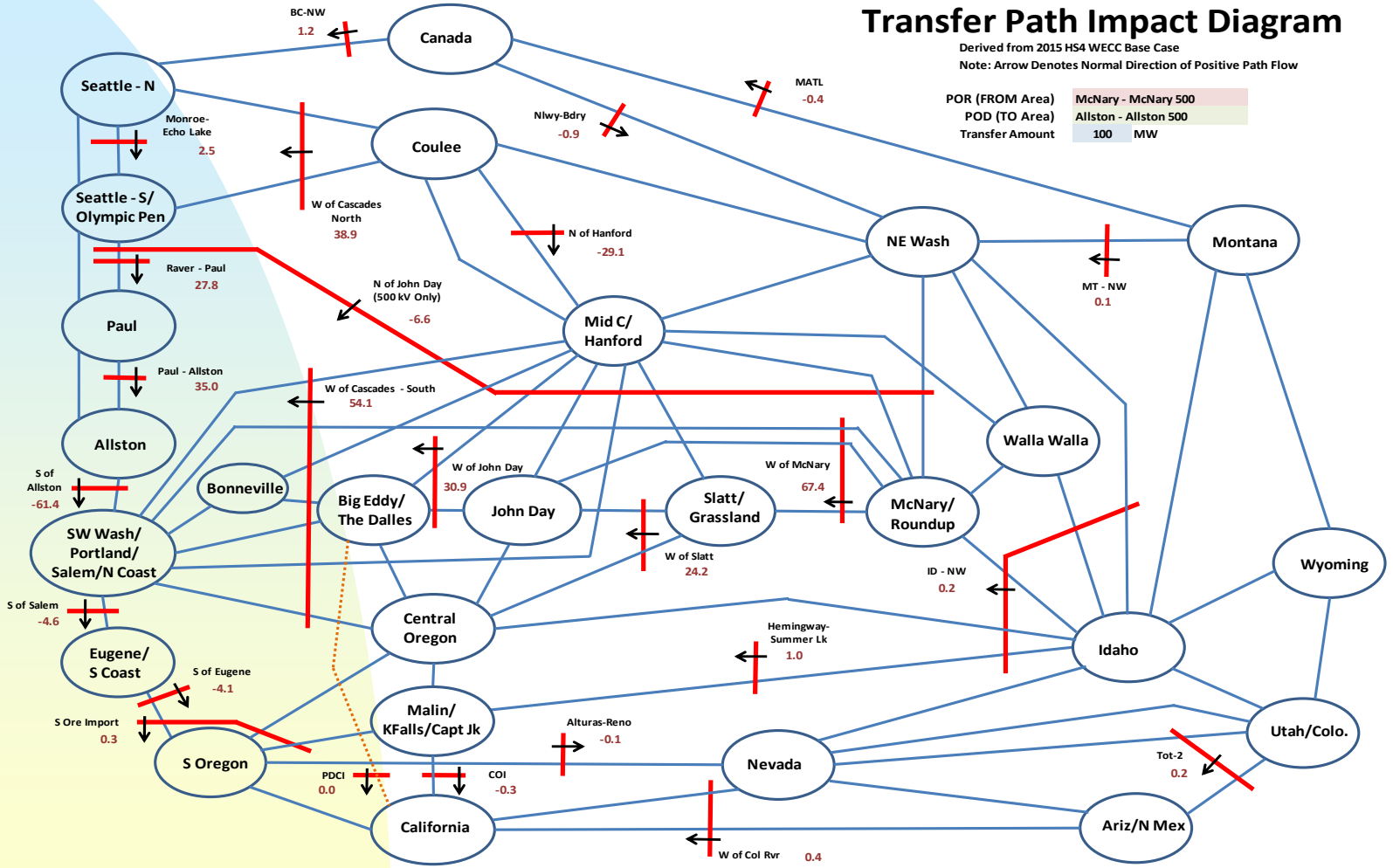
# Excel Spreadsheet (Data)– PODFs for Interfaces

Used AC Linearized Method for Determination of Factors

Existing System (Big Eddy-Knight) - Case 1
POD - Boise Bench 230 (Transfer TO Bus)
Path Transfer (% Change)

| POR - Area/Bus (Transfer FROM Bus) | Monroe-Echo Lake | Raver-Paul | Paul-Allston | S of Allston | S of Salem | S of Eugene | West of Cascades North | North of John Day | North of Hanford | West of McNary | West of Slatt | West of John Day | West of Cascades South | BC-NW | Nelway-Boundary | Matl | MT-NW | ID-NW | Hmwy-Sum Lk | COI | PDCI | Alturas-Reno | S Ore Import | Tot-2 | W of Col River |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sea N - Monroe 500 | 52.1 | 13.4 | 16.3 | 19.6 | 9.9 | 8.7 | -73.3 | 58.1 | 49.6 | -1.6 | 10.4 | -14.8 | -9.6 | -5.8 | 4.5 | 2.0 | -6.9 | -68.1 | -37.2 | 11.9 | 0.0 | 1.4 | 0.8 | -7.0 | -9.7 |
| Sea S - Maple Valley 500 | -11.1 | 14.9 | 17.9 | 21.6 | 10.1 | 9.0 | -74.8 | 59.1 | 50.2 | -2.1 | 10.2 | -15.5 | -11.1 | -3.5 | 2.6 | 1.5 | -7.3 | -69.1 | -37.9 | 12.2 | 0.0 | 1.4 | 0.8 | -7.2 | -10.0 |
| Paul - Paul 500 | -4.0 | -38.3 | 48.0 | 49.0 | 12.1 | 10.8 | -49.3 | -16.1 | 30.1 | -7.1 | 4.9 | -23.9 | -34.8 | -2.3 | 1.6 | 1.1 | -7.0 | -70.4 | -39.2 | 12.9 | 0.0 | 1.5 | 0.7 | -7.7 | -10.5 |
| Allston - Allston 500 | -3.1 | -27.6 | -34.7 | 61.7 | 13.2 | 11.7 | -37.8 | -15.2 | 21.2 | -9.4 | 2.6 | -27.8 | -45.6 | -2.0 | 1.3 | 1.0 | -6.8 | -71.4 | -40.0 | 13.2 | 0.0 | 1.6 | 0.7 | -7.9 | -10.9 |
| Allston - Trojan 230 | -2.7 | -22.2 | -24.7 | 66.6 | 13.4 | 11.9 | -33.0 | -13.6 | 17.7 | -10.4 | 1.9 | -29.1 | -49.4 | -1.9 | 1.2 | 0.9 | -6.7 | -71.3 | -40.1 | 13.3 | 0.0 | 1.6 | 0.6 | -8.0 | -10.9 |
| PDX/Salem - Troutdale 230 | -1.6 | -9.3 | -11.0 | -13.5 | 14.0 | 12.4 | -12.9 | -17.1 | 2.8 | -13.8 | -2.1 | -40.3 | -69.0 | -1.4 | 0.8 | 0.8 | -6.5 | -73.2 | -41.6 | 13.9 | 0.0 | 1.6 | 0.6 | -8.4 | -11.5 |
| PDX/Salem - Keeler 230 | -1.9 | -13.4 | -16.0 | -19.5 | 15.4 | 13.6 | -19.1 | -16.9 | 6.8 | -13.3 | -1.3 | -34.4 | -63.1 | -1.5 | 0.9 | 0.8 | -6.6 | -73.4 | -41.7 | 14.0 | 0.0 | 1.7 | 0.5 | -8.5 | -11.6 |
| PDX/Salem - Pearl 230 | -1.7 | -10.9 | -13.2 | -15.8 | 16.0 | 14.2 | -15.2 | -18.3 | 3.3 | -13.6 | -2.7 | -35.8 | -67.1 | -1.4 | 0.9 | 0.8 | -6.5 | -73.3 | -41.8 | 14.1 | 0.0 | 1.7 | 0.5 | -8.6 | -11.7 |
| Eugene - Alvey 230 | -1.2 | -5.3 | -6.5 | -7.7 | -69.8 | 25.8 | -7.0 | -20.3 | -3.6 | -15.0 | -6.6 | -24.3 | -62.6 | -1.2 | 0.7 | 0.7 | -5.8 | -74.9 | -43.7 | 15.2 | 0.0 | 1.9 | -3.0 | -9.6 | -12.9 |
| S Oregon - Meridian 230 | -1.0 | -3.7 | -4.6 | -5.5 | -40.3 | -31.0 | -4.8 | -19.6 | -4.9 | -15.3 | -8.5 | -11.4 | -35.0 | -1.0 | 0.6 | 0.6 | -4.9 | -76.5 | -46.0 | 16.4 | 0.0 | 2.4 | -88.2 | -11.3 | -15.0 |
| Malin - Malin 500 | -0.8 | -2.2 | -2.7 | -3.2 | -8.8 | -7.8 | -2.6 | -18.6 | -6.1 | -15.3 | -10.3 | 2.8 | -5.6 | -0.9 | 0.5 | 0.5 | -3.9 | -76.4 | -47.4 | 19.3 | 0.0 | 2.1 | 3.0 | -12.3 | -16.4 |
| Cent OR - Redmond 230 | -0.9 | -2.3 | -2.9 | -3.4 | 1.5 | 1.3 | -2.7 | -19.4 | -6.3 | -15.6 | -10.0 | -5.3 | 4.7 | -1.0 | 0.5 | 0.6 | -5.0 | -75.2 | -44.9 | 15.2 | 0.0 | 2.0 | 2.3 | -9.6 | -12.8 |
| Big Eddy - Big Eddy 230 | -1.1 | -2.7 | -3.3 | -3.9 | 9.5 | 8.4 | -3.0 | -18.9 | -5.0 | -15.7 | -5.4 | -59.1 | 12.5 | -1.1 | 0.6 | 0.7 | -6.3 | -72.2 | -41.2 | 13.8 | 0.0 | 1.6 | 1.0 | -8.3 | -11.3 |
| John Day - John Day 500 | -1.0 | -1.4 | -1.8 | -2.1 | 7.9 | 7.0 | -1.2 | -22.2 | -8.9 | -17.5 | -9.4 | 21.1 | 10.2 | -1.1 | 0.6 | 0.6 | -6.1 | -71.8 | -41.3 | 13.8 | 0.0 | 1.6 | 1.1 | -8.3 | -11.3 |
| Bonneville - Bonneville 230 | -1.6 | -10.1 | -11.7 | -14.7 | 13.1 | 11.6 | -14.2 | -12.6 | 7.3 | -12.8 | 0.0 | -35.4 | -60.4 | -1.4 | 0.8 | 0.8 | -6.5 | -71.2 | -40.2 | 13.4 | 0.0 | 1.6 | 0.7 | -8.1 | -11.1 |
| Idaho - Boise Bench 230 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Mid C - Midway 230 | 0.2 | 5.5 | 6.9 | 8.2 | 9.6 | 8.5 | 9.8 | 45.8 | 44.2 | 3.6 | 11.8 | -15.7 | -3.2 | -1.3 | 0.6 | 0.9 | -7.5 | -69.7 | -37.9 | 12.3 | 0.0 | 1.4 | 0.8 | -7.3 | -10.0 |
| Mid C - Hanford 500 | -0.7 | 4.6 | 5.5 | 6.5 | 9.5 | 8.4 | 8.0 | 66.2 | -25.2 | -0.4 | 14.8 | -10.3 | 2.8 | -1.2 | 0.6 | 0.7 | -7.4 | -69.6 | -38.3 | 12.5 | 0.0 | 1.5 | 0.9 | -7.4 | -10.2 |
| Coulee - Coulee 500 | 2.8 | 9.3 | 11.4 | 13.6 | 9.3 | 8.2 | 15.5 | 58.0 | 51.8 | -0.1 | 11.7 | -12.6 | -4.4 | -1.1 | 0.3 | 0.9 | -8.1 | -66.9 | -36.4 | 11.6 | 0.0 | 1.4 | 0.8 | -6.8 | -9.5 |
| Slatt - Slatt 500 | -0.8 | -0.5 | -0.7 | -0.8 | 8.5 | 7.5 | 0.2 | -23.5 | -10.0 | -20.1 | 62.3 | 6.8 | 9.4 | -1.0 | 0.5 | 0.6 | -6.4 | -71.5 | -40.5 | 13.5 | 0.0 | 1.6 | 1.0 | -8.1 | -11.1 |
| McNary - McNary 500 | -0.6 | 0.2 | 0.3 | 0.3 | 8.6 | 7.6 | 1.1 | -21.8 | -7.9 | 58.0 | 26.8 | 3.1 | 8.5 | -0.8 | 0.4 | 0.6 | -6.7 | -71.2 | -39.0 | 12.9 | 0.0 | 1.5 | 1.0 | -7.7 | -10.5 |
| Walla Walla - Walla Walla 230 | 0.2 | 2.4 | 3.0 | 3.5 | 7.4 | 6.6 | 3.8 | 20.9 | 11.0 | 23.6 | 14.7 | -5.8 | 3.7 | -0.1 | -0.2 | 0.4 | -6.9 | -76.5 | -30.7 | 9.9 | 0.0 | 1.2 | 0.7 | -5.8 | -8.1 |
| NE Wash - Bell 500 | 4.1 | 7.2 | 9.0 | 10.8 | 8.5 | 7.6 | 8.1 | 54.3 | 33.3 | 3.0 | 12.4 | -10.4 | -2.4 | 3.4 | -3.9 | -0.1 | -11.7 | -65.2 | -34.4 | 10.3 | 0.0 | 1.3 | 0.7 | -5.8 | -8.3 |
| Montana - Broadview 500 | 3.9 | 5.3 | 6.6 | 7.9 | 6.7 | 6.0 | 3.8 | 45.3 | 20.4 | 3.3 | 10.8 | -7.8 | -1.3 | 4.8 | -1.7 | -3.7 | 71.5 | -57.7 | -29.6 | 6.5 | 0.0 | 1.0 | 0.6 | -2.7 | -5.1 |
| Wyoming - Dave Johnston 230 | 1.1 | 1.0 | 1.2 | 1.5 | -0.6 | -0.5 | 0.2 | 8.3 | 4.6 | -4.4 | -0.2 | -1.4 | -2.1 | 1.4 | -0.3 | -1.3 | 20.9 | -35.3 | -15.7 | -14.3 | 0.0 | -0.3 | -0.3 | 16.5 | 13.1 |
| Utah/Colorado - Bonanza 345 | 0.2 | -0.2 | -0.3 | -0.3 | -3.0 | -2.6 | -0.7 | -2.1 | 0.2 | -7.3 | -3.5 | 0.3 | -2.6 | 0.4 | 0.0 | -0.5 | 8.6 | -34.3 | -15.1 | -24.0 | 0.0 | -0.8 | -0.7 | 25.3 | 21.6 |
| Ariz/N Mex - Palo Verde 500 | -0.4 | -1.5 | -1.8 | -2.2 | -7.1 | -6.3 | -2.0 | -12.5 | -3.7 | -12.7 | -7.8 | 1.6 | -4.9 | -0.4 | 0.3 | 0.1 | 1.2 | -60.3 | -34.0 | -56.4 | 0.0 | -0.8 | -0.6 | -33.1 | 51.7 |
| Nevada - Harry Allen 500 | -0.4 | -1.5 | -1.9 | -2.2 | -7.1 | -6.3 | -2.0 | -12.6 | -3.8 | -12.7 | -7.9 | 1.6 | -4.9 | -0.4 | 0.3 | 0.1 | 0.9 | -59.9 | -33.6 | -55.5 | 0.0 | -1.4 | -1.2 | -30.2 | 50.2 |
| California - Telsa 500 | -0.8 | -2.2 | -2.7 | -3.2 | -9.5 | -8.4 | -2.6 | -18.1 | -5.8 | -15.7 | -10.2 | 2.3 | -6.3 | -0.8 | 0.5 | 0.4 | -2.7 | -77.4 | -47.1 | -78.9 | 0.0 | 1.2 | 1.6 | -19.1 | -25.9 |
| Canada - Nicola 500 | 36.4 | 10.6 | 13.0 | 15.5 | 8.5 | 7.5 | -54.3 | 51.3 | 42.0 | -0.5 | 9.8 | -12.3 | -7.0 | 73.5 | 15.1 | 4.9 | -4.1 | -60.4 | -32.8 | 10.3 | 0.0 | 1.2 | 0.7 | -6.0 | -8.4 |
| System Specific Values (POR-POD) | 2.5 | 27.8 | 35.0 | -61.4 | -4.6 | -4.1 | 38.9 | -6.6 | -29.1 | 67.4 | 24.2 | 30.9 | 54.1 | 1.2 | -0.9 | -0.4 | 0.1 | 0.2 | 1.0 | -0.3 | 0.0 | -0.1 | 0.3 | 0.2 | 0.4 |
| POR (From Bus) | McNary - McNary 500 | | | | | | | | | | | | | | | | | | | | | | | | |
| POD (To Bus) | Allston - Allston 500 | | | | | | | | | | | | | | | | | | | | | | | | |

# Sample Output



# Line Outage Distribution Factors (LODF)

- LODFs are similar to PTDF linearized calculation
- Calculate the impact of opening (outage) or closing a branch
- Calculated the percent of power flow specified for a transmission line that occurs due to switching will appear on other lines

# LODF Diagram

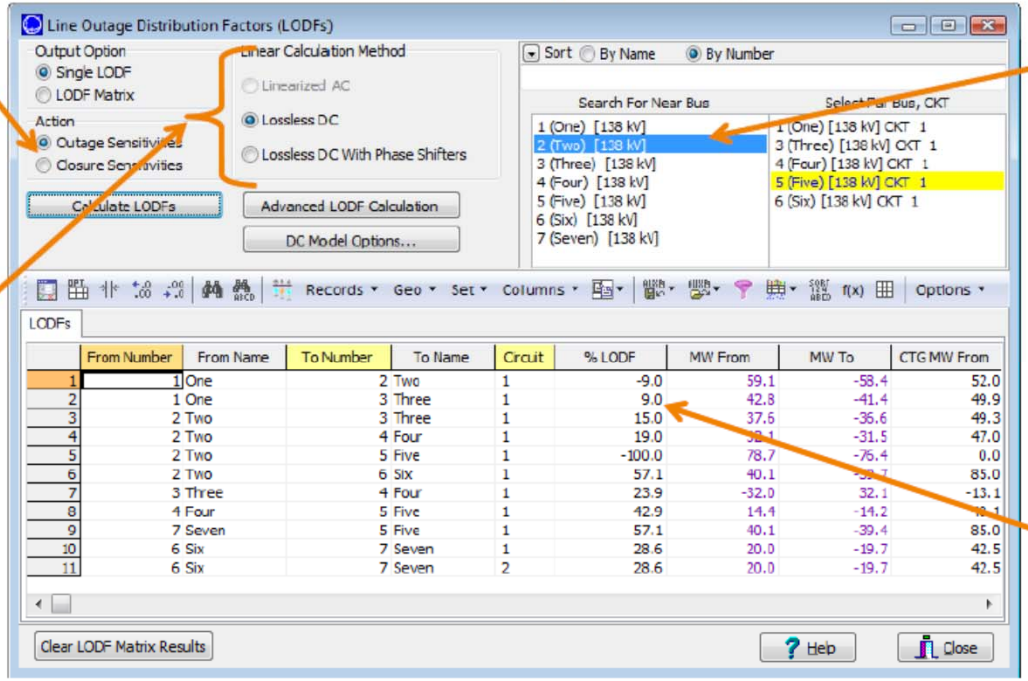
- Choose **Tools** ribbon tab → **Sensitivities** →**Line Outage Distribution Factors (LODFs)**

Action will actually be determined for you

(If the line is presently closed, then it will automatically do an outage sensitivity)

Select the transmission branch

Select Calculation Method to Use




LODF values in percent (or LCDF)

# LODF Matrix

Select LODF Matrix

Type of sensitivity

Lines to outage/ close

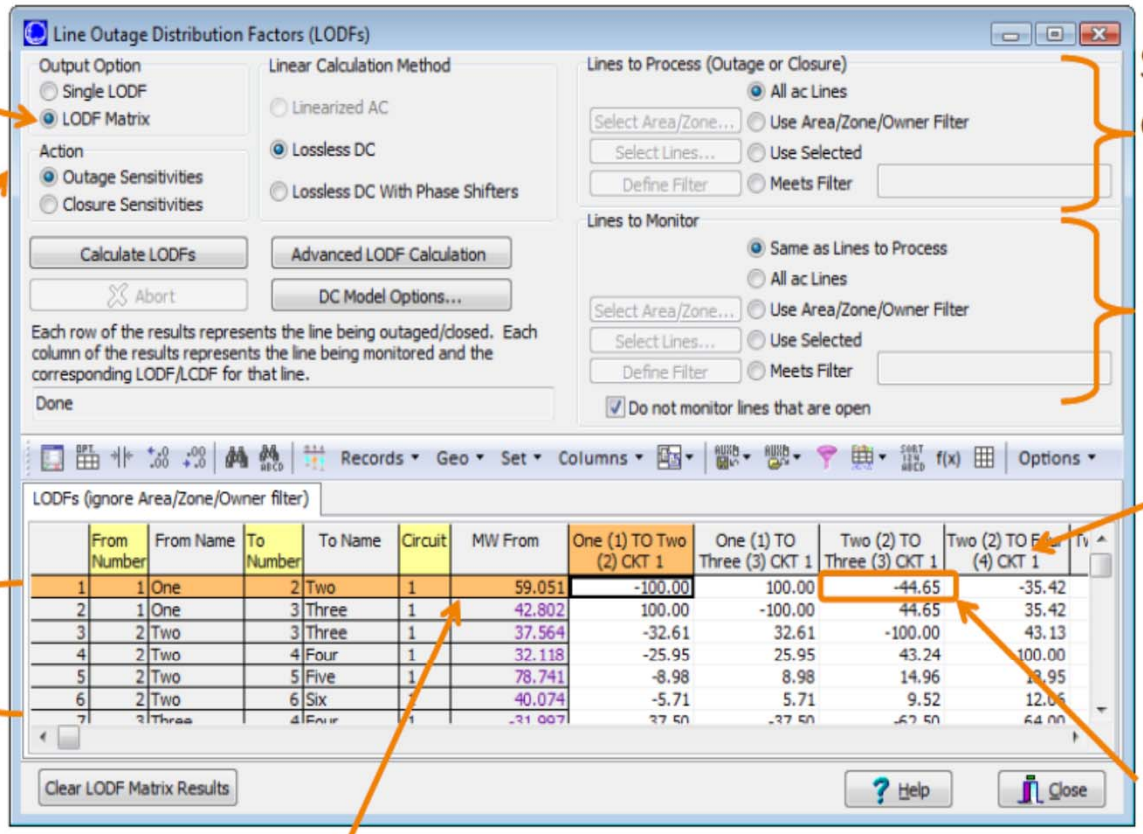
Present MW flow on line

Select lines to outage/close

Select lines to monitor

Lines to monitor

LODF on Line 2-3 for outage of Line 1-2




| | From Number | From Name | To Number | To Name | Circuit | MW From | One (1) TO Two (2) CKT 1 | One (1) TO Three (3) CKT 1 | Two (2) TO Three (3) CKT 1 | Two (2) TO F... (4) CKT 1 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | One | 2 | Two | 1 | 59.051 | -100.00 | 100.00 | -44.65 | -35.42 |
| 2 | 1 | One | 3 | Three | 1 | 42.802 | 100.00 | -100.00 | 44.65 | 35.42 |
| 3 | 2 | Two | 3 | Three | 1 | 37.564 | -32.61 | 32.61 | -100.00 | 43.13 |
| 4 | 2 | Two | 4 | Four | 1 | 32.118 | -25.95 | 25.95 | 43.24 | 100.00 |
| 5 | 2 | Two | 5 | Five | 1 | 78.741 | -8.98 | 8.98 | 14.96 | 18.95 |
| 6 | 2 | Two | 6 | Six | 1 | 40.074 | -5.71 | 5.71 | 9.52 | 12.06 |

# More Information

Good Tutorial available on the Powerworld website: http://www.powerworld.com

Under Training & Events, Online Training, in the Topic I11: Linear Sensitivity Analysis

# Questions?