Training Program on webNetUse for CERC

Sharing of inter-state transmission charges and losses CERC regulations 2010

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October 21-22, 2010

Outline

- Introduction to PAL
- Salient features of sharing of inter-state transmission charges and losses CERC regulations 2010
- Salient features of webNetUse
  - Load Flow Analysis
  - Transmission system Usage Cost Allocation
  - Transmission system Loss Allocation
- Case studies & demo
  - Five + two bus system
  - 11 bus test system
  - CERC Monsoon Peak Scenario
  - CERC Monsoon Off Peak Scenario
- Discussion

Training Agenda

Morning Session

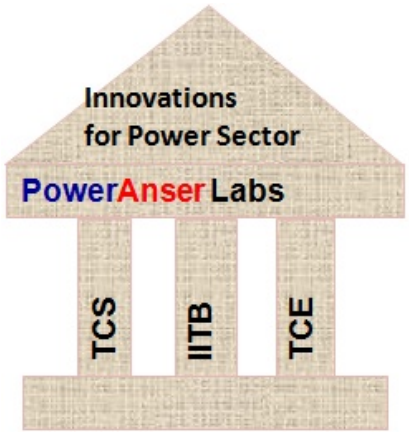
- Presentation by PAL
- webLFA

Afternoon Session

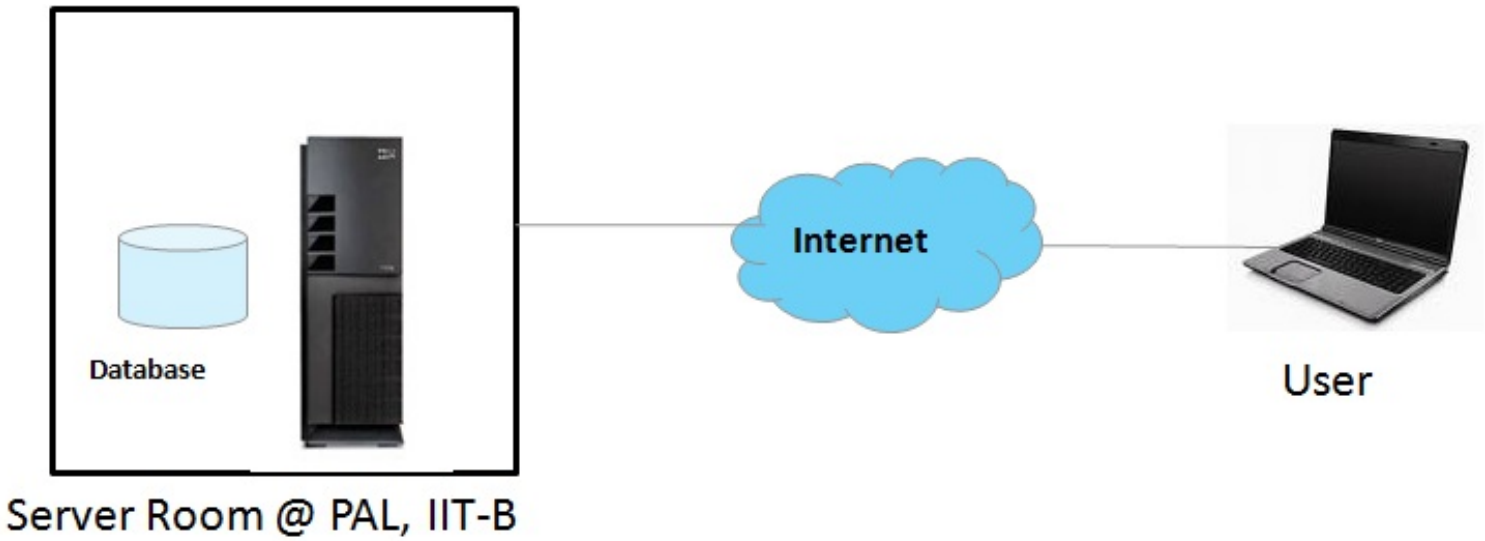
- NetUse (Cost Allocation)
- NetUse (Loss Allocation)

Introduction to PowerAnser Labs

- **Start date:** April 2, 2007
- **Purpose**
  - Conceptualizing & developing power system network analysis application services over the web; conduct joint R&D activities with TCS & TCE in the areas of mutual interest
  - Services meant to facilitate Open Access through state of the art applications and support
- **Areas of Interest**
  - Electric power system network analysis application functions including power markets area & delivery of these application functions services over the web
  - Current offerings of PAL- webLFA, webNetUse(Cost and Loss Allocation), webSTLF



Introduction to PowerAnser Labs (cont.)



Rationale for New Regulations

- Should meet the expectations of both utility and consumer i.e.,
  - Charges paid by the consumer should be based upon the extent of usage of the grid (consumer requirement)
  - Complete recovery of usage costs for approved assets should take place subject to availability guarantees (TRANSCO requirement)
  - Methods should be designed to encourage equity within usage based cost allocation framework (fairness requirement)
- Charges due to consumer should not be volatile
  - *Ex-ante computation of charges preferred to Ex-post calculations*
- **Simplicity** - the user only needs to provide details (forecast values) of MW injection/drawl and a software works out point of connection tariff/loss allocation factors
- **Transparency** -the complete methodology is available on CERC website

Rationale for New Regulations (cont.)

- Who should pay- source and/or sink ?
  - The bottom line is that a generator will always recover the cost it pays for the line usage from the load
  - Pricing load alone is called load neutrality principle
  - In India regulator has opted to price both generators and loads to unravel usage patterns which will lead to optimal usage of grid

Transmission System Usage Cost Allocation Methods

- MW-Mile based usage schemes
  - Marginal Participation Method
  - MP-AP approach
  - MP min-max approach
  - Tracing Method
  - Proportionate Tracing
- Cooperative Game Theoretic Methods
  - Shapley Value Computation
  - Nucleolus
  - Aumann Shapley Method
  - Minmax Fair Tracing Method

MW-Mile Cost Allocation Methods

- Usage based Cost Allocation Method
  - Cost of a line depends kV class, length of line, conductor configuration, terrain, year of commissioning of line etc.
    - A user using costly assets should pay more (and vice-versa).
  - Usage of network depends upon:
    - Point of Injection & drawal
    - Amount of MWs transacted and duration of transaction
    - Direction of flow
- Challenges
  - It is extremely difficult to quantify, uniquely, the MW-miles used by a transaction
  - When you buy or sell in a pool market, it is not possible to identify source-sink transactions
  - Calls for a PoC tariff mechanism

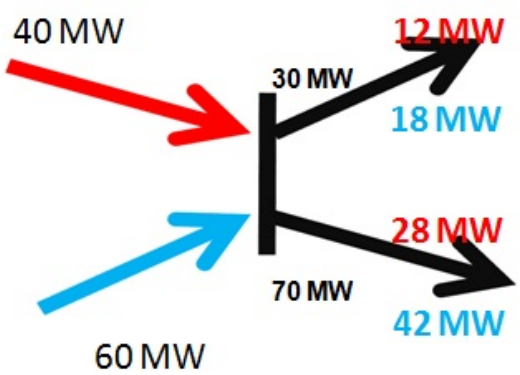
MW-Mile Cost Allocation Methods (cont.)

- For each line, compute the extent of usage of the line by each generator and load
  - While computing this usage, certain assumptions will be made in the design which should be clearly brought out, discussed and accepted across the board
- Recover the cost of line from an entity in proportion to the extend of usage
  - Average Participation approach
  - Marginal Participation approach
- Aggregate entity's usage cost and divide it by MWs injected or consumed and time duration leads to Point of Connection tariff (PoC)
  - At the same bus, PoC can be different for generators and loads
  - It can change with time
- A note of caution - transportation investments, reliability investments and inefficient investments cannot be distinguished

Principle of Tracing

- Flow on a line should be decomposed into
  - Commodity flows consisting of generators/loads.
  - The commodity flow should sum to the actual flow on the line.
    - Apply this for generator independently
    - Apply this for loads independently
  - The commodity flow should be in the direction of the actual flow on the line
  - Conservation of the commodity flow at a node:
    - Analogous to conservation of total flow at a node (Consequence of KCL)
  - Multiplicity in the solution space of tracing
    - Which tracing solution should be used for pricing?
- Two approaches feasible:
  - Local proportionate tracing method
  - Minmax fair tracing solution method

Average Participation Method



$$30 \times \frac{40}{(60+40)} = 12$$

- Also, known as proportionate tracing method
- Proposed by Kirschen in 1996
- The procedure assumes that the power reaching a certain node in the electric network is proportionately shared by all the paths going out from that node

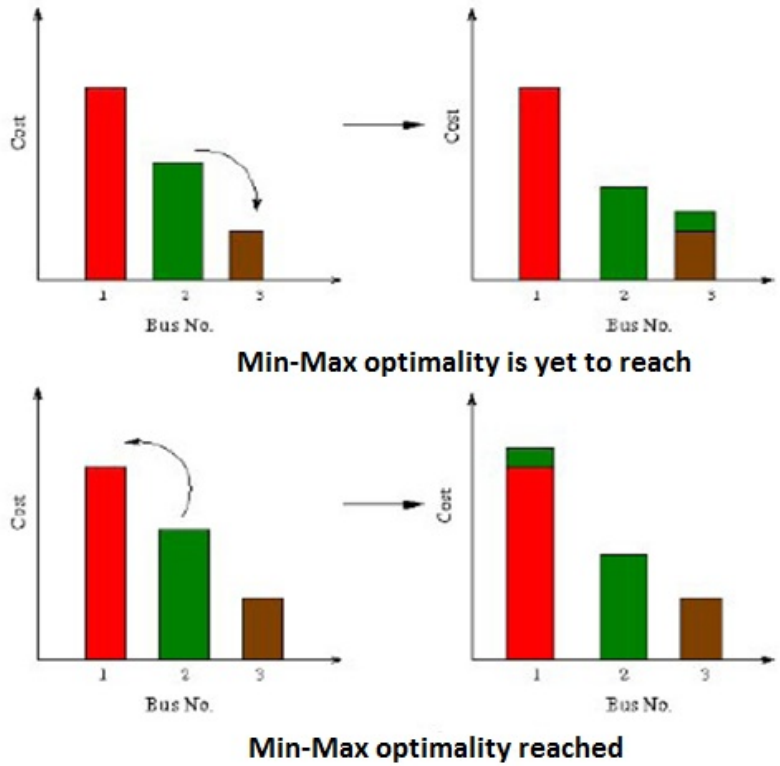
Critique of Tracing Approach

- Tracing solutions are superimposed upon load flow solution using principle of multi-commodity flow decomposition
  - This decomposition need not adhere to laws of Physics
- There is a multiplicity in solution space of tracing, different tracing rules will lead to different usage costs/PoC tariffs
  - Which solution would be a fair one?
    - AP rule quite arbitrary in nature
    - Min-max tracing is the resolves the fairness problem

Critique of Average Participation Method

- Term proportionate is misnomer, proportionate being used only in a local sense
- Greedy algorithm, the term being used in technical sense with reference to literature on algorithms in computer science
  - Fails on circular flows
- It has been observed that transiting networks end up with excessive payments
- Not fair as large price takers may have more favorable tracing solutions which reduce their POC

Min-Max Fairness

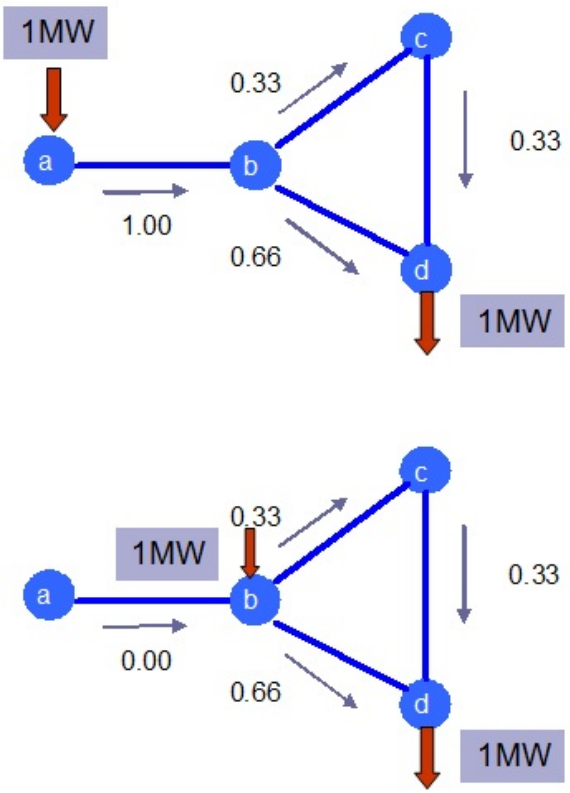


- It is achieved when no alternative can reduce PoC of a constituent without increasing PoC of another constituent which is equal or already higher. Meets rigors of fairness â
  - Equity
  - Usage based pricing e.g., with tracing
- Based upon the principle of minimum regret

For further reading

M. S. S. Rao, S. A. Soman, P. Chitkara, R. K. Gajbhiye, N. Hemachandra, and B. L. Menezes, Min-max Fair Power Flow Tracing for Transmission System Usage Cost Allocation: A Large System Perspective, IEEE Trans. Power Systems, vol.25, no.3, pp.1457-1468, Aug 2010

Marginal Participation Method- Line Wise



- Run the base case load flow
- For each source node (one at a time), increment injection by1 MW and rerun the load flow
  - Calculate the marginal flows for transmission lines resulting from this injection
- For each sink node (one at a time), increment drawal by1 MW and rerun the load flow
  - Calculate the marginal flows for transmission lines resulting from this drawal
- Recover the cost of the line from an entity in proportion to its marginal participation

This method is sensitive to the location of the slack bus

Marginal Participation Method

- Sharing charges in proportion to marginal flows alone ignores the magnitude of injection or drawal
  - Solution weigh the marginal flows by the MWs of injections and drawals
    - Fractional charge of the line cost to be borne by a load (L_i) for line (lm) is given by

$$\rho_{lm}^{L_i} = \frac{\Delta P_{lm}^{L_i} \times P_{L_i}}{\sum_j \Delta P_{lm}^{L_j} \times P_{L_j} + \sum_k \Delta P_{lm}^{G_k} \times P_{G_k}}$$

$$\forall \; P_{lm}^{L_j} > 0 \quad \& \quad \forall \; P_{lm}^{G_k} > 0$$

- If the marginal flow is negative, then entity will be paid and (vice-versa). This incentive will have to be borne by other payers of the network

Marginal Participation Method (cont.)

- Is this incentive required?
  - Negative marginal flows are also called as *counter flows*
  - Counter flows imply that if the corresponding load (or injection) is increased, then line loading will be reduce
    - A TRANSCO will like to encourage such drawals to reduce line loading, reduce losses and improve security
    - At the same time, an end user would not like pay these incentive
- A fair solution is to exempt counter flows from payment of line charges but not make other uses pay them incentive

Issue with Choice of Slack Bus

- Extent of usage evaluation directly dependent upon choice of slack bus
- If the slack bus is nearby, then marginal usage reduces and vice-versa
- How to be fair in the choice of slack bus?

Dispersed slack bus

Choice 1: One slack bus for all loads and one slack for all generators

- 1 MW incremental injection to loads in proportion to base case injections
- 1 MW incremental drawal in proportion to base case generation

Choice 2: From AP method - tailor made slack buses for each entity

- From tracing determine participation factors for loads and generators
  - Generator tracing will lead to load dispersion factors
  - Load tracing will lead to generation dispersion factors
  - Each entity disperses its incremental MW in proportion to these dispersion factors

Choice 3: From min-max principle

- Improves equity in PoC

Modeling of HVDC Lines in MP Method

- Flow on HVDC lines is set by the power order
- Hence, marginal participation of the HVDC lines is zero
- Regulations prescribe a with & without usage scheme to model HVDC lines in the MP method
  - Consider a base case with all HVDC lines in service
  - Compute usage cost of each entity
    - This is the usage cost (entity wise) for the AC network
  - Now simulate flows with an single HVDC outage
    - Again compute the usage cost of each entity
    - Share the cost of the HVDC line in proportion to the increase in usage cost

      # Exempt those users from sharing the HVDC line cost whose usage cost reduces in the 'without' scenario

Cost Allocation vs. Loss Allocation Problem

- Losses increase in quadratic proportion to current
- Loss evaluation requires ac load flow solution
- Transmission system usage cost allocation can be done using dc load flow as usage costs are always calculated on MWs transacted and not MVAR transacted
- AC load flow based usage cost allocation will improve accuracy

Salient Features of Hybrid Methodology

- Based upon AC load flow methodology
- Uses MP method with dispersed slack bus selection by AP method
- Each year is divided into multiple intervals (5) with two typical.
- PoC calculation is done ex-ante
- Loss allocation to be also done by AP-MP method
- Obtain PoC tariff (or loss factors) for each bus in the network
- In a PX scenario an injection will pay generator PoC and load will pay load PoC
- A bilateral transaction will have transmission charges which are sum of load and injection PoCs

Sharing of Inter State Transmission Charges and Losses- CERC Regulations, 2010

- Regulations No.L-1/44/2010-CERC dated June 15, 2010
- Applies to all Designated ISTS Customers, Inter State Transmission Licensees, NLDC, RLDC, SLDCs, and RPCs
- Comes into force from Jan. 1, 2011 - remain in force for 5 years
- Some key definitions (details on Pages-1 to 4 of the Order):
  - **Hybrid Methodology** means the hybrid of the Marginal Participation Method and the Average Participation method
  - **Loss Allocation Factor (LAF)** of a bus measures the losses attributed to that node
  - **Point of Connection (PoC) Charging Method** shall mean the methodology of computation of sharing of ISTS charges and losses
  - **Point of Connection (PoC) transmission charges** are the nodal / zonal charges determined using the Point of Connection charging method

Sharing of Inter State Transmission Charges and Losses- CERC Regulations, 2010 (cont.)

- **Yearly Transmission Charge (YTC)** means the Annual Transmission Charges for existing lines determined by the Commission

- Based on the YTC of ISTS, the PoC & LAF shall be computed
  - Using load-flow based methods; and
  - based on the Point of Connection Charging method
- Sharing of ISTS transmission charges shall determined in advance and shall be subject to periodic true-up
- PoC transmission charges shall be computed in terms of Rupees per MW per month - for short term open access transaction, it shall be in terms of Rupees per MW per hour
- ISTS energy losses shall be apportioned based on the LAF determined using the Hybrid methodology

Sharing of Inter State Transmission Charges and Losses- CERC Regulations, 2010 (cont.)

- PoC shall be computed normally for peak (8 hours) & other than peak hours for each block of: Apr to Jun; Jul to Sep; Oct to Nov; Dec to Feb; & Mar. For ex-ante computations, peak & other-than-peak can be based on load conditions
- While transiting to the new PoC method for YTC recovery, for the first 2 years, 50% of YTC shall be recovered using Hybrid Methodology & 50% using the Uniform Charge sharing method (Postage Stamp method)- after 2 years, the weightages shall be reviewed. Similarly for loss allocation too
- No ISTS transmission charges & losses for solar based generation
- Each ISTS Customer to provide details of the network dataset models on or before the 4th week of November in each FY
  - Requirement is injection/drawal forecasted values
  - For injections below the forecast , payments are by the forecasted values

Sharing of Inter State Transmission Charges and Losses- CERC Regulations, 2010 (cont.)

- In case the metered MWs (ex-bus) of a power station or the aggregate demand of a Designated ISTS Customer exceeds, in any time block, then
  - for first 20% deviation in any time block, the Designated ISTS Customer shall be required to pay transmission charges for excess generation or demand at the same rate and
  - beyond this limit, the Designated ISTS Customer shall be required to pay additional transmission charges which shall be 25% above the zonal Point of Connection charges determined for zone where the Designated ISTS Customer is physically located.
- Information to be published by the Implementing Agency shall include:
  - Approved Basic Network Data, base load flows, & Assumptions, if any;
  - Zonal or nodal transmission charges for the next financial year differentiated by block of months;
  - Zonal or nodal transmission losses data;
  - Schedule of charges payable by each constituent for the future Application Period, after undertaking necessary true-up of costs as per the regulations & detailed procedures

THANKS

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