

Network Modeling for EPS Metering with Loss Compensation

Background Information

The following aspects of net metering facilities have been considered:

- NPRR 035 has proposed the methodology for settlements for net metering facilities including calculation of SPPs for EPS meters as time weighted LMPs for net load and Base Point weighted LMPs for net generation
- Calculation of LMPs for EPS meters with multiple Current Transformers (CT) is the aggregate of LMPs at the CT locations weighted by SE power flows across the CTs
- Procedures for Resource Node Definition provide the principles and procedures for determination of Electrical Buses that are specified as Resource Nodes where SPPs are calculated.

This background information is used here without specification of already proposed solutions. This proposal considers additional settlement aspects of net metering facilities with loss compensation. Variety of EPS meter arrangements and loss compensation methods are considered into details.

1. Line Loss Compensation

In some EPS metering facilities the meters are compensated for line losses. The EPS meters are physically located at one network location while they effectively meter energy at another network location. The line losses between these two network nodes are included in the meters energy measurements. To maintain consistency between metered energy and EPS meter prices the LMPs at effective metering locations should be considered as EPS meter LMPs.

A typical net metering arrangement with line loss compensation is illustrated in figure 1.

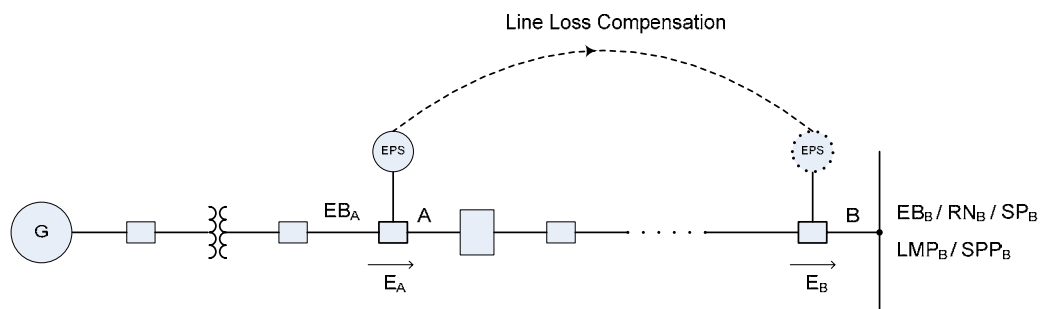


Figure 1: EPS Meter with Line Loss Compensation

Network Modeling for EPS Metering with Loss Compensation

The EPS meter is physically located at Electrical Bus EB_A . Physical energy E_A is compensated for transmission line losses between Electrical Bus A and Electrical Bus B, i.e. the EPS meter effectively meters energy E_B . The Electrical Bus B should be specified as Resource Node for generator G and Settlement Point for generator G and EPS meter. The LMP_B at Electrical Bus B should be used to calculate Settlement Point Price for EPS meter due to line loss compensation.

Within CIM network model the EPS meter should be connected at Electrical Bus B where energy is effectively metered. In this case all downstream applications will properly calculate settlement determinants for generator G and associated EPS meter.

If Electrical Bus B represents a T-connection of transmission lines, then this T-connection could be represented in network model as separate sub-station or as a part of the existing substation. In any case, the Electrical Bus B should be accommodated and specified as Resource Node and Settlement Point.

2. Transformer Loss Compensation

In some EPS metering facilities the meters are compensated for transformer losses. The EPS meters are physically located at the low side of a transformer winding while they effectively meter energy at the high side of the transformer. The transformer losses between these two network nodes are included in the meters energy measurements. To maintain consistency between metered energy and EPS meter prices the LMPs at effective metering locations should be considered as EPS meter LMPs.

A typical net metering arrangement with transformer loss compensation is illustrated in figure 2.

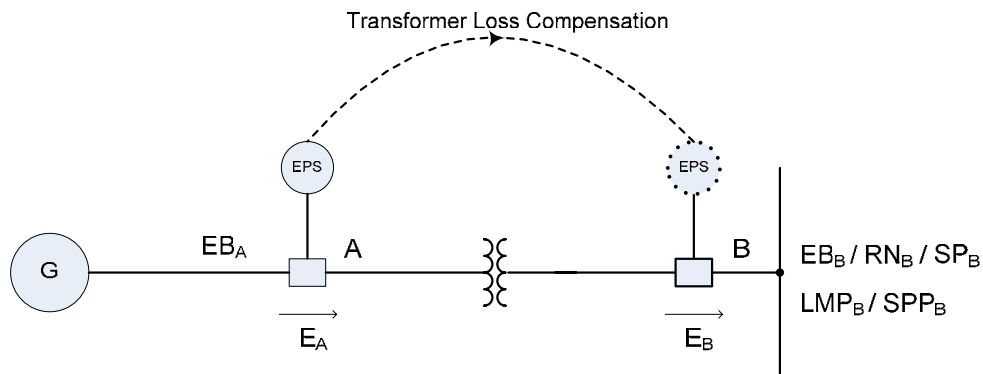


Figure 2: EPS Meter with Transformer Loss Compensation

Network Modeling for EPS Metering with Loss Compensation

The EPS meter is physically located at Electrical Bus EB_A . Physical energy E_A is compensated for transformer losses between Electrical Bus A and Electrical Bus B, i.e. the EPS meter effectively meters energy E_B . The Electrical Bus B should be specified as Resource Node for generator G and Settlement Point for generator G and EPS meter. The LMP_B at Electrical Bus B should be used to calculate Settlement Point Price for EPS meter due to transformer loss compensation.

Within CIM network model the EPS meter should be connected at Electrical Bus B where energy is effectively metered. In this case all downstream applications will properly calculate settlement determinants for generator G and associated EPS meter.

3. Representation of an Auto-Transformer with a Tertiary Winding in the Network Model

An auto-transformer with tertiary winding is represented in network model as three two-winding transformers in T-arrangement as it is illustrated in figure 3:

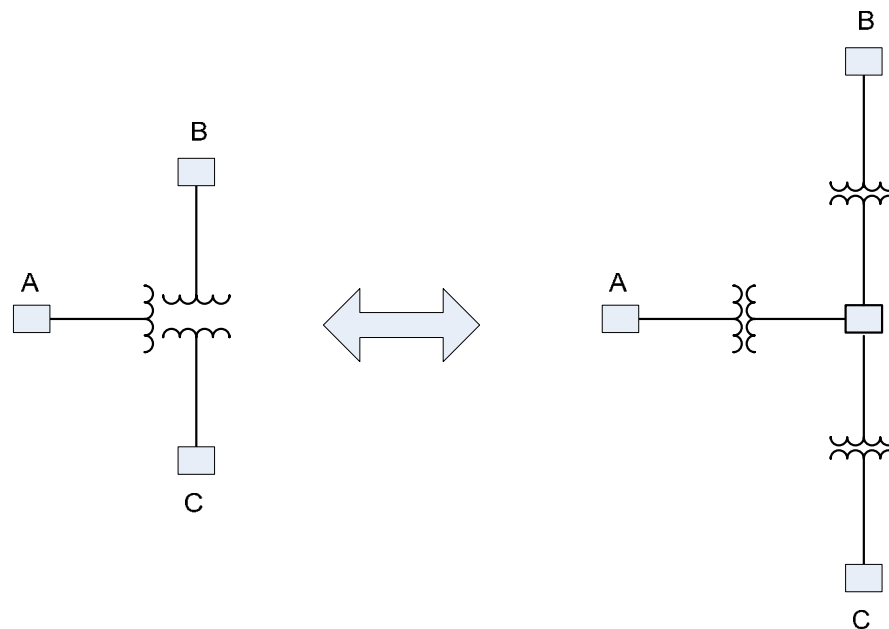


Figure 3: Network Model for Auto-Transformer with Tertiary Winding

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4. Loss Compensation for Auto-Transformers with Tertiary Winding

There are net metering facilities where a generator is connected at transformer tertiary winding and EPS meter is compensated for only copper losses in tertiary winding. The energy is effectively metered at the middle point of transformer T-representation.

For metered energy the LMP at the middle point is needed. But current CIM data model can not accommodate Electrical Bus at the middle point. Even if the CIM data model is extended the downstream systems are not capable to handle this data structure. For these reasons the EPS meter is represented in network model at its physical location, i.e. at low side of the transformer.

A typical net metering arrangement with partial loss compensation is illustrated by figures 4a and 4b:

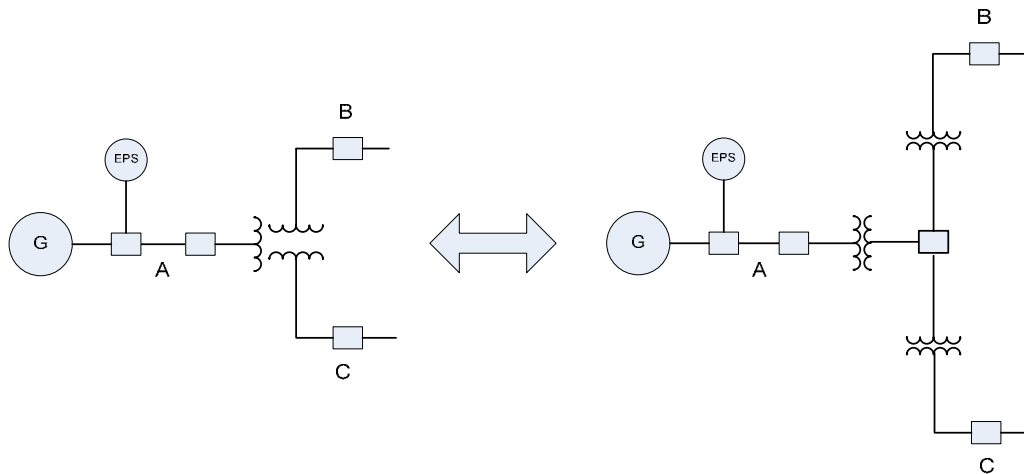


Figure 4a: EPS Meter with Partial Loss Compensation - Generation

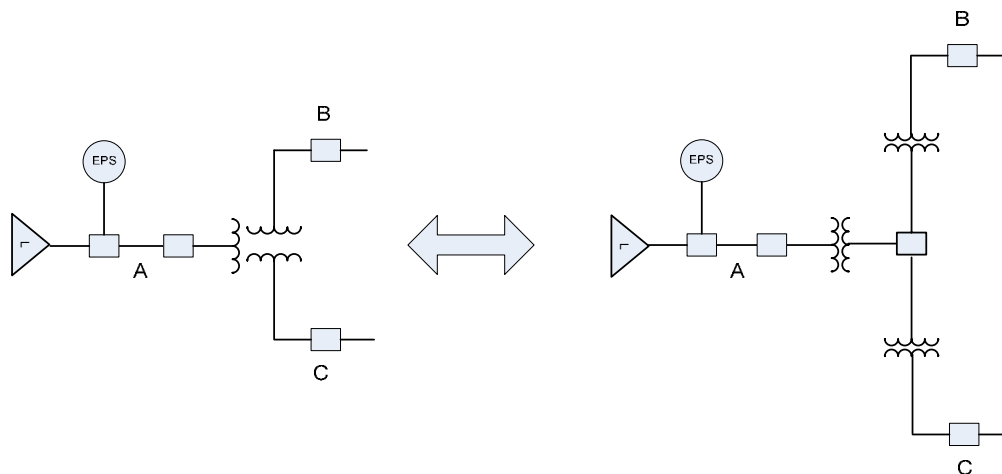


Figure 4b: EPS Meter with Partial Loss Compensation Load Point

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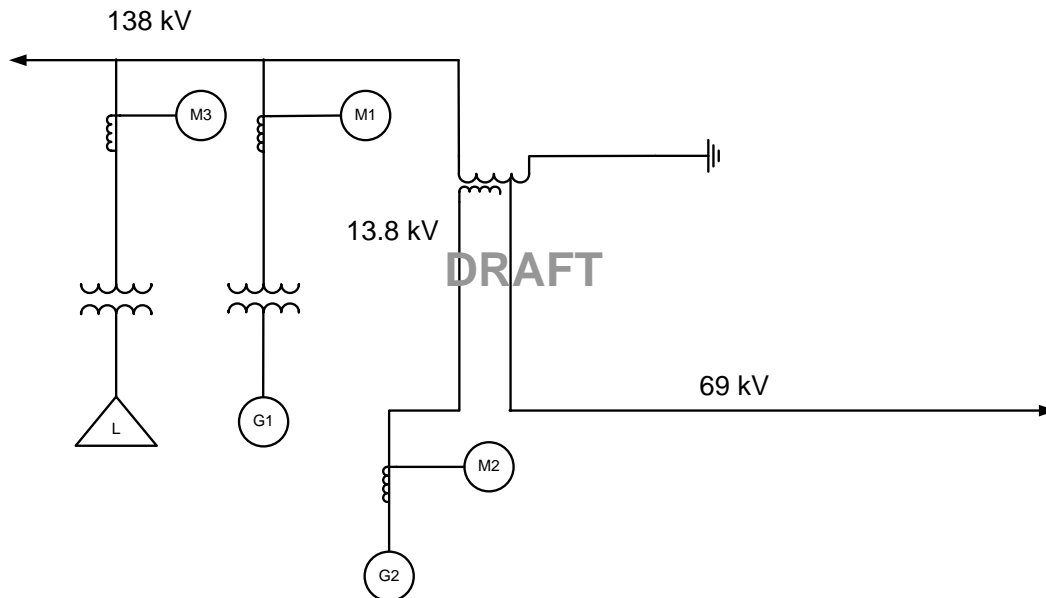
The physical EPS meter is represented in network model and treated as any other EPS meter with single Current Transformer. An Electrical Bus, Resource Node and Settlement Point are created at low side, i.e. at location A where EPS meter LMP and SPP are calculated.

In this arrangement, the tertiary winding is treated as part of transmission system because it is owned and operated by a TDSP. That means, the limitation of power flow across all three windings including tertiary winding can be enforced. If the tertiary winding limit is the binding constraint, then LMP at EPS meter location will be lower for generators than LMP at the middle point of the transformer.

To avoid this LMP differential, the power flow across tertiary winding can be limited by generator power output. That means eventual limitation of power flow across tertiary winding can be enforced by setting generation HSL below the tertiary winding limit. In this case, the LMP at low side of transformer will be equal to the LMP at the middle point of the transformer.

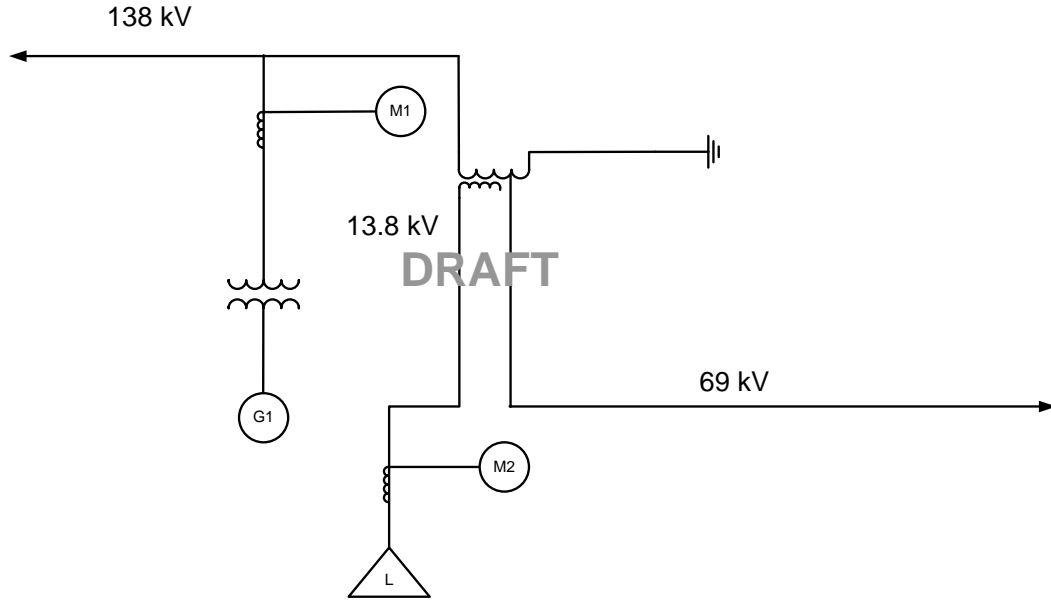
5. Some typical drawings previously discussed with TPTF that depict the scenario with EPS metering on the tertiary winding of auto-transformers are shown below.

Net Metering with Interconnection to the Transmission Grid at Different Transmission Voltages (Method K)



Network Modeling for EPS Metering with Loss Compensation

Net Metering with Interconnection to the Transmission Grid at Different Transmission Voltages (Method L)



Net Metering with Interconnection to the Transmission Grid at Different Transmission Voltages (Method M)

