Intelligent Energy Systems

17 July 2019

Mr Andrew Splatt
Project Leader
Australian Energy Market Commission

Dear Mr Splat

AEMC Ref: ERC0251: Transmission Loss Factors

Intelligent Energy Systems (IES) has already submitted a response to the Consultation Paper issued by the AEMC on the above proposed rule change. We include now some additional technical detail on the approach proposed in that response.

We recommend that AEMO arrange to prototype the approach outlined before a final decision is made.

I would be pleased to answer any further questions you may have.

Yours sincerely

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Adding Quadratic Loss Modelling within Regions to NEMDE

1 Background

The proposition is to add a quadratic, variable loss factor capability within NEMDE with minimal changes to the underlying NEMDE model. Building quadratic losses into NEMDE eliminates the risk of instability if MLFs were to be based on the results of the previous dispatch interval.

2 Outline of Implementation Procedure

2.1 Single Region Case

Imagine single region as modelled within NEMDE:

1. Don't divide by MLF as per current practice; MLFs will be calculated using a DC power flow model external to NEMDE and dispatch results from NEMDE.
2. Add a linear loss variable to the energy balance equation.
3. Add a new equation defining losses as a function of injections and offtakes, defined as an n-dimensional variable given by vector **x,** where:

    Losses - **x**'*M***x**
    M is a square, symmetric and positive semidefinite matrix of dimension nxn
    This gives losses as a quadratic form based on Matrix M, which is directly calculable from a DC power flow representation of the network, easily updateable if required in the few seconds prior to each dispatch interval.
4. Estimate the non-dispatchable elements of **x** and solve for the remainder in NEMDE.
5. Estimate the marginal loss factor vector as 2*M***xs** where xs is the solution.
6. Settle the period based on the shadow price of the energy balance constraint and the MLFs as calculated above.

Some minor adjustment to forecasting procedure may be desirable which can be determined at the prototyping stage.

2.2 Multi-Region Case

There are several approaches one could take to deal with the NEM's multiple regions:

1. Implement real time regional MLFs and retain current approach to inter-regional losses.
2. Recognising that we can now model real time quadratic losses, model quadratic inter-regional losses directly while retaining regional energy balance constraints for regional pricing.
3. Recognising that we can now model real time quadratic losses, model quadratic inter-regional losses directly while maintaining a single energy balance constraint and generating efficient regional prices.

While any of these approached could be feasible, the last has some useful properties and will be outlined in a little more detail.

1. Implement the NEMDE model with a single energy balance constraint, essentially as outlined in Section 2.1.
2. Define regional prices as the weighted sum of all the shadow prices affecting each regional reference node. Prototyping might highlight some need to re-orient some constraints or undertake other measures to make this work.
3. Regional prices differences and flows across inter-region cut-sets should leave the in-IRSR and auctions essentially unchanged.

3 Implementation Issues

Some issues are noted below but are best resolved through prototyping.

1. The modest additions to the NEMDE formulation described convert the problem from a linear to a simple semi-definite structure. Such a problem is solvable using highly reliable quadratic procedures (standard in commercial solvers), provided one maintains positive semi-definiteness of M. The only case where this might be an issue is when some regional prices are negative, in which case the problem structure offers a very direct fix. All this needs prototyping.
2. Is DC power flow model adequate for calculating marginal losses and, specifically, determining the matrix M? It is surely orders of magnitude better than any averaging methodology based on AC power flow modelling. Estimating M by incremental analysis of an AC model would be too time-consuming. The DC approximation could be improved by using measured or estimated 5 minute voltages.
3. Forecasting methodology could be due for an overhaul with an MLF fix, even more so as variable and uncertain renewables make estimating load by measuring generation more problematic.
4. One very large advantage of using DC power flow logic is that the factors used in N-1 thermal contingency modelling can be calculated directly and efficiently in seconds, even starting from scratch, for all possible combinations of line failure and line impact (most of which would not generate a constraint). Again, this can be prototyped to test speed and accuracy.
5. How does one deal with non-scheduled inputs/outputs? Using matrix M they can be aggregated into each dispatchable MLF, given suitable estimates. Requires thought and prototyping.
6. Is here merit in restricting the variable MLFs to those situations where the variability appears to matter? Prototyping using real data is required.

CHB

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