Appendix G

Transmission & Distribution Work Group Report

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Michigan Capacity Need Forum:
Transmission & Distribution Work Group Report

Michigan Transmission Assessment for 2009

January 2006

Copies of this report are available from the Michigan Public Service Commission's Web site, at: http://www.dleg.state.mi.us/mpsc/electric/capacity/cnf.

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1 Executive Summary

The Transmission and Distribution Work Group was responsible for estimating the transmission import capability into Michigan for the Capacity Needs Forum. The Work Group was assigned the added task of identifying transmission upgrades that could be implemented to increase transmission transfer capability within Michigan and into Michigan. Finally, the Work Group also reviewed issues that may have an impact on the State's ability to utilize or expand the transmission system.

The Work Group focused on the projected 2009 summer peak electric demand condition and found:

- Approximately 3,000 MWs of power can be imported into the Lower Peninsula of Michigan under peak load conditions, if only "thermal" transmission facility limits are considered and when there is no power flow from Michigan to Ontario;
- Approximately 400 MWs of power can be imported into the Upper Peninsula of Michigan under peak load conditions, if only "thermal" transmission facility limits are considered;
- There is a significant reduction in Michigan import capability if power is flowing from Michigan to Canada (Michigan import capability is reduced approximately 1 MW for every 1 MW of power flow to Ontario);
- Voltage limitations may exist that restrict import capability more than "thermal" limits;
- Transmission upgrades that significantly increase import capability can be made within Michigan;
- Both real and reactive losses will significantly increase as the import level into Michigan increases and the greater the distance between generation and load.

Two groups of transmission system upgrades – TIER I and TIER II – were developed to mitigate "thermal" facility limits and increase transmission import capability. Transmission system upgrades to improve transmission system voltage performance were not developed as part of the CNF effort. However, it is expected that the TIER II upgrades would improve the transmission system voltage performance at a given transfer level (TIER I upgrades are expected to have little voltage impact, therefore, additional projects may be needed to achieve the appropriate voltage performance). TIER I upgrades consist of new transmission facilities in the ITC transmission system that are designed to (1) increase transmission import capability across Michigan into the ITC footprint from the METC footprint by approximately 1,000 MWs for approximately $50 million in transmission facility investment and (2) increase transmission import capability into the Lower Peninsula of Michigan by 1,000 MWs for an additional estimated $50 million investment. In other words, transfer capability within Michigan and into Michigan can be improved by 1,000 MWs for approximately $100 million under peak load conditions. TIER II upgrades consisted of major transmission system expansion into or across the lower portion of the Lower Peninsula of Michigan. The TIER II projects are designed to further increase transmission import capability into the Lower Peninsula of Michigan. TIER II upgrades would increase import capability by 2,500 MWs total (1,500 MWs above that achieved by the TIER I upgrades) for an approximate $500 to $700 million investment.

2 Introduction

The Transmission and Distribution Work Group was responsible for:

1. Estimating the transmission import capability into Michigan in 2009 with no transmission system modifications above those planned or proposed in the 2005 Midwest ISO Transmission Expansion Plan (MTEP);
2. Identifying transmission upgrades that may be available to increase transmission transfer capability within Michigan and into Michigan;
3. Reviewing issues that may have an impact on the State's ability to utilize or expand its transmission system.

The initial focus of the transmission capabilities study was to determine the amount of transmission import capability into Michigan for the year 2009 given the transmission system planned and proposed to be in place at that time. For the purposes of this study, Michigan was divided into three regions: International Transmission Company (ITC), Michigan Electric Transmission Company (METC) and American Transmission Company "zone 2" (ATC-z2)[1] footprints in the State. Imports into the portion of southwestern Michigan served by American Electric Power (AEP) were not studied. Generation in the Michigan portion of AEP (I&M) far exceeds the load in that area, as does the transfer capability of the transmission system in that portion of I&M's service territory.

The transmission regions defined in the study are "geographical" areas. In the Lower Peninsula, there is substantial overlap between ITC and the Detroit Edison service territory and between METC and the Consumers Energy service territory. However, in some cases, distribution utilities own generation in one transmission region, but serve load outside its "primary" transmission region (or may not own all the generation or serve all the load within its "primary" transmission region). Therefore, the transmission area numbers reported herein cannot be applied to the associated load serving utility. For example, the base case power flow model assumptions for these studies include 1,860 MWs of power imports into ITC. This does not mean, however, that Detroit Edison's load exceeds its generation by 1,860 MWs under the base case conditions. In fact, Detroit Edison owns approximately 900 MWs of capacity at the Ludington pumped storage facility that is not included as capacity within the ITC footprint while MPPA and WPSC in the METC footprint own and/or have purchased over 400 MW of Detroit Edison's generating capacity. In addition, up to 1,500 MW of load in the Detroit Edison area is served by alternative suppliers. Some, if not most, of these suppliers procure power from outside of the Detroit Edison area and this adds to the imbalance between load and generation in this particular geographical area.

For convenience, this report may refer to ITC, METC, ATC-z2, or MECS "imports". These transmission companies are not actually contracting for those imports. Instead,

[1] American Transmission Company serves more than Michigan, this study focused on an area ATC refers to as "zone 2" which largely lies within the Upper Peninsula of the state.

this convention was adopted as a more convenient way of stating "imports into the area served by" ITC, METC, ATC-z2, or MECS".

After determining the amount of transmission import capability into Michigan for the year 2009, given the transmission system planned and proposed for that time, the Work Group began analyzing conceptual transmission system enhancements designed to achieve certain import capability targets. These analyses were performed to provide a rough estimate of the transmission transfer expansion that might be achievable for various levels of investment and to provide an indication of the types of system upgrades that might be involved. Much more detailed analysis would be needed (including a more robust review of alternatives) before any of the conceptual transmission system enhancements could be considered as proposed projects for purposes of transmission planning. Some of the alternatives considered were major new additions, and as such, they could have an impact over a broad area. The full impact of these enhancements would need to be studied more thoroughly (including analysis of resultant system voltages and losses), if they were selected as resource options.

The analyses were performed using the MISO 2005 transmission expansion plan power flow model that included all the planned and proposed transmission system upgrades that are contained in the MISO 2005 MTEP, Appendix A. Electric load modeled for the Michigan companies (except for the Michigan portion of AEP) reflected the peak electric demand forecasted by the Demand Work Group.

Michigan's electric transmission network is a portion of a very large and complex electrical system comprising North America's eastern interconnect. Flows through the transmission system (and the ability to move power from one point to another) can be influenced by many factors. The physical factors that influence flows through the transmission system include the amount and location of electric load across geographical areas, the amount and location of operating generation across the geographical areas, and the addition or retirement of new transmission facilities in Michigan or surrounding states or provinces. In turn, these physical factors are influenced by the local market and the amount of local load being served by imports and suppliers as well as by the other markets in the region including those in MISO, PJM and Ontario. Changes in the assumptions surrounding these variables can and do change transfer capability results. As part of the effort to review issues that may have an impact on the State's ability to utilize or expand the transmission system, the Transmission and Distribution Work Group attempted to identify sensitivities to the most critical variables (large generator outages and flows due to non-Michigan load and generation). However, it is possible that the actual transfer capabilities could differ significantly from those estimated in this report. This is especially true because of the forward looking nature of this analysis and the assumption that all of the planned and proposed projects in the MISO MTEP 05 will be constructed and operational by the end of 2009.

This report focuses on import capability into Michigan. It should be noted that import capabilities can differ depending on whether the imports are occurring for reliability purposes or for economic purposes. For example, when imports into an area are needed to maintain service to load ("reliability"), the likely condition causing the need is a large, perhaps multiple large, generating unit that is not available (that is forced off-line). In general, large units tend to be more economical on a marginal cost basis and, therefore, operate when available – assuming sufficient energy is needed. On the other hand, if transfers are occurring for economic purposes, it is likely that a collection of the smaller units may not be operating. Scenarios with large units out ("reliability") can result in different import capabilities than scenarios with small unit outages ("economics"). Further, unit outages in neighboring regions (Ohio, Indiana, METC when considering ITC, etc.) have an impact on transfer capability into a study region. It is possible that a neighboring region has a large unit forced off-line at the same time there is a need for imports to support reliability needs within a study region. The probability of this occurring, however, is expected to be lower than other contingencies reviewed by this study. It may prove valuable, on the other hand, to determine a study area's import capability for economic purposes under a neighboring area's large unit -out scenario. Given the study's schedule, it was not possible to look at "reliability" and "economic" scenarios separately. The Transmission and Distribution Work Group study focused on "reliability."

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3 Major Assumptions

In order to keep the scope of the studies manageable within the CNF's schedule, the Transmission and Distribution Work Group made several assumptions. Major assumptions are:

- "The market will provide" – there will be sufficient generation capacity outside Michigan available as a source to be brought through the transmission system.
- For imports into the Lower Peninsula, there is sufficient transmission capacity outside of the AEP, FE, ITC and METC (the Lower Peninsula study area) to allow outside generation capacity to get into that study area.
- For imports into the Upper Peninsula, there is sufficient transmission capacity outside of ATC, MAIN, ITC and METC (the Upper Peninsula study area) to allow outside generation capacity to get into that study area.
- Any transfer capability impacts of additional generation in Michigan are either negligible or would be mitigated by transmission upgrades (in other words, new generation and associated transmission added will not result in a net change in transfer capabilities).
- All "planned" and "proposed" projects listed in Appendix A of the 2005 MISO Transmission Expansion Plan are implemented[2]. These are the projects that have been identified to enhance MISO system performance. Listed below are projects of particular significance to the Upper and/or Lower Peninsula of Michigan import capability that have been included in the study.

    - Morgan-Falls-Pioneer-Stiles 138 kV rebuild
    - Plains-Stiles 138 kV double circuit rebuild
    - West Marinette-Amberg 69 kV to 138 kV voltage conversion
    - Gardner Park two 345/115 kV transformers
    - Cranberry-Conover-Plains 138 kV
    - Indian Lk-Hiawatha 138 kV double circuit
    - Hiawatha-Pine River-Straits 69 kV to 138 kV voltage conversion
    - Tippy- Hodenpyl 138 kV rebuild
    - North Belding-Eureka 138kV rebuild
    - American Bumper-David Junction 138kV rebuild
    - Tallmadge 345/138kV third transformer
    - Edenville Junction-Warren 138kV rebuild

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[2] The Morgan-Werner West 345 kV project, a significant component of ATC's Northern Umbrella Plan, was not included in the study due to the fact the new project is for a winter 2009 completion date.

- Mullins-Wealthy 138kV rebuild
- Battle Creek-Morrow 138kV rebuild
- Brickyard-Felch Road 138kV rebuild
- Stover-Clearwater 138 kV rebuild
- Thetford transformer reactors
- Almeda-Saginaw River 138 kV rebuild
- Four Mile-Mullins 138 kV rebuild
- Keystone-Clearwater 138 kV rebuild
- Gaylord-Livingston 138 kV rebuild
- David Junction-Bingham 138 kV rebuild
- Barnum Junction-Verona 138 kV rebuild
- Sag clearance improvement on several 138 & 345 kV lines
- Numerous capacitor additions
- Numerous terminal upgrades and CT changes
- West Thumb Loop rebuild
- Wixom-Quaker 230 kV
- Majestic 345/120 kV transformer and Majestic-Madrid 120 kV
- Bismarck-Troy 345 kV

- Limited consideration was given to facility constructability – however, in general, uncertainty over the ability to construct did not preclude inclusion of a conceptual future project.
- A reasonable approximation of the projected 2009 off-peak conditions in Michigan could be achievable by reducing load in the relevant area and altering the generation units dispatched to meet load.
- The phase shifters controlling the Michigan-Ontario interface have adequate phase angle range to control the flow. If they are not able to control flow, at least they are able to reduce flow from East to West[3] across Ontario such that facilities on that path would not be limiting.

[3] The inability of the phase shifters to control flow west to east (more west to east flow than targeted) would not be expected to result in causing facilities on the Ontario path to be limiting. However, as noted in this report, flow from Michigan to Ontario increases loadings on the facilities through which Michigan imports flow. Therefore, this condition would result in a decrease in Michigan import capability relative to what it would be if the phase shifters were able to control west to east flow to the targeted level.

4 Study Results

The results discussed in this section are the total transfer capabilities into the three regions discussed previously. Caution must be used when considering these numbers because transfer capabilities are identified for regions separately, but it is not possible to simultaneously achieve all these transfers. For example, the imports into METC may be reported as X while the imports into ITC are Y. The imports into the combined METC and ITC areas (MECS) would not be X + Y. Rather imports into MECS were determined independently and reported as into MECS. In the peak base case, there are significant imports into ITC and exports from METC. The base case METC import numbers have been "normalized" so that they reflect how much METC could import if there were no simultaneous imports into ITC. Similarly, in the peak base case, flows are coming out of the METC area and the ITC numbers were "normalized" to reflect how much ITC could import if METC were not exporting in the base case.

The study included sensitivity runs to analyze the impacts of simultaneous outages of major generating units in the area immediately surrounding Michigan, including the impact of the generating units which are in Michigan, but are owned and operated by AEP. When these external generating units are forced off-line, transfer limits are created outside of Michigan that are close to the limits within Michigan. Under certain conditions, it is possible that if these external generating units were not dispatched, they could restrict imports into Michigan. Further, for generating unit outages in the portion of the study with conceptual transmission upgrades identified, these limits could limit transfer capabilities into Michigan. While this is a possible simultaneous condition (non-Michigan generator out with heavy transfers into Michigan), the transfers are reported with the non-Michigan generator in-service. This assumption is supported by additional analysis that indicates these generator outages could be mitigated by redispatching limited remaining non-Michigan generators in a manner different than that reflected in the study case.

The base analysis was performed with the flows between Michigan and Ontario held to 0 MW by phase angle regulating transformers (phase shifters). A sensitivity analysis was also performed by assuming a 1,500 MWs flow from Michigan to Ontario (again flow is held by phase shifters). The analysis revealed that a nearly one-for-one correlation exists between flows to Ontario and Michigan import capabilities. When flows from Michigan to Ontario increase from 0 to 1,500 MWs, transfer capabilities into Michigan are reduced by approximately 1,500 MWs. Without the phase shifter control, imports into Michigan flow partly through Ontario. It is possible that the Ontario system or the International Transmission Company ties to Ontario could limit transfer capabilities, particularly if Ontario is simultaneously importing (eastern Ontario facilities might limit) or if there are significant east to west loop flows (western Ontario facilities or International Transmission Company ties to Ontario could limit). The "no phase shifter control", or free flow, scenario was not studied.

The spider diagram attached as Chart 1 reveals transfer capabilities based on thermal limits resulting from the base case assumptions. The transfer capabilities were estimated based upon the source and sink of the projected power flow. For example, the source might be the Tennessee Valley Authority (TVA) and the sink might be ITC. Numerous other combinations were calculated including a proportional flow from “around the compass”, that is from all sources simultaneously (denoted as non-Michigan in the diagrams) to ITC and METC separately and MECS collectively. As noted in the diagram, the estimated total transfer capability into MECS from all sources proportionally for 2009, based on MTEP05 planned and proposed projects, is approximately 3,000 MWs. This assumes that the phase shifters hold the power flow to Ontario to zero. Chart 7 shows that the capacity for the same source-sink combination declining to approximately 1,500 MWs if phase shifters are holding the flow to Ontario to 1,500 MWs.

The spider diagrams attached as Chart 2-9 show other thermal related limits. In summary these charts show:

- Chart 2 – based on thermal capability, imports into ITC, METC and MECS can be increased by about 500-1,500 MWs from the south by implementing TIER I south projects (although not contained in these charts, voltage related limits and losses may preclude these transfer enhancements from being fully realized or attempted without additional upgrades)
- Chart 3 – based on thermal capability, imports into ITC from METC can be increased by about 1,000 MWs by implementing TIER I cross-state projects (although not contained in these charts, voltage related limits and losses may preclude these transfer enhancements from being fully realized or attempted without additional upgrades)
- Chart 4 – based on thermal capability, TIER II projects result in increasing import capabilities into ITC, METC and MECS from all external areas included in the modeling (non-Michigan) by about 2,400 MWs above the base case and about 1,100 MWs more than the TIER I projects. While not tested, it is expected that the TIER II projects could also help alleviate voltage limitations and would likely result in lower losses for a given transfer level. Some of the upgrade scenarios tested in TIER II were found not to be as effective.
- Chart 5 – based on thermal capability, TIER II projects result in increasing import capabilities into ITC from METC by about 700 MWs more than the base case and about 600 MWs more than the TIER I south projects. While not tested, it is expected that the TIER II projects could also help alleviate voltage limitations and would likely result in lower losses for a given transfer level. Some of the upgrade scenarios tested in TIER II were found not to be as effective. The TIER I cross-state projects were not modeled in this analysis. Had they been modeled, the transfer capability differences between TIER I and the base case and between TIER II and the base case would likely be significantly higher.

- Chart 6 – shows that if particular units outside of MECS were off-line simultaneously with the imports into ITC from “non-Michigan”, the import capabilities would decrease by about 700 MWs for the TIER I south and TIER II upgrade scenarios. Some of the upgrade scenarios tested in TIER II were found not to be as sensitive to unit outages outside of MECS. Although not reflected in the chart, analysis indicated that a relatively small redispatch of units outside of MECS could offset the impact of the non-MECS generator outage so that the transfer level that did not consider non-MECS generator outages could be achieved.
- Chart 7 – shows that the import capability into Michigan is significantly decreased as flows from Michigan to Ontario go from 0 MWs to 1,500 MWs. Although not reflected in the chart, the converse would also be true. Michigan import capability would increase as flows increase from Ontario to Michigan. There is an upper limit on these increases. The upper limit is realized when facilities in Ontario or in the Michigan-Ontario interface begin to reach their limits.
- Chart 8 – ATC zone 2 peak load results – shows the thermal transfer capability into ATC zone 2 to be around 400 MWs for peak load conditions, regardless of whether the incremental transfers were from the South or from the East. It should be noted, however, that the Northern Lower Peninsula transmission system can only accommodate about a 125 MW transfer at the Straits of Mackinaw on a first contingency basis. Other facilities in the Northern Lower Peninsula are even more limiting.
- Chart 9 – ATC zone 2 70 percent of peak load results – shows the thermal transfer capability into ATC zone 2 to be 150-250 MWs for 70 percent of peak load with the Ludington Pumped Storage Plant operating in pumping mode. The maximum incremental import transfer capability from the South the ATC zone 2 was 250 MWs. The maximum incremental transfer import capability was 150 MWs from the East. This simulation represented the system conditions when the Ludington pumped storage facility is consuming 2040 MWs.
- Chart 10 – shows that import capabilities into Michigan under 70 percent of peak load conditions and with Ludington pumping 6 units are approximately 2,400 MWs from the south. This is only slightly higher than the base case imports for this scenario of 2,147 MWs.

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5 Upgrade Scenarios

The general approach used to find conceptual upgrades was to identify "plateaus" where multiple limits in different areas were found to exist simultaneously. These "plateaus" were assumed to be logical breakpoints, because addressing all these simultaneous limits would require a significant increase in the level of transmission upgrades. The limits for the upgrade scenarios were based on thermal capabilities (that is how much power can flow through the transmission facilities without loading the facilities beyond applicable ratings). A number of other factors such as voltages and losses would have to be considered in a more detailed study before adopting any of these upgrade scenarios. It is quite possible that low voltages or unacceptably high losses could result in limiting transfers to levels below the values shown herein, unless additional projects are undertaken.

5.1 TIER I Improvements for Transfers from the South

In the 2009 system as currently planned and proposed, for transfers into ITC, METC and MECS (other than METC to ITC transfers), the limits were generally found in the southern part of the ITC system. Several scenarios were tested to relieve these limits. In performing these analyses, it quickly became apparent that improvements in southern ITC shifted the problem to another facility in western ITC with little gain in import capabilities. Therefore, an upgrade to relieve the western ITC facility would also be needed in order to expand transmission capacity from the South. The first "plateau" was found after the western and southern ITC limits were addressed.

Transmission projects needed to increase Michigan import capabilities from their levels given the projected 2009 system to the first "plateau" are referred to as TIER I southern improvements and include:

1. Adding transformation in western ITC.
2. Building a station in southwestern ITC, and
3. Reconfiguring some southern ITC circuits.

Reconfiguring the southern ITC circuits would take the construction of some new double circuit towers. Almost all of this new construction is believed to be on Detroit Edison property, which may make acquisition of any necessary right-of-way easier. Besides this line construction, these upgrades can be implemented largely by working on existing ITC sites. Or, in the case of the new station, on property that is currently owned by ITC but is largely undeveloped. The conceptual TIER I southern project is believed to require minimal investment from transmission companies other than ITC. Of course, should a decision be made to work toward implementing this level of upgrades, much more detailed analysis would be needed which could result in a different set of projects ultimately being chosen which may involve greater investment outside of ITC. Overall, the TIER I southern projects are conceptually estimated to be $50 million, again subject to more detailed analysis. Although not tested, these set of TIER I improvements are not expected to improve the ability to move power into Michigan under the 70 percent peak load with Ludington pumping scenario nor are they expected to be effective in mitigating the potential voltage limits identified.

5.2 TIER I Improvements for Cross-State Transfers

In 2004 under the MISO umbrella, ITC, with cooperation from METC, investigated and began implementing improvements on transmission facilities between ITC and METC resulting in some mitigation of the west to east limits within Michigan. West to east limits within Michigan remain a concern to reliability within Southeastern Michigan, so projects designed to increase transfer capability from west to east within the State were identified. TIER I projects are those that are projected to increase west to east, and east to west, flows, but do not require large investments or additional right of way.

The TIER I METC-ITC upgrade scenario analyzed included:

1. Building a new 345/230 kV interconnection between the METC system and the ITC system in the northern portion of the METC-ITC interface.
2. Build a new 138/120 kV interconnection between the METC system and the ITC system in the southern portion of the METC-ITC interface.

Overall, the TIER I cross-state projects are conceptually estimated to be $50 million, again subject to more detailed analysis. Although not tested, TIER I improvements are not expected to improve the ability to move power into Michigan under the 70 percent peak load with the Ludington pumping scenario, nor are they expected to be effective in mitigating potential voltage limits.

5.3 TIER II Improvements for Transfers from the South

Analysis of the TIER I South upgrades revealed that these projects pushed transfer limitations outside of Michigan. Further, in the absence of significant new infrastructure, a high level analysis and engineering judgment suggests that losses and voltages may be of increasing concern at some of the higher transfer levels for either the base system or if only the TIER I upgrades are implemented. In order to mitigate these losses and voltage performance concerns and to facilitate higher transfers available from TIER I upgrades only, TIER II upgrades were developed and analyzed.

The projects analyzed in TIER II include several new high voltage direct current (DC) links with 1,000 or 2,000 MWs of capacity, new 345 kV double circuit tower (DCT) lines or new 765 kV scenarios. All of the TIER II projects involve significant and lengthy new transmission lines and involve much larger investment and, in some cases, the need for additional right of way. The 345 kV DCT and 765 kV alternatives would require development of significant new transmission corridors. While it is uncertain, it may be possible to site a DC line in an existing corridor, instead of creating a new corridor. All of these projects achieve the same basic goal of strengthening the link between Michigan and the south as well as across Michigan.

Overall, the TIER II projects are conceptually estimated to cost $500-700 million, again subject to more detailed analysis. Although not tested, these set of TIER II improvements would be expected to improve the ability to move power into Michigan under the 70 percent peak load with Ludington pumping scenario and would be expected to be effective in mitigating (at least partially) some of the potential voltage limits identified in the power flow models.

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6 Voltage Performance

The resulting degradation of voltage performance related to increasing reactive losses may constrain transmission transfer capabilities before thermal limitations are reached. For example, Chart 11 shows that METC voltage limit A would limit ITC import capability to approximately 2,350 MWs for incremental transfers from METC under base transmission configuration conditions. The thermal limits shown on Chart 1 show that for the same conditions (incremental transfers from METC to ITC), the thermal limit would be approximately 4,000 MWs.

Similarly Chart 12 shows that lower Michigan voltage limit #1 would restrict ATC zone 2 imports to around 330 MWs while the thermal results shown on Chart 8 indicate the thermal ATC import limit to be approximately 400 MWs.

Finally, for peak load conditions, Chart 14 shows that the Central Ohio 138 kV voltage limit is only slightly higher (approximately at 3,250 MWs imports) than the comparable thermal transfer limit.

For 70 percent peak load Ludington pumping conditions, METC voltage limit B was found to limit Michigan imports to around 2,950 MWs, or approximately 500 MWs more than the thermal limit under the same condition. This is shown on Chart 13.

Other voltage charts were developed in this effort. However, only those with the most significant results are discussed in this report.

Care must be taken when attempting to interpret future results. This is especially true for future results showing voltage limits related to transfers, since these results can be particularly sensitive to assumptions about reactive load and compensation contained in the power flow models. Further, given the locations of the voltage limits and the thermal limits, it appears that the voltage limits would be much more sensitive to the direction of the transfers than would the thermal limits. It should also be noted that the cost to mitigate voltage transfer limits can vary significantly depending on a number of factors. It may be possible to mitigate some voltage limits via the addition of capacitors, while other voltage limits may require much more comprehensive measures be used.

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7 Transmission Losses

Some analysis was performed under the Transmission and Distribution Work Group umbrella related to the impact on real and reactive losses of the high power transfers across the transmission system. Due to the complexity of such an analysis, it is not possible to make specific definitive statements in this report based on the limited scope of the loss study. However, the loss study, logic and experience all point to several observations.

1. The greater the distance between generation and load, the higher the losses.
2. As transfers increase, losses increase at a faster rate (for a given facility, losses are related to the square of the current through that facility)
3. As reactive losses increase, voltage performance degrades.
4. Transmission system loss implications should be considered when selecting the portfolio of options to address the State's capacity needs
5. For the Lower Peninsula study area (AEP, FE, ITC and METC) real losses under heavy import scenarios can be hundreds of MWs higher than in the case with no transfers. Similarly reactive losses can be thousands of MVAR higher.

Only TIER II type transmission upgrades would be expected to reduce losses incurred under heavy transfer conditions.

8 Generation Deliverability

As part of the MTEP 05, the MISO has examined the deliverability of generation into the transmission grid to see if any generation was "bottled up." In other words, the MISO test examined whether existing generation could be utilized to its fullest extent. With a few possible minor limitations on some small peaking units, the MISO has found that generation in Michigan is generally "deliverable."[4]

[4] Although it passed the MISO test (due to the presence of a special relaying scheme), it should be noted that the generation at Greenwood can be forced off-line following a single transmission line outage. Given the apparent need to keep as much generation as possible available for use, consideration should be given to whether it is in the state's interest to make the out-of-plant transmission at Greenwood more robust so that the plant could remain in-service following the single most critical transmission outage.

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9 Conclusion

The Transmission and Distribution Work Group evaluated various scenarios related to import and transfer capability into and within Michigan as documented by the various charts attached to this report. Overall, the current transmission system is reliable but can be further enhanced via the type of transmission system upgrades defined throughout this report. TIER I would increase transfer capability within Michigan and into Michigan by approximately 1,000 MW for a projected cost of $100 million. The TIER II option would increase import capability into the Lower Peninsula by another 1,500 MW for an estimated cost in the range of $500 to $700 million. In either case, further, more detailed analysis is needed before work could begin on implementing either of these type options. This report is based on several significant assumptions included (1) transmission could be built in the Lower Peninsula in a timely manner; (2) there will be suppliers to provide the needed generation capacity; (3) there is sufficient transmission capacity outside of Michigan and Northern Ohio to support these imports; (4) voltage degradation due to reactive losses will be compensated (this could drive additional transmission expansion expenditures to reach the stated improvements particularly for TIER I options) ; and (5) real power losses will not be restrictive (estimated to be more likely a concern for the TIER I options). These assumptions will have to be addressed in any scenario involving increasing or modifying the sources of capacity to serve the State. The attached charts identify impacts into ITC, METC and MECS based on the TIER I and TIER II options.

Transmission flows between Michigan and Ontario also have a significant impact on import capability. The base case analysis showed that approximately 3,000 MWs can be imported into the Lower Peninsula and approximately 400 MWs into the Upper Peninsula at peak conditions under the assumption that flows between Michigan and Ontario are negligible. A sensitivity to analyze import capability was performed assuming 1,500 MWs flow from Michigan to Ontario. This analysis revealed the almost one-for-one correlation between decreased Lower Peninsula import capability and increased flow from Michigan to Ontario.

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Attachments to

Michigan Transmission Assessment

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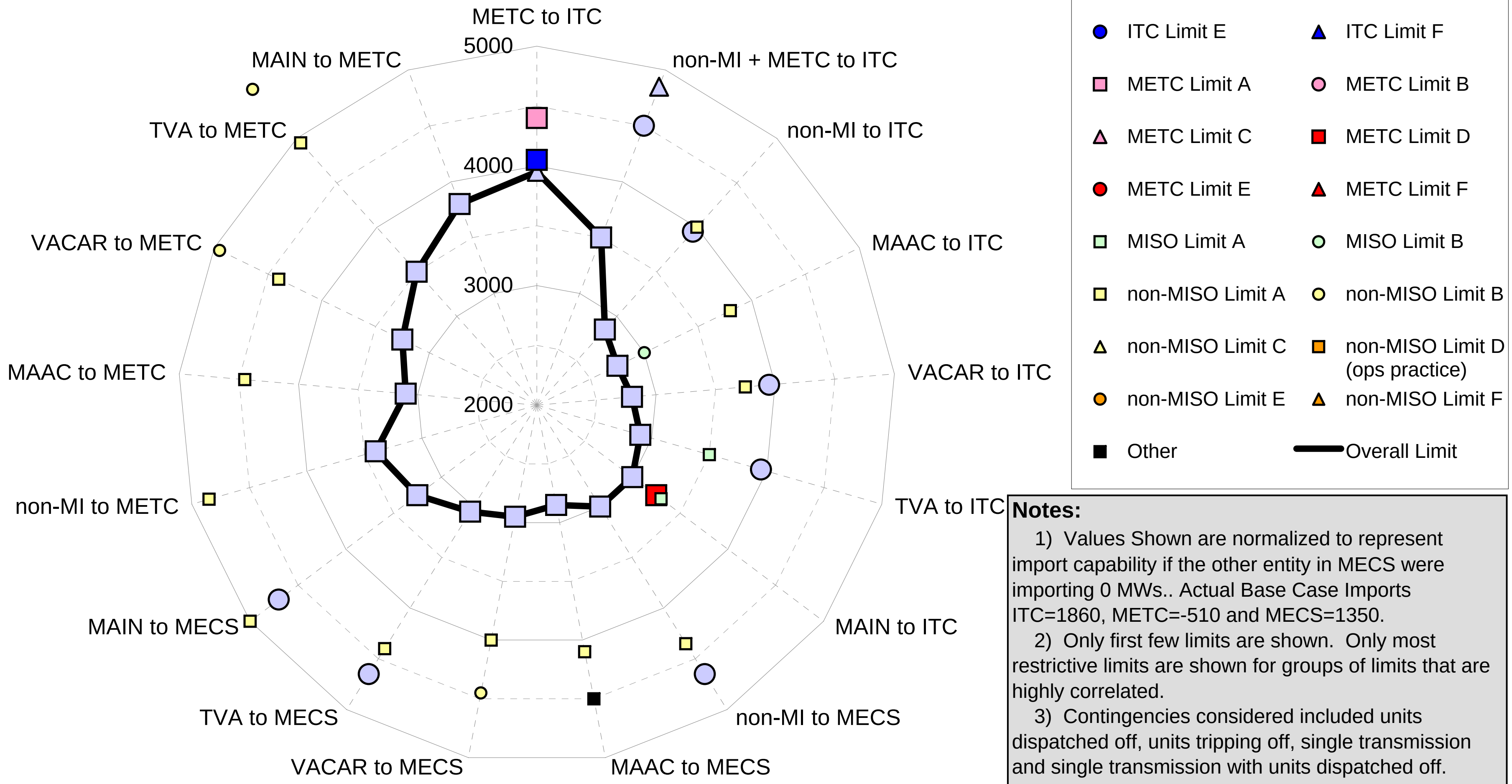
Chart 1

Currently Planned System[4]

2009 Summer -- Total Normalized[1] Import Capabilities for Various Incremental Transfer Scenarios



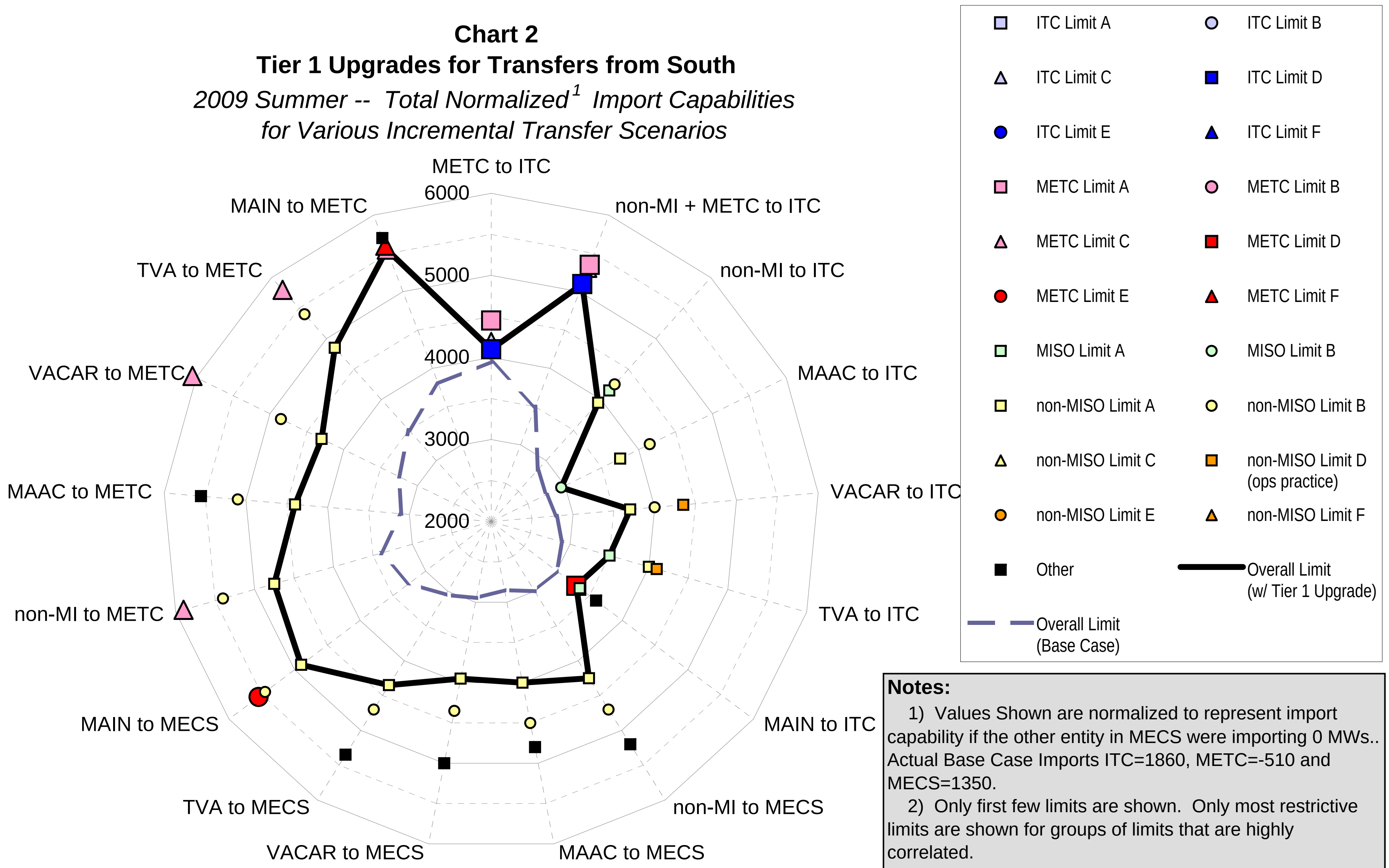
Notes:

1) Values Shown are normalized to represent import capability if the other entity in MECS were importing 0 MWs.. Actual Base Case Imports ITC=1860, METC=-510 and MECS=1350.

2) Only first few limits are shown. Only most restrictive limits are shown for groups of limits that are highly correlated.

3) Contingencies considered included units dispatched off, units tripping off, single transmission and single transmission with units dispatched off.

4) Base Case has 0 MWs flowing between Michigan and Ontario controlled by phase shifting transformers.



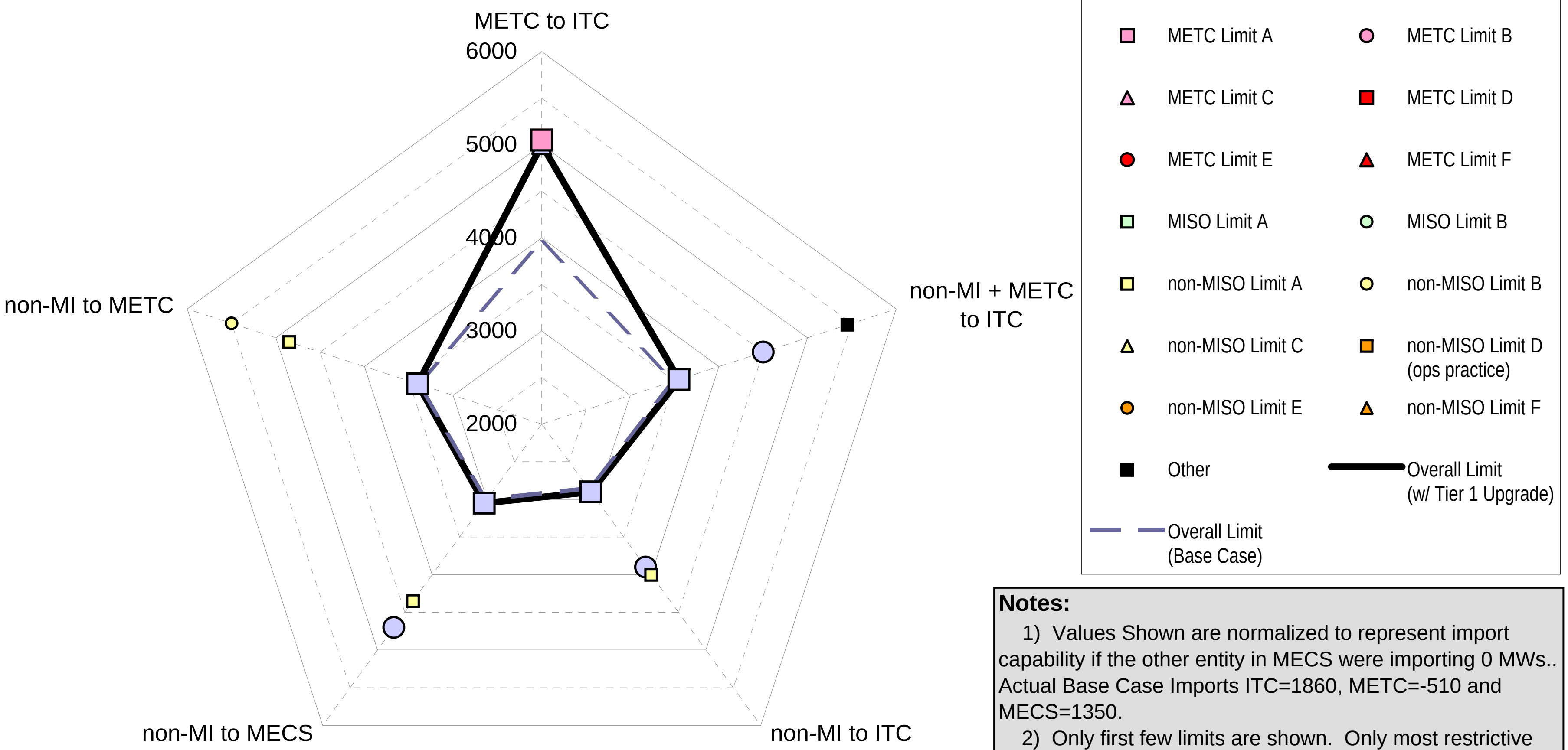
Notes:

1) Values Shown are normalized to represent import capability if the other entity in MECS were importing 0 MWs.. Actual Base Case Imports ITC=1860, METC=-510 and MECS=1350.

2) Only first few limits are shown. Only most restrictive limits are shown for groups of limits that are highly correlated.

3) Contingencies considered included units dispatched off, units tripping off, single transmission and single transmission with units dispatched off.

Chart 3
Tier 1 Upgrades for Cross State Transfers
2009 Summer -- Total Normalized[1] Import Capabilities
for Various Incremental Transfer Scenarios



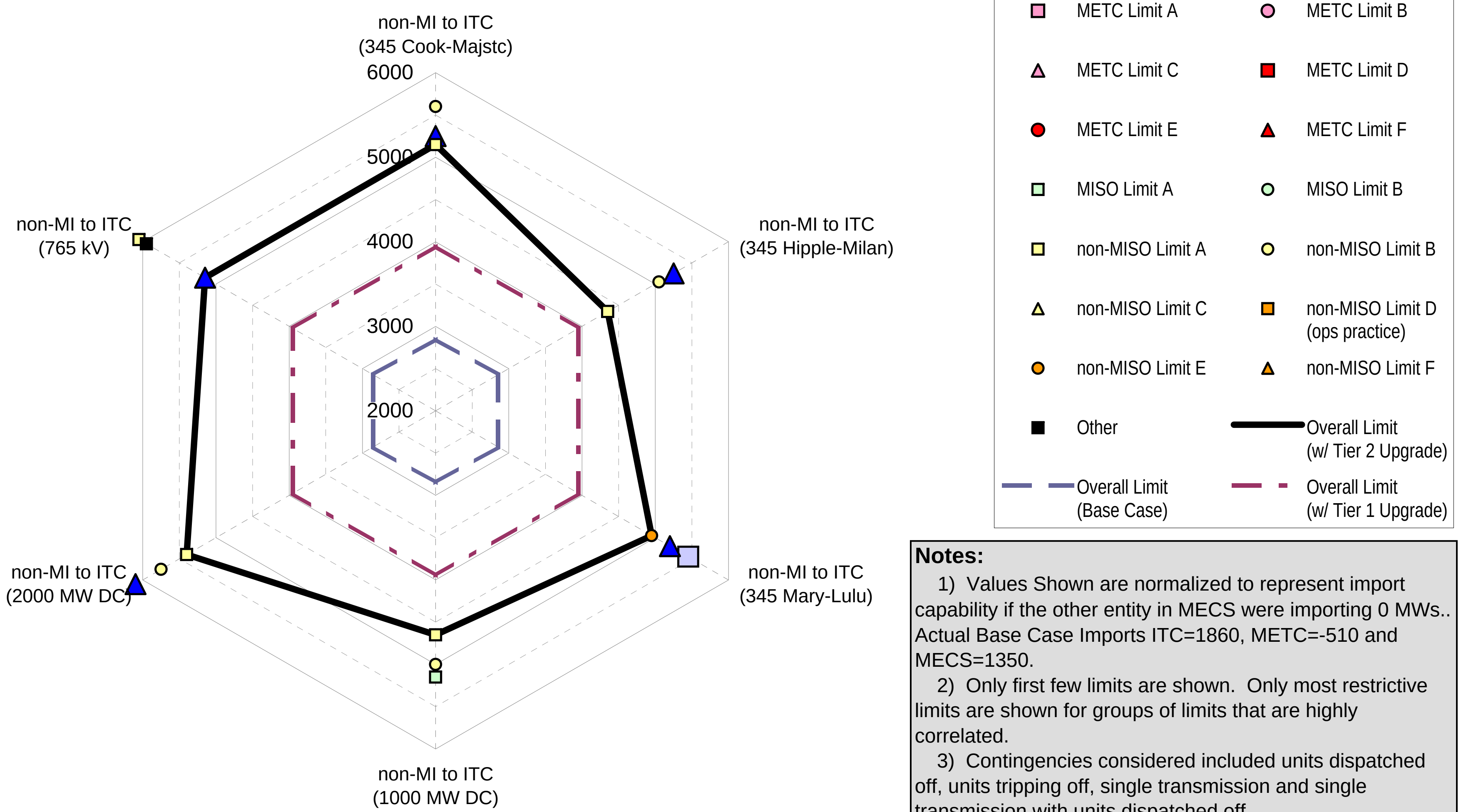
Notes:

1) Values Shown are normalized to represent import capability if the other entity in MECS were importing 0 MWs.. Actual Base Case Imports ITC=1860, METC=-510 and MECS=1350.

2) Only first few limits are shown. Only most restrictive limits are shown for groups of limits that are highly correlated.

3) Contingencies considered included units dispatched off, units tripping off, single transmission and single transmission with units dispatched off.

Chart 4
Tier 1 + Tier 2 Upgrades for Transfers from South
2009 Summer -- Total Normalized[1] Import Capabilities
for non-MI to ITC Incremental Transfer Scenarios



Notes:

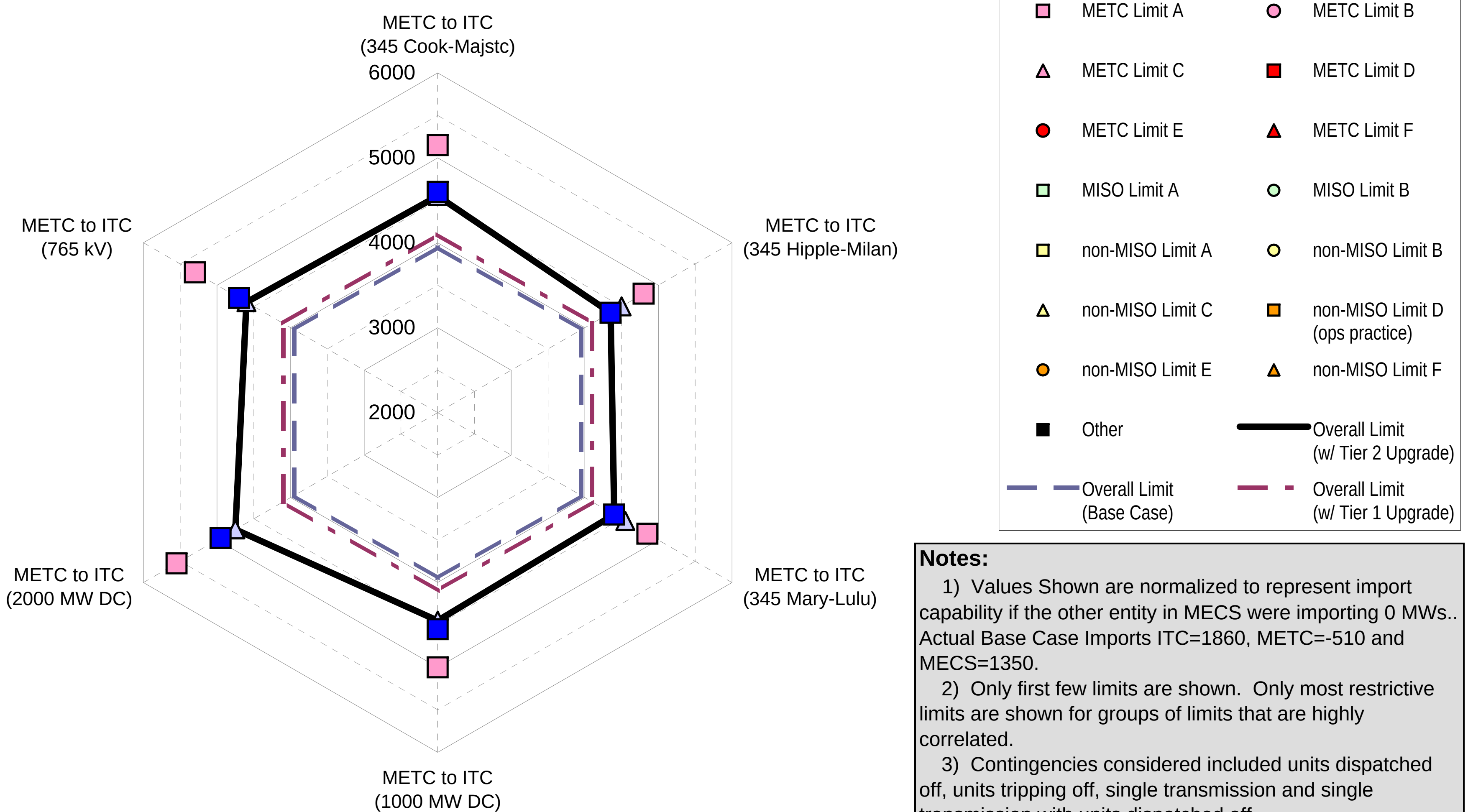
1) Values Shown are normalized to represent import capability if the other entity in MECS were importing 0 MWs.. Actual Base Case Imports ITC=1860, METC=-510 and MECS=1350.

2) Only first few limits are shown. Only most restrictive limits are shown for groups of limits that are highly correlated.

3) Contingencies considered included units dispatched off, units tripping off, single transmission and single transmission with units dispatched off.

Chart 5
Tier 1 + Tier 2 Upgrades for Transfers from South

2009 Summer -- Total Normalized[1] Import Capabilities
for METC-ITC Incremental Transfer Scenarios



Notes:

1) Values Shown are normalized to represent import capability if the other entity in MECS were importing 0 MWs.. Actual Base Case Imports ITC=1860, METC=-510 and MECS=1350.

2) Only first few limits are shown. Only most restrictive limits are shown for groups of limits that are highly correlated.

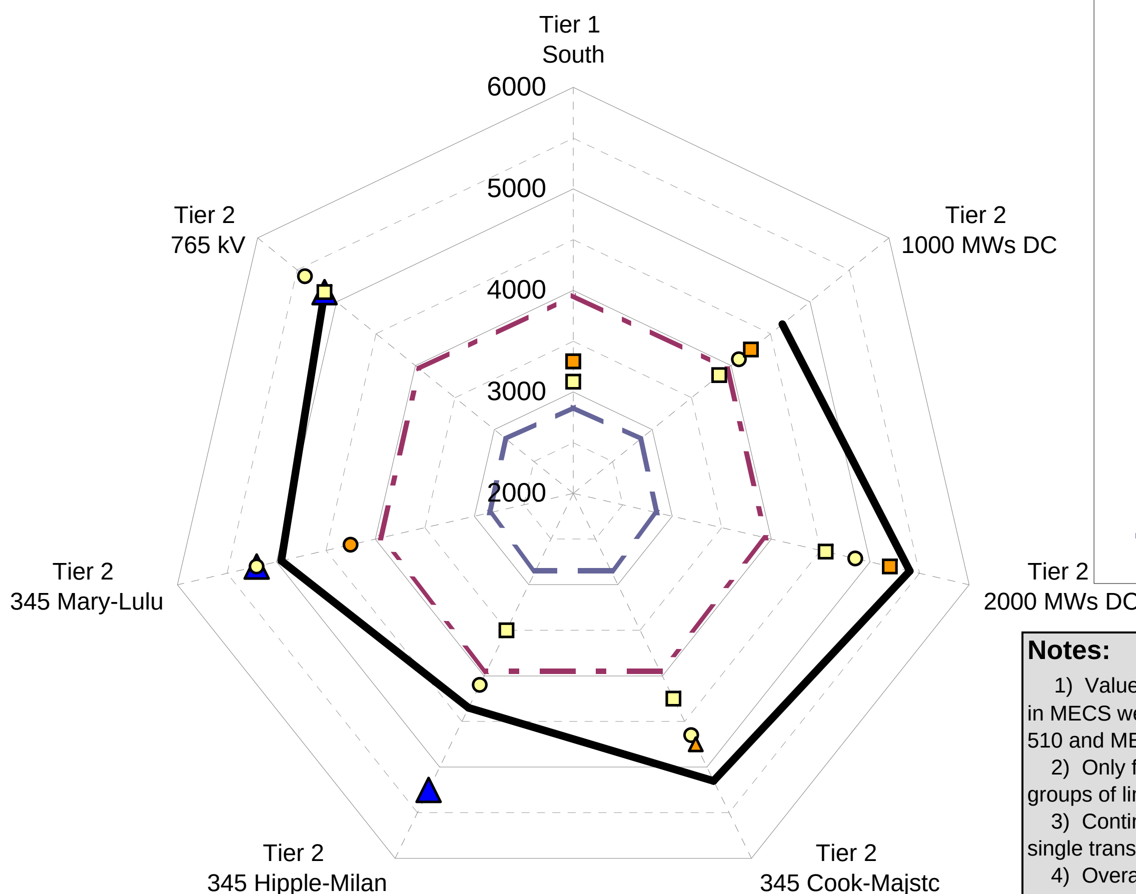
3) Contingencies considered included units dispatched off, units tripping off, single transmission and single transmission with units dispatched off.

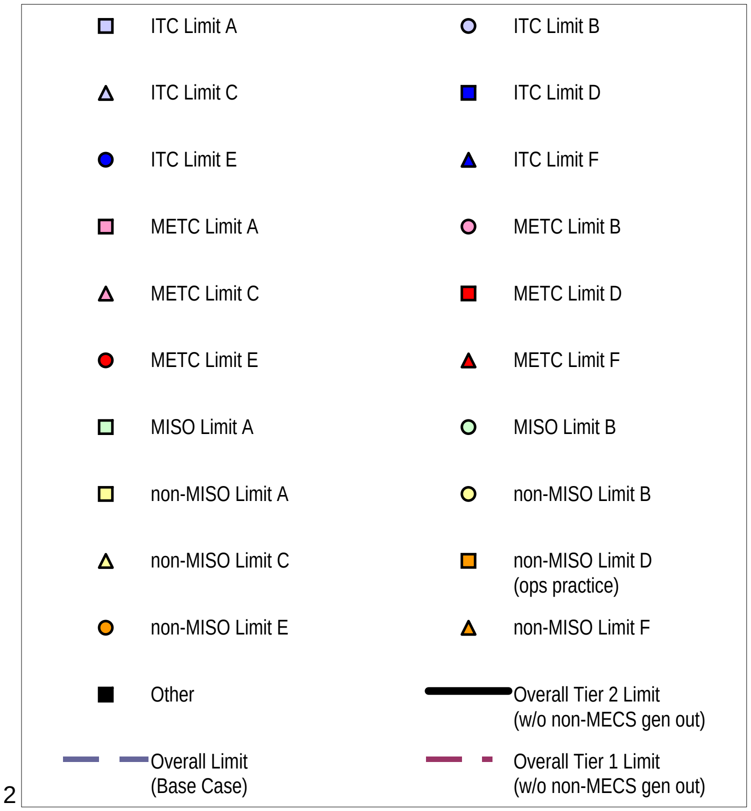
Chart 6

Sensitivity of Limits to non-MECS Generator Outages

2009 Summer -- Total Normalized[1] Import Capabilities

for non-MI to ITC Incremental Transfer Scenarios





Notes:

1) Values Shown are normalized to represent import capability if the other entity in MECS were importing 0 MWs.. Actual Base Case Imports ITC=1860, METC=-510 and MECS=1350.

2) Only first few limits are shown. Only most restrictive limits are shown for groups of limits that are highly correlated.

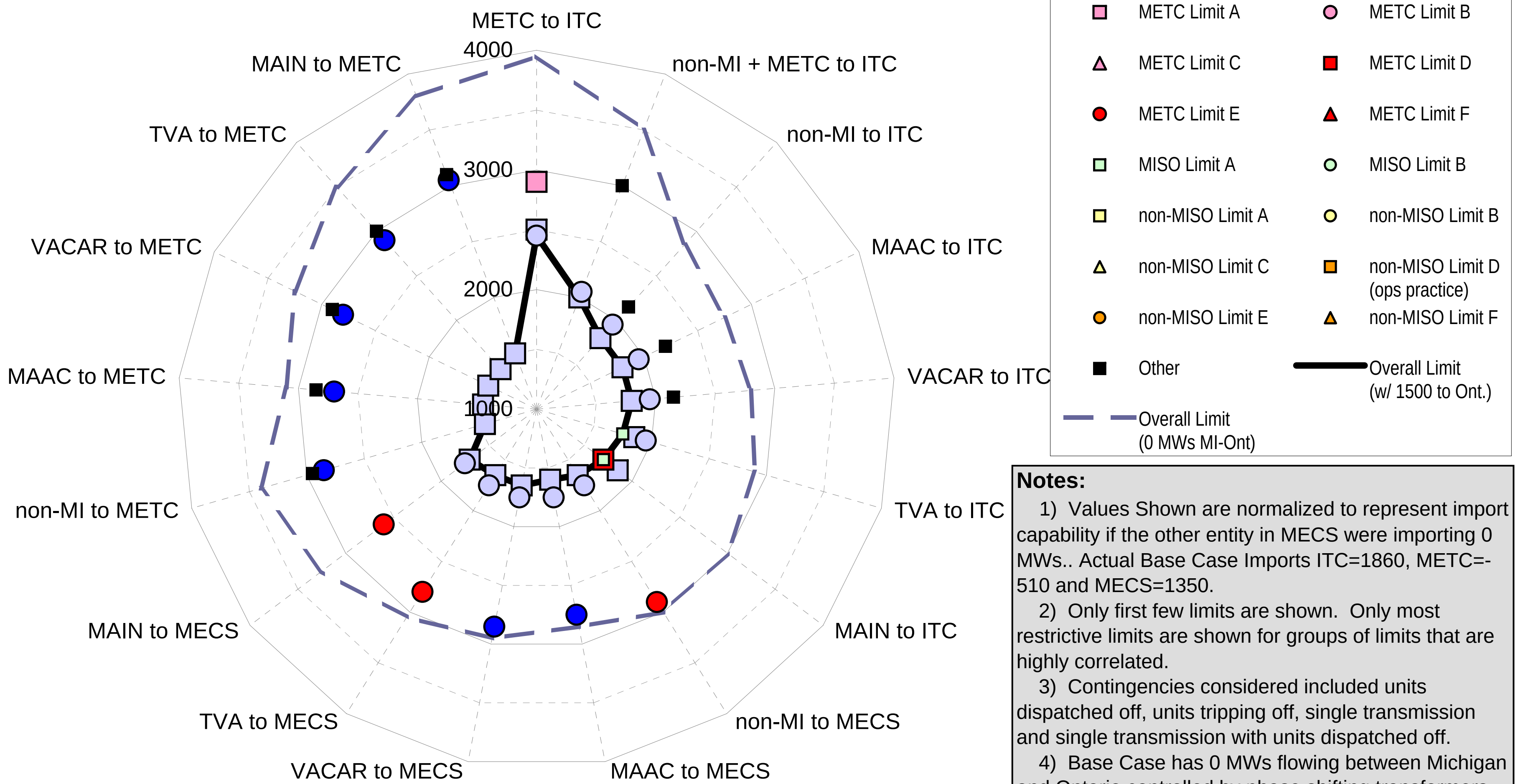
3) Contingencies considered included units dispatched off, units tripping off, single transmission and single transmission with units dispatched off.

4) Overall limit in base case not impacted by a single generator dispatched off outside of MECS.

Chart 7

Impact of 1500 MWs Flow from Michigan to Ontario[4]

2009 Summer -- Total Normalized[1] Import Capabilities for Various Incremental Transfer Scenarios



Notes:

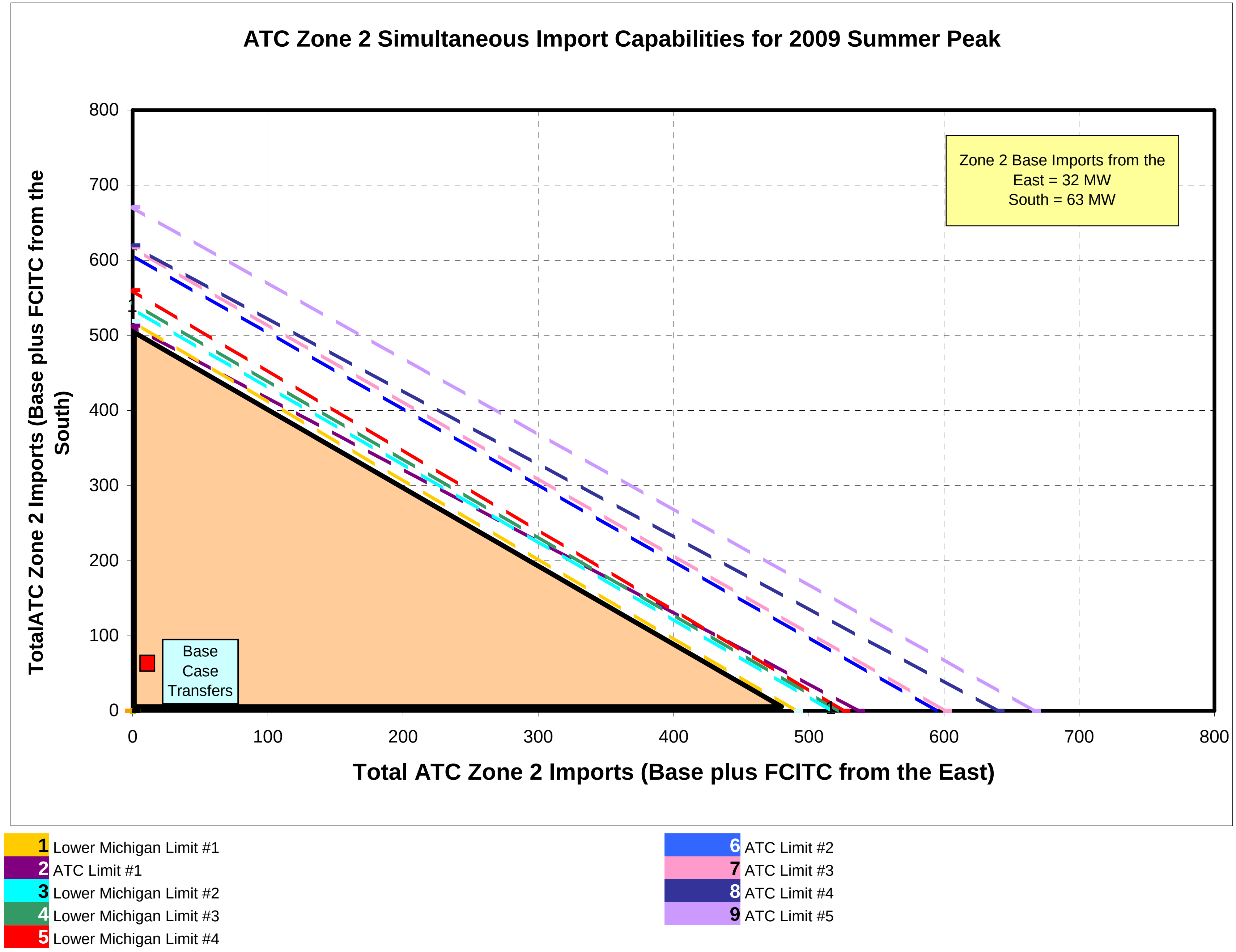
1) Values Shown are normalized to represent import capability if the other entity in MECS were importing 0 MWs.. Actual Base Case Imports ITC=1860, METC=-510 and MECS=1350.

2) Only first few limits are shown. Only most restrictive limits are shown for groups of limits that are highly correlated.

3) Contingencies considered included units dispatched off, units tripping off, single transmission and single transmission with units dispatched off.

4) Base Case has 0 MWs flowing between Michigan and Ontario controlled by phase shifting transformers.

Chart 8



ATC Zone 2 Simultaneous Import Capabilities for 2009 Summer Peak
Zone 2 Base Imports from the East = 32 MW South = 63 MW
Base Case Transfers
TotalATC Zone 2 Imports (Base plus FCITC from the South)
Total ATC Zone 2 Imports (Base plus FCITC from the East)
0
100
200
300
400
500
600
700
800
1 Lower Michigan Limit #1
2 ATC Limit #1
3 Lower Michigan Limit #2
4 Lower Michigan Limit #3
5 Lower Michigan Limit #4
6 ATC Limit #2
7 ATC Limit #3
8 ATC Limit #4
9 ATC Limit #5

Chart 9

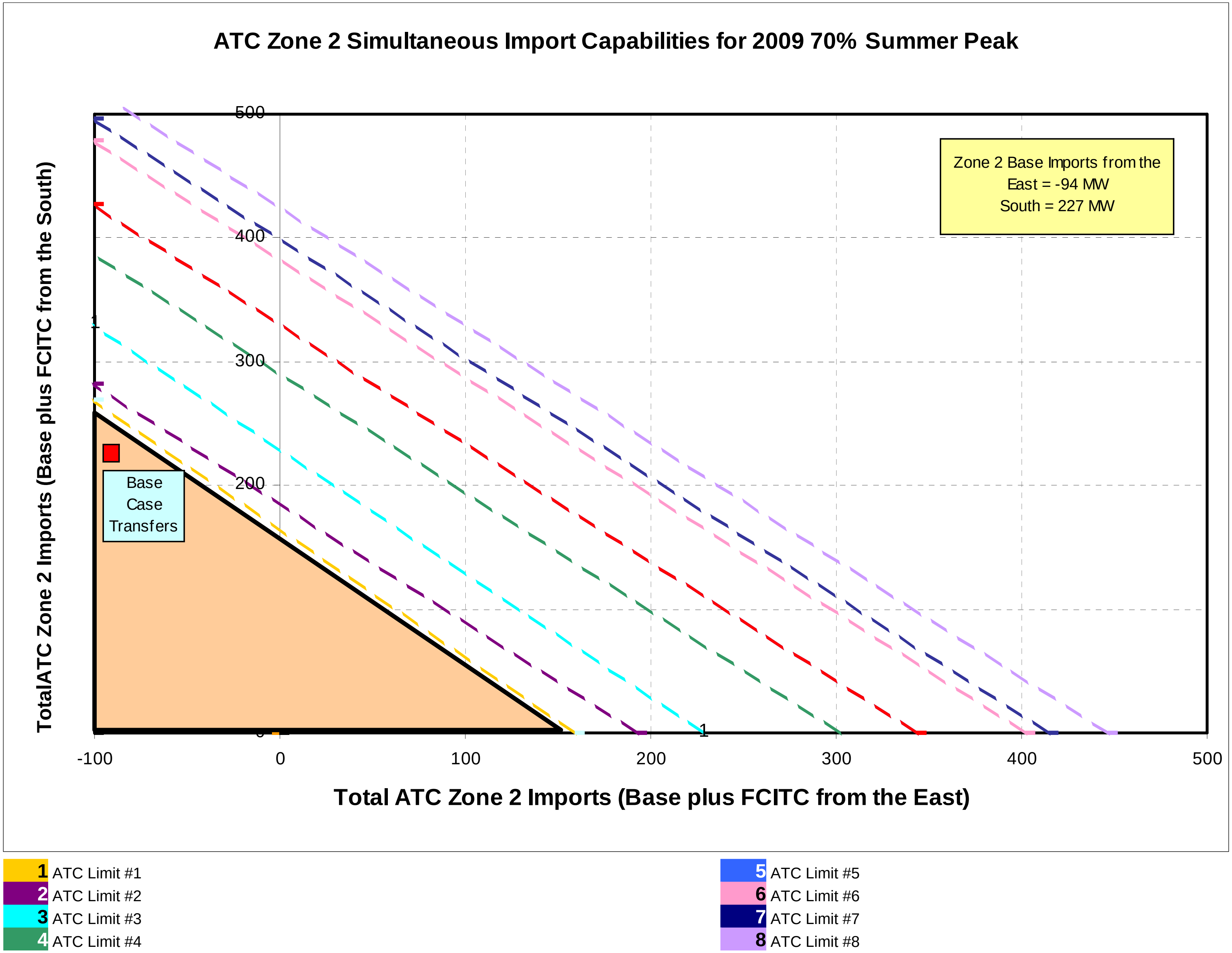
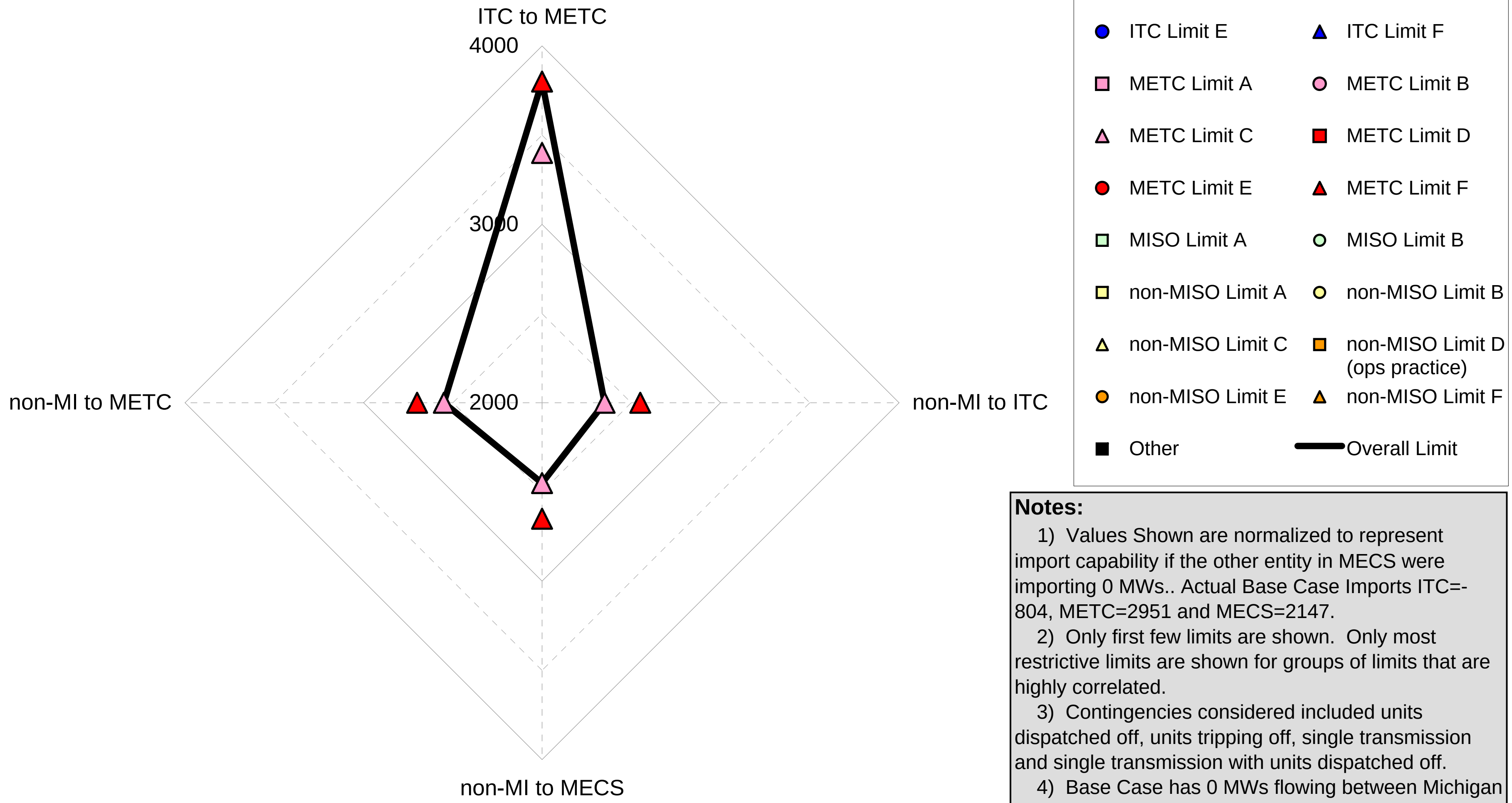

ATC Zone 2 Simultaneous Import Capabilities for 2009 70% Summer Peak
Zone 2 Base Imports from the East = -94 MW
South = 227 MW
Base Case Transfers
TotalATC Zone 2 Imports (Base plus FCITC from the South)
Total ATC Zone 2 Imports (Base plus FCITC from the East)
500
400
300
200
0
-100
0
100
200
300
400
500
1
1
1 ATC Limit #1
2 ATC Limit #2
3 ATC Limit #3
4 ATC Limit #4
5 ATC Limit #5
6 ATC Limit #6
7 ATC Limit #7
8 ATC Limit #8

Chart 10

70% Peak Load with Ludington Pumping[4]

2009 Summer -- Total Normalized[1] Import Capabilities for Various Incremental Transfer Scenarios



Notes:

1) Values Shown are normalized to represent import capability if the other entity in MECS were importing 0 MWs.. Actual Base Case Imports ITC=-804, METC=2951 and MECS=2147.

2) Only first few limits are shown. Only most restrictive limits are shown for groups of limits that are highly correlated.

3) Contingencies considered included units dispatched off, units tripping off, single transmission and single transmission with units dispatched off.

4) Base Case has 0 MWs flowing between Michigan and Ontario controlled by phase shifting transformers.

Chart 11

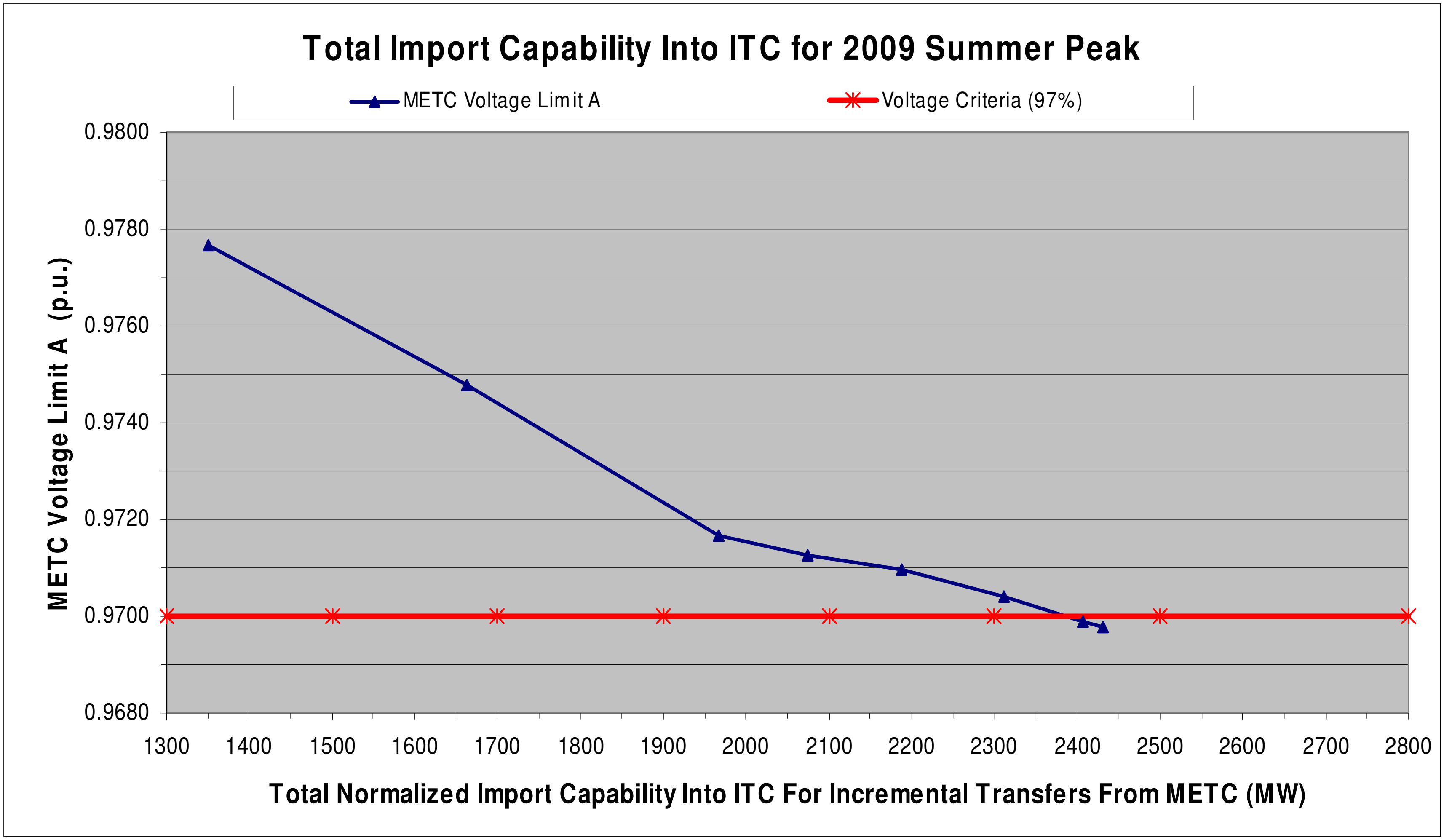
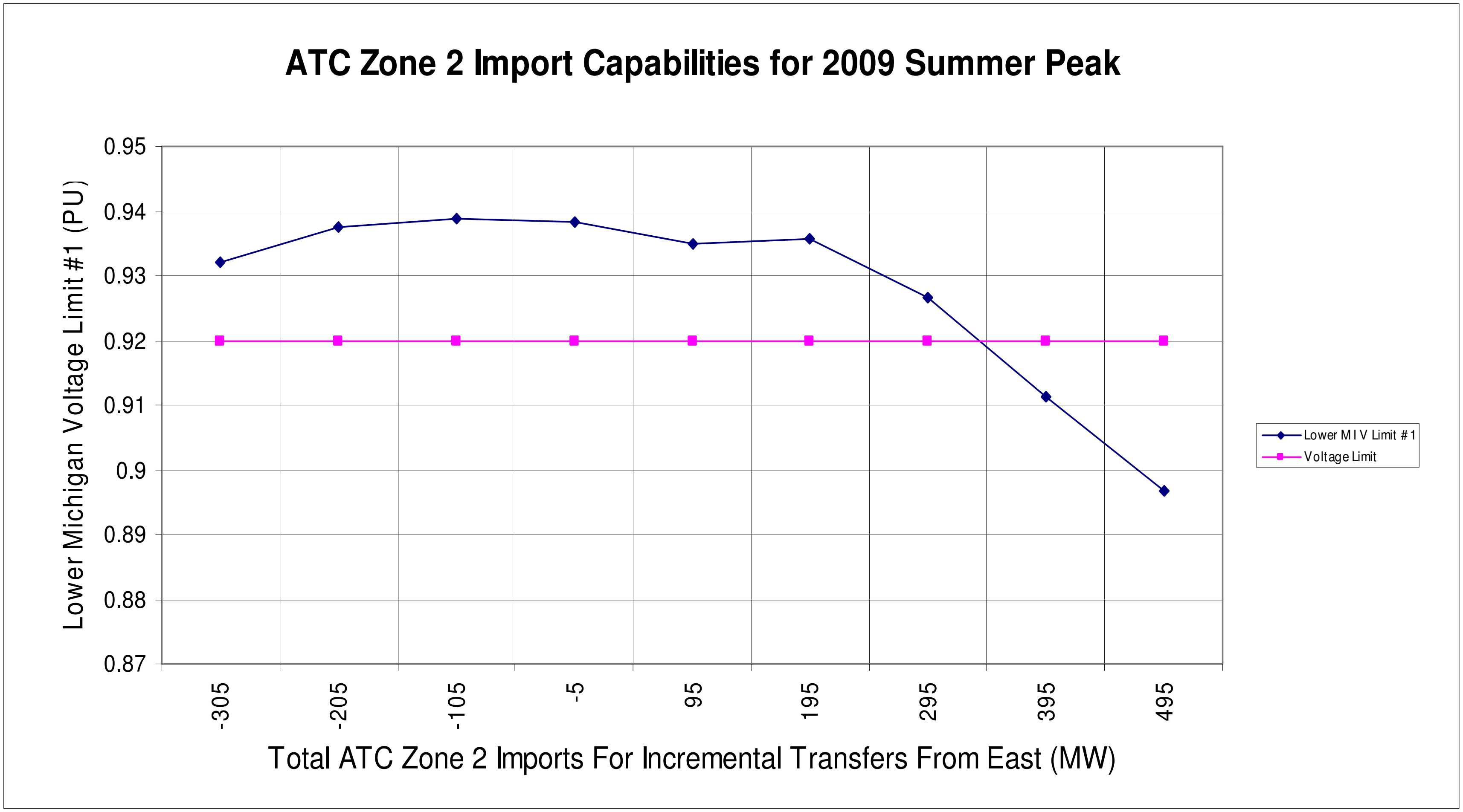
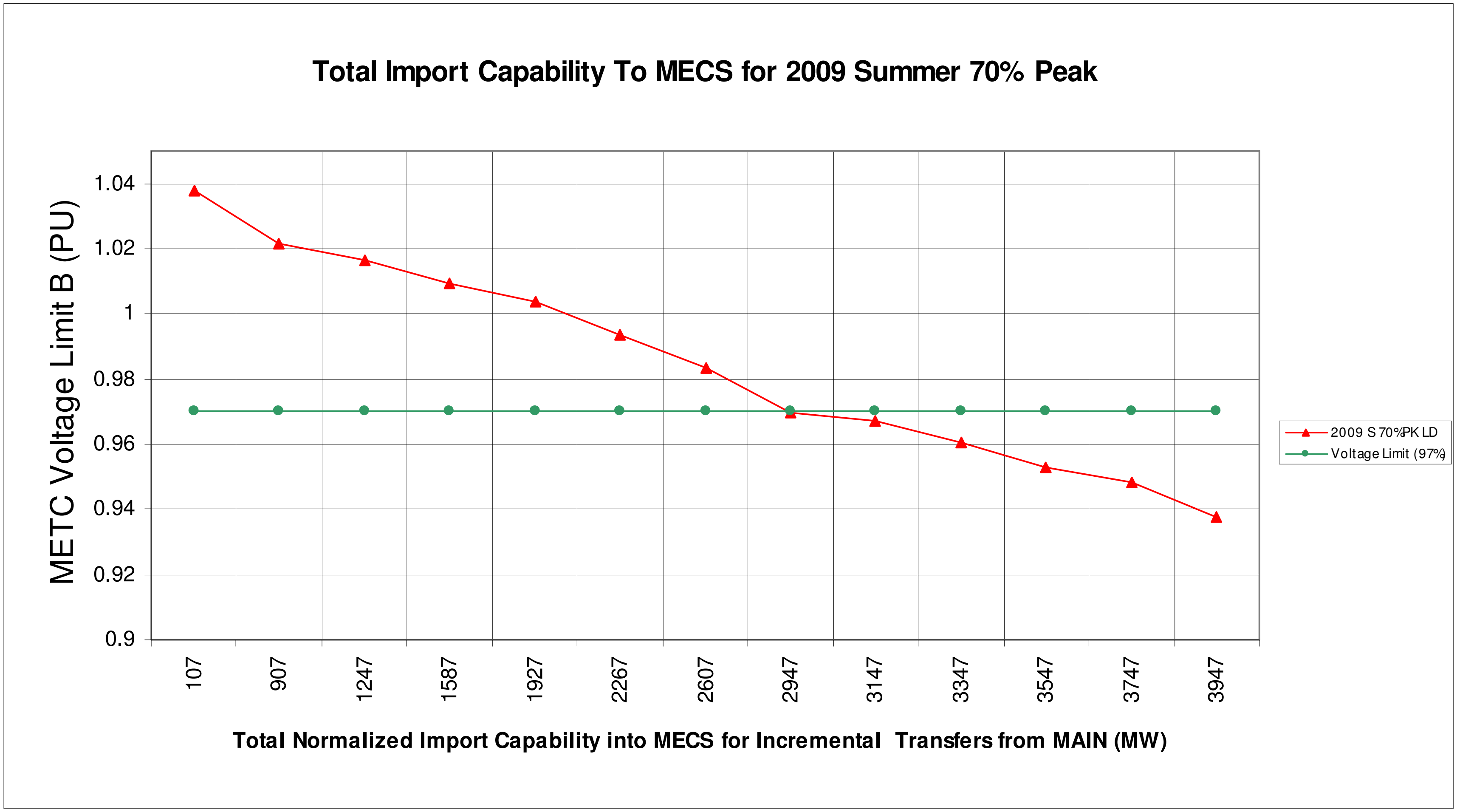

Total Import Capability Into ITC for 2009 Summer Peak
METC Voltage Limit A
Voltage Criteria (97%)
METC Voltage Limit A (p.u.)
0.9800
0.9780
0.9760
0.9740
0.9720
0.9700
0.9680
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400
2500
2600
2700
2800
Total Normalized Import Capability Into ITC For Incremental Transfers From METC (MW)

Chart 12



ATC Zone 2 Import Capabilities for 2009 Summer Peak
Lower Michigan Voltage Limit #1 (PU)
0.95
0.94
0.93
0.92
0.91
0.9
0.89
0.88
0.87
-305
-205
-105
-5
95
195
295
395
495
Total ATC Zone 2 Imports For Incremental Transfers From East (MW)
Lower M I V Limit # 1
Voltage Limit

Chart 13



Total Import Capability To MECS for 2009 Summer 70% Peak
METC Voltage Limit B (PU)
1.04
1.02
1
0.98
0.96
0.94
0.92
0.9
107
907
1247
1587
1927
2267
2607
2947
3147
3347
3547
3747
3947
Total Normalized Import Capability into MECS for Incremental Transfers from MAIN (MW)
2009 S 70%PK LD
Voltage Limit (97%)

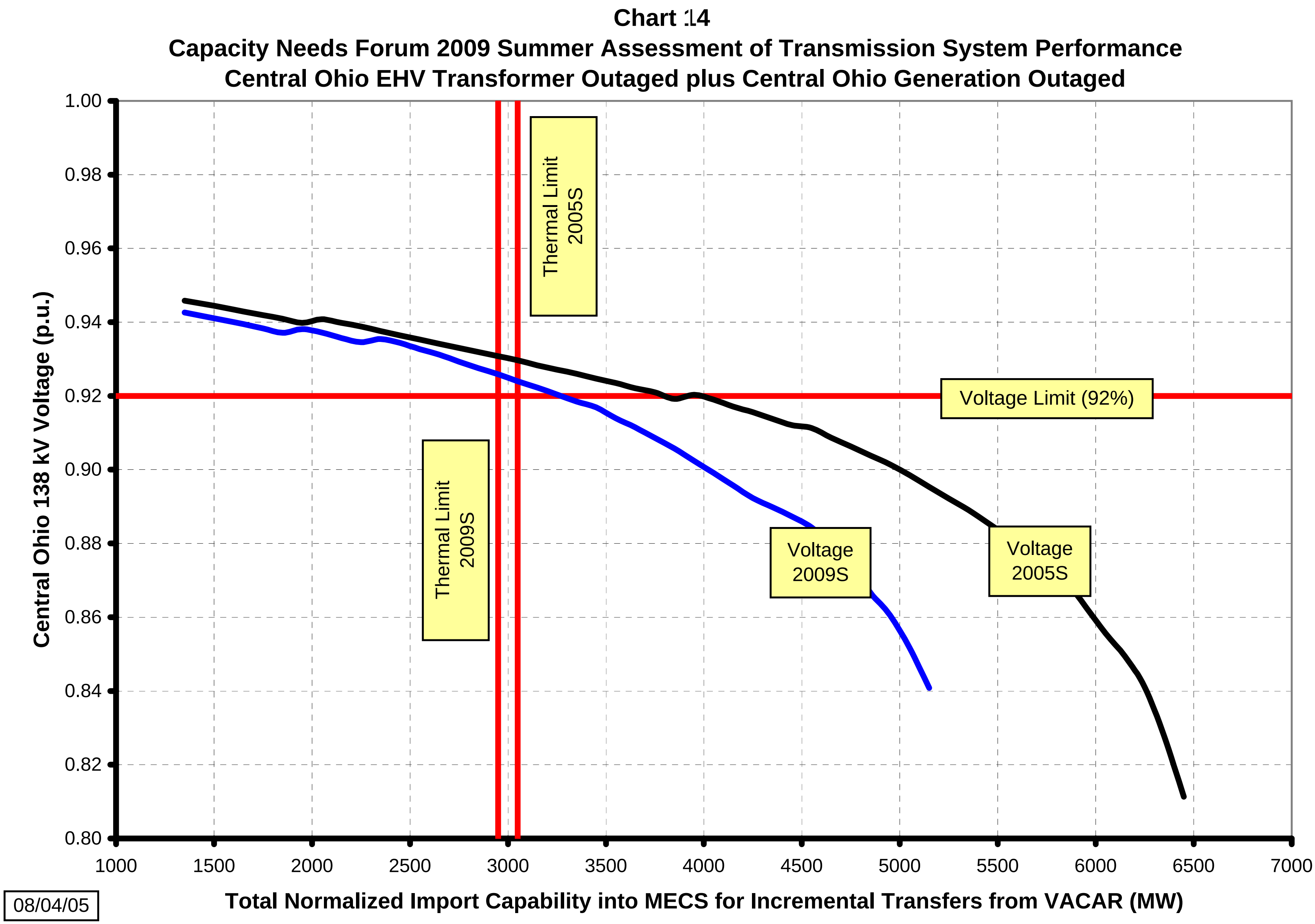


Chart 14
Capacity Needs Forum 2009 Summer Assessment of Transmission System Performance
Central Ohio EHV Transformer Outaged plus Central Ohio Generation Outaged
Central Ohio 138 kV Voltage (p.u.)
1.00
0.98
0.96
0.94
0.92
0.90
0.88
0.86
0.84
0.82
0.80
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
6500
7000
Thermal Limit 2005S
Thermal Limit 2009S
Voltage Limit (92%)
Voltage 2009S
Voltage 2005S
Total Normalized Import Capability into MECS for Incremental Transfers from VACAR (MW)
08/04/05