Loop Flow Study Phase II
Joint and Common Market Initiative

Midwest ISO-PJM Joint Stakeholder
Web Conference
November 14, 2008

pjm

MidwestISO
Energizing the Heartland

Review of Loop Flow Study Phase I

- Purpose:
  - Increase the understanding of the impact that external market participants have on the creation of loop flows. Focused on Lake Erie circulation flow and PJM Southeast versus Southwest interface flows.
  - Provide details on plans and actions to address the problems of external loop flow

Phase I Recommendations

- Recommendation
  - Commissioning of the Michigan-Ontario PARs as soon as possible to mitigate the loop flows around Lake Erie.
    - PJM/NYISO and NYISO/IESO commit to review NY/PJM and St. Lawrence PAR operations to assess contributions to Lake Erie Loop Flow.
    - The four parties will develop a comprehensive plan on the operation of the Michigan-Ontario and NYISO/PJM PARS to control loop flows around Lake Erie,
- Status
  - Facilities Agreement has been signed by transmission owners.
  - Midwest ISO and IESO are developing Standard Operating Procedures for the PARs.
  - PARS currently available to regulate during an emergency.

Phase I Recommendations, cont.

- Recommendation
  - IESO and NYISO should adopt a Congestion Management Process whereby they report their market flows to the IDC and participate with Midwest ISO and PJM to manage circulation flows around Lake Erie when congestion occurs.

- Status
  - IESO has stated they want to have the Michigan Ontario PARs Operational to determine if that will resolve loop flow on the interface before any further consideration of implementing a Congestion Management Process.
  - PJM and NYISO are having ongoing discussions about the possibility of implementing a Congestion Management Process.

Phase I Recommendations, cont.

- Recommendation
  - Create an Energy Schedule Tag Archive that contains tag impacts, market transfer impacts, and generation-to-load impacts for flowgates in the IDC

- Status
  - This recommendation is being addressed under the Parallel Flow Visualization/Mitigation for RCs in EI SAR.

Purpose of Loop Flow Study Phase II

- Purpose:
  - Identify the source and magnitude of parallel flows on key flowgates that result from tags, market transfer & generation-to-load.

- Scope:
  - Thirty-five flowgates were included that have a history of significant transmission congestion, significant market-to-market coordination, high number and/or duration of TLR implementation.

Identified Flowgate List

OWNER	FLOWGAT	CONSTRAINTNAME
PJM	20	Erie West-Erie South 345 kV line
PJM	23	Roseland-Cedar Grove F 230 kV l/o Roseland-Cedar Grove B
PJM	100	Kammer #200 765/500 kV xfmr l/o Belmont-Harrison 500
PJM	122	Wylie Ridge #7 tx l/o Wylie #5 tx (SPS in-service)
PJM	141	Elrama-Mitchell 138 kV l/o Sammis-Wylie Ridge 345 kV
MISO	291	Pierce B 345/138 kV transformer l/o Pierce-Foster 345 kV
PJM	310	Person-Halifax 230 kV line l/o Wake-Carson 500 kV
PJM	500	Pontiac-Wilton Center 345 kV l/o Pontiac-Dresden 345 kV (8014 line)
MISO	2086	Newtonville 138/161 Xfm T3 flo Newtonville 138/161 Xfm T5
MISO	2336	BentnHrbr-Palisades345/Cook-Palisades345
PJM	2352	PRNTY-MTSTM500/BLACKO-BEDNGT500
PJM	2353	BLACKO-BEDNGT500-PRNTY-MTSTM500
PJM	2377	Darwin-Eugene 345 kV l/o Jefferson-Rockport 765 kV
MISO	2517	Northeast Ohio Interface
MISO	2519	Ohio Eastern Interface
MISO	2470	Ashtabula-Erie West 345 (flo) Sammis-Wylie Ridge 345
MISO	2980	Dune Acres-Michigan City 138 1&2 (flo) Wilton Center-Dumont 765
MISO	3006	EAU CLAIRE-ARPIN 345 KV
MISO	3012	Paddock 345/138 Xfm (flo) Wempletown-Rockdale 345
MISO	3145	PANA XFMR + COFFEEN-COFFEEN NORTH
MISO	3167	St. Francois - Lutesville 345k
PJM	3250	155 Nelson-111 Electric Junction (15502) 345 kV l/o Cherry Valley-Silver Lake (15616) 345 kV
MISO	3270	State Line-Wolf Lake 138 flo Burnham-Sheffield 345
MISO	3352	Lanesville Xfmr 345/138kV (flo) Kinc-Lath-Pont & Kinc-Pawnee
MISO	3529*	N. Appleton-Werner W. 345
MISO	3532	Ellington-Hintz 138 for N.Appleton-Werner West 345
MISO	3706	Arnold - Hazleton
MISO	6004	MWSI (Minnesota Wisconsin Stability Interface)
MISO	6007	GENTLMN3 345 REDWILO3 345 1
MISO	6126	S1226-Tekamah 161kV flo S3451-Raun 345kV
MISO	6164	Plymouth-Sioux City 161kV flo Raun-Sioux City 345kV
MISO	6168	Hills-Parnell 161kV flo Hills-Montezuma 345kV
ONT	7102*	QFW-(Queenston Flow West)
MISO	9159	ONT-ITC
MISO	14551	Alma-Elk Mound 161 FLO King-Eau Claire-Arpin 345

* no real-time data available for analysis

Flowgate Analysis Methodologies

- Analysis Tools and Data
  - Transmission Adequacy and Reliability Assessment (TARA)
  - PJM's EMS state estimator outputs
- Method I: Contract Path Flow
  - Gen-to-load impact for each entity
  - Tagged impacts only include PJM historical data
  - Tagged impacts are assigned to the exporting entity
- Method II: Actual Energy Flow
  - Gen-to-load impact for each entity
  - Generation transfer impact based on observed energy exchanges between two entities

Analysis Results

- Analysis Results by Region
  - This presentation has a few example flowgates
    - Results for all 35 flowgates results are in a separate presentation

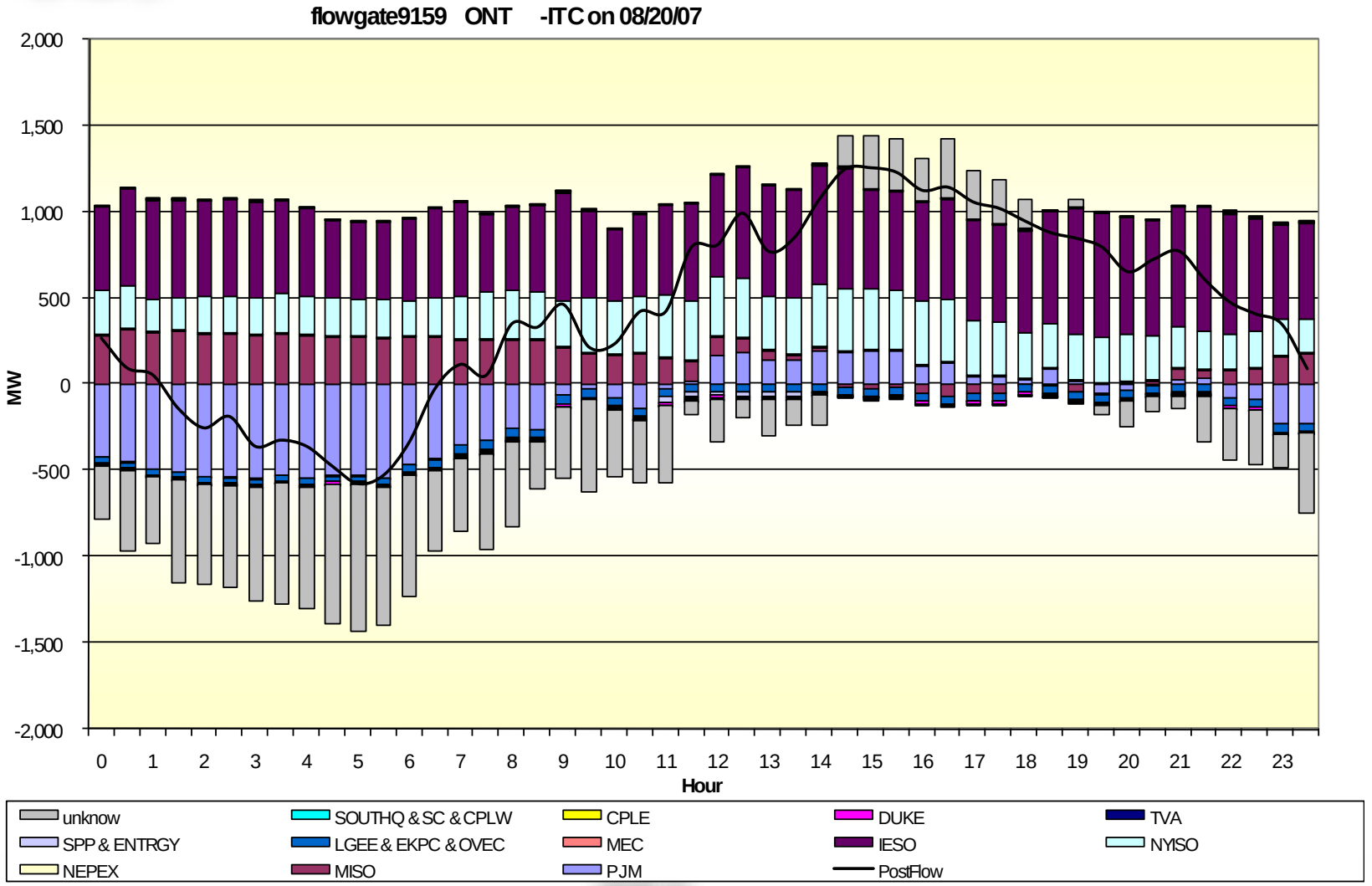
Region	Flowgate ID	Flowgate Name
Northeast	23 *	Roseland-Cedar Grove F 230 kV I/o Roseland-Cedar Grove B
	9159	***ONT-ITC***
PJM/Midwest ISO Central Seam	100 *	Kammer #200 765/500 kV xfmr I/o Belmont-Harrison 500
Southeast	310 *	Person-Halifax 230 kV line I/o Wake-Carson 500 kV

* See Appendix for Analysis Results

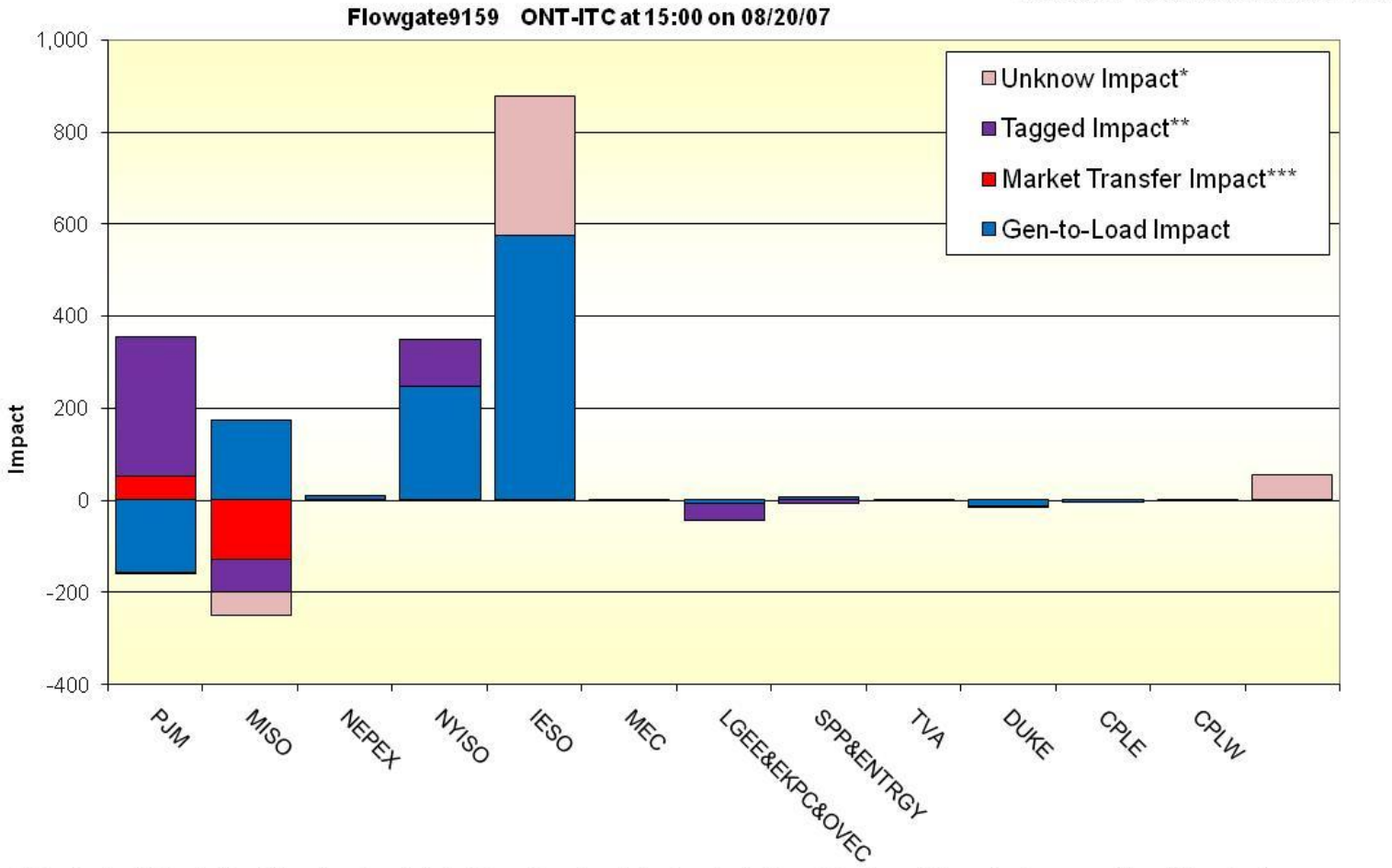
- Flowgate 9159 is the interface between the IESO and the Midwest ISO

- Summary of results at 15:00 on 8/20/2007
  - Generation-to-load impacts of NYISO, IESO, and Midwest ISO are counter-clockwise around Lake Erie
  - PJM generation-to-load impact is clockwise around Lake Erie
  - Contracts from PJM to Midwest ISO have a counter-clockwise impact of 300 MW
  - Contract from PJM to NYISO have a clockwise impact of 123 MW

Method I - Based on Contract Path



Method I - Based on Contract Path

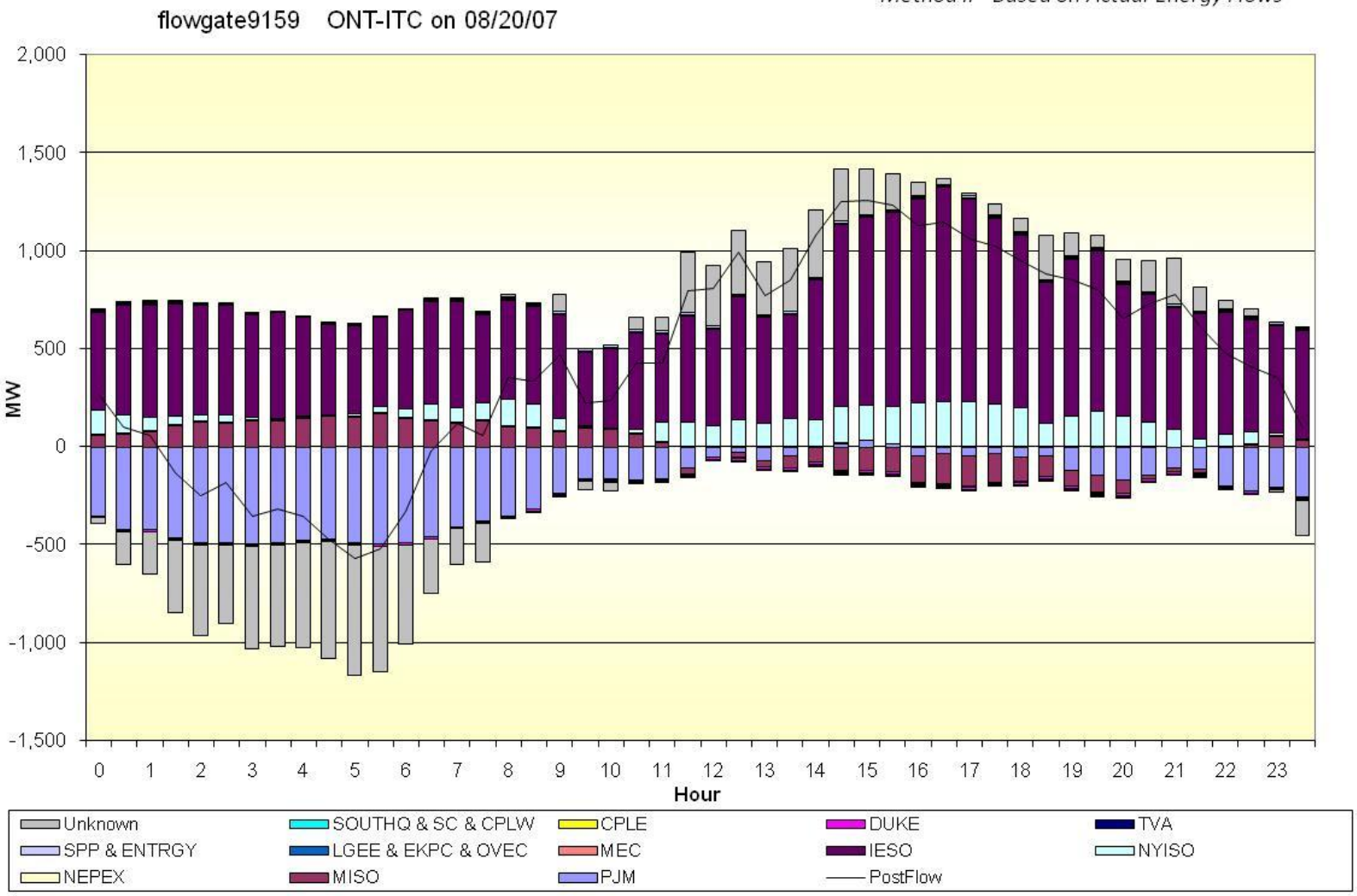


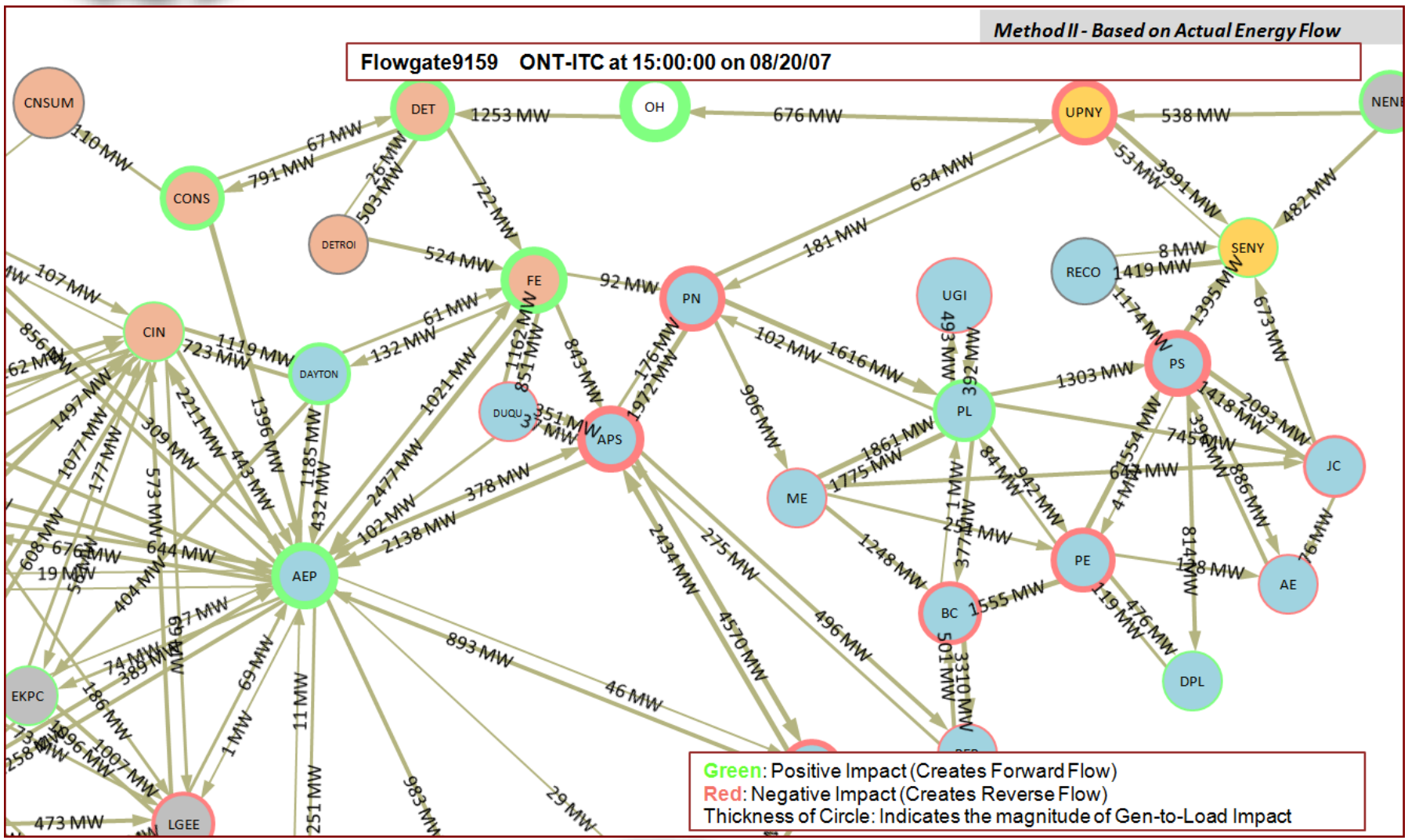
* Due to insuffcient data, this value is calculated based on inputs to the simulation. The type of impact also can not be determined.

** Only the Contracts between PJM and other entities are known

*** The Market Transfer Impact is only calculated for PJM and Midwest ISO (MISO)

Method II - Based on Actual Energy Flows




Method II - Based on Actual Energy Flow
Flowgate9159 ONT-ITC at 15:00:00 on 08/20/07
CNSUM
DET
OH
UPNY
NENE
CONS
DETROI
FE
PN
UGI
RECO
SENY
CIN
DAYTON
DUQU
APS
PL
PS
ME
JC
AEP
PE
AE
BC
DPL
EKPC
LGEE
Green: Positive Impact (Creates Forward Flow)
Red: Negative Impact (Creates Reverse Flow)
Thickness of Circle: Indicates the magnitude of Gen-to-Load Impact

Phase II Conclusions

- Full analysis of the causes of flowgate impacts are limited by lack of consistent data.
  - Scheduling Impacts, Transfer Distribution Factors (TDF) are not observable since data is not saved in the Interchange Distribution Calculator (IDC).
  - Generation-to-Load impacts are only calculated by Midwest ISO, PJM, and SPP with external area impacts remaining largely unknown.

- Analysis of the causes of flowgate impacts using TARA
  - Create Transfer Distribution Factors (TDF)
  - Calculate generation-to-load impacts for entities other than Midwest ISO & PJM.

Phase II Conclusions (continued)

- Many Midwest ISO & PJM flowgates show that a significant amount of flow cannot be determined with readily available data without using simulation tools.

- Calculations using the simulation tool (TARA) and PJM's EMS state estimator data show that a significant amount of flow on many Midwest ISO and PJM flowgates are from other entities.

Recommendations

- Midwest ISO, PJM and all of their neighbors need to increase the transparency of their systems to clarify Loop Flow impacts:
  - Market and Non-Market areas alike need to calculate and share the generation-to-load impacts on regional flowgates.
  - IDC Schedules, TDFs and Market Flows need to be archived for historical data mining.

Loop Flow Study Phase I and II Wrap Up

- Recommendations are consistent from both Phase I and Phase II efforts

- Tracking of recommendation implementation will be provided under current Midwest ISO and PJM Stakeholder process.

Appendix

Analysis Results by Region

➢Northeast Region

20	Erie West-Erie South 345 kV line
23	**Roseland-Cedar Grove F 230 kV l/o Roseland-Cedar Grove B**
9159	ONT-ITC
7102	QFW-(Queenston Flow West)

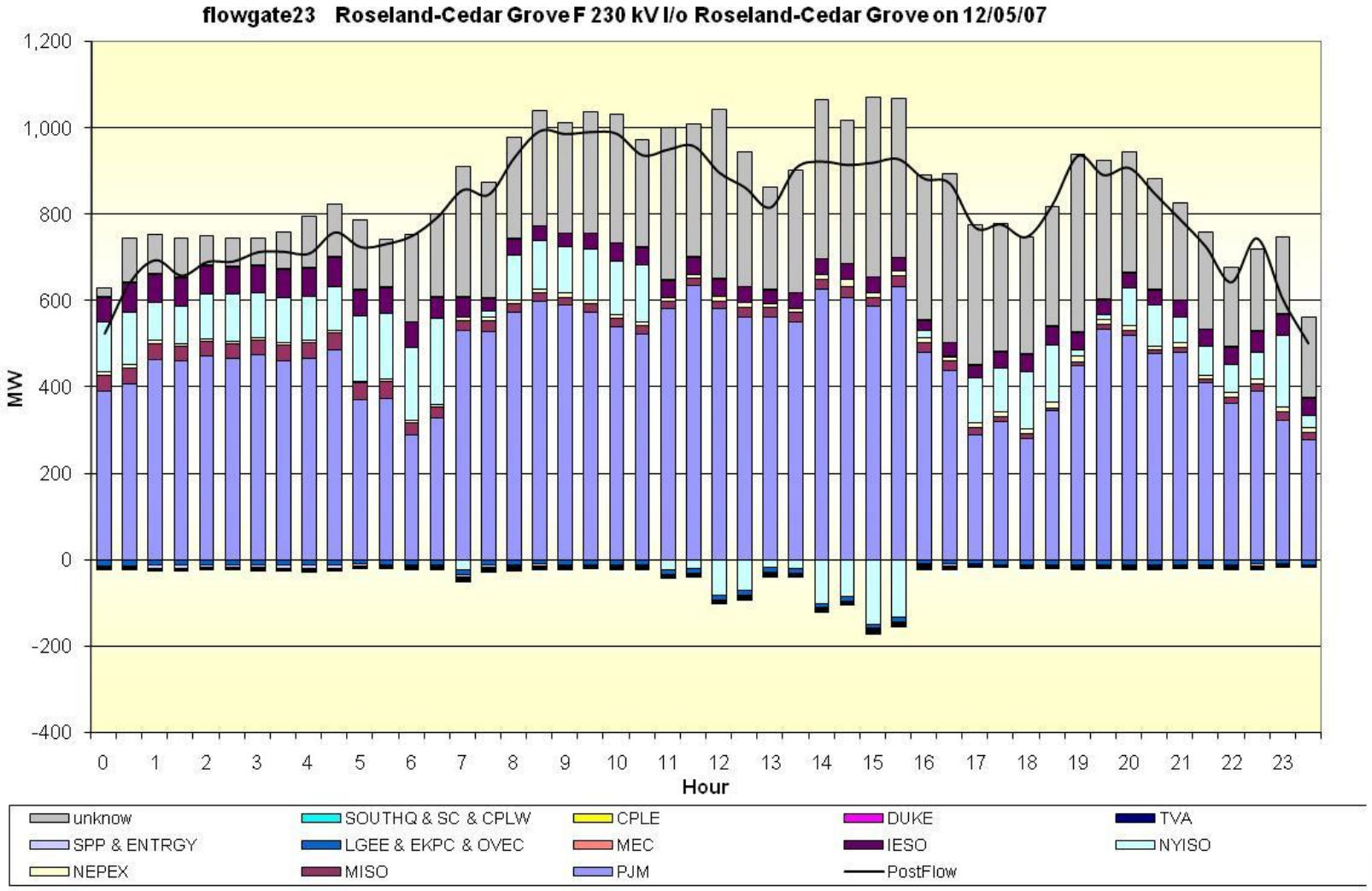
➢These flowgates are impacted by Lake Erie loop flows

Flowgate23 Roseland-Cedar Grove F I/o Roseland-Cedar Grove B

- Flowgate 23 is currently the most frequently congested flowgate near the border between NYISO and PJM

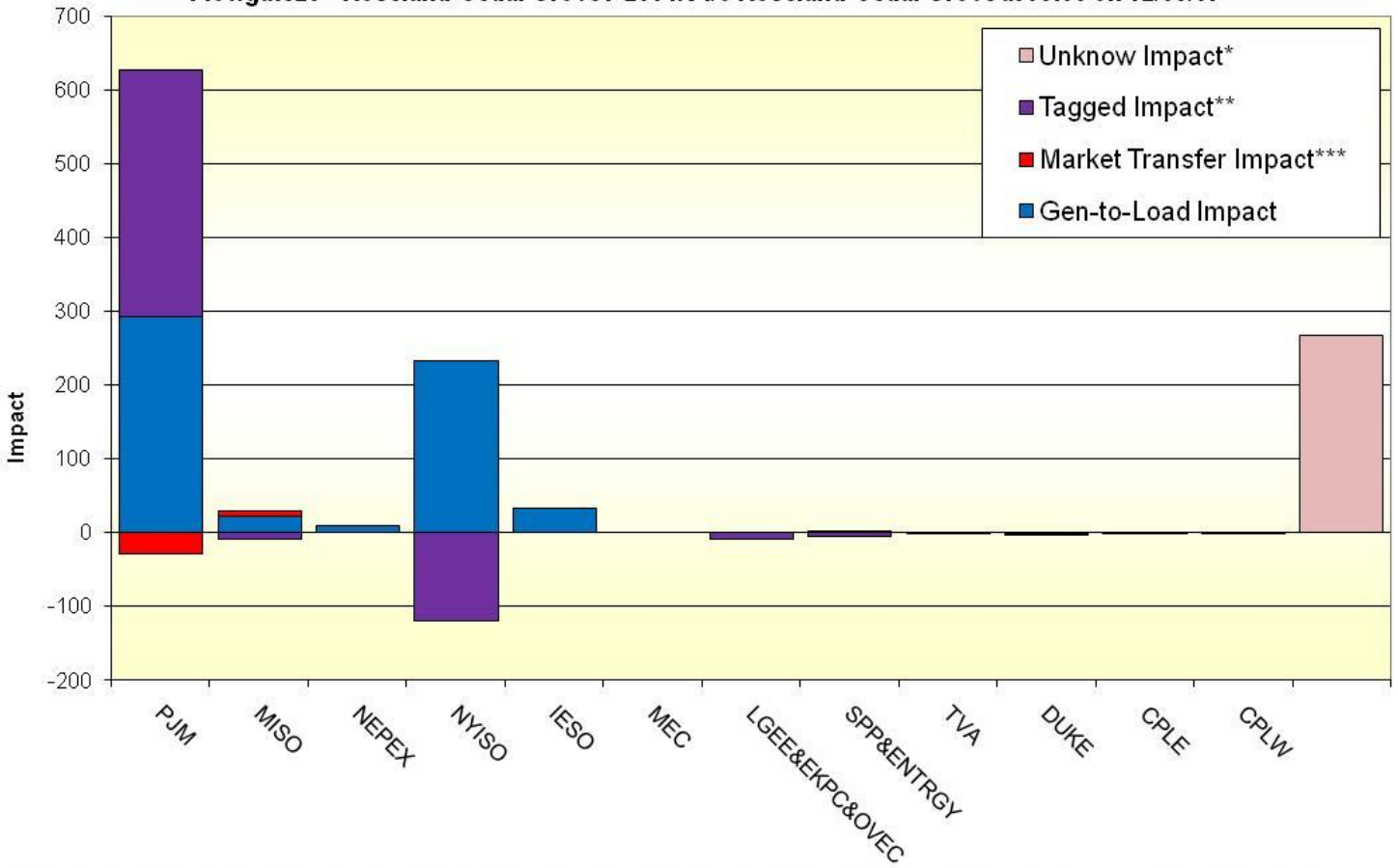
- Comparison of Method I and Method II Analysis
  - Method I: Shows the majority of flows on flowgate 23 are caused by PJM's market
    - PJM exports to NYISO make up approximately half of PJM's impact on flowgate 23
    - PJM generation serving load in Public Service North make up the other half of PJM's impact on flowgate 23
    - NYISO generation to load makes up about 1/3 of the total impact observed on flowgate 23
  - Method II: Both PJM and NYISO have a large impact on flowgate 23
    - PJM and NYISO flow impacts are about equal on flowgate 23
    - Unknown flows make up the remaining 1/3 of the flows observed on flowgate 23

Method I - Based on Contract Path



Method I - Based on Contract Path

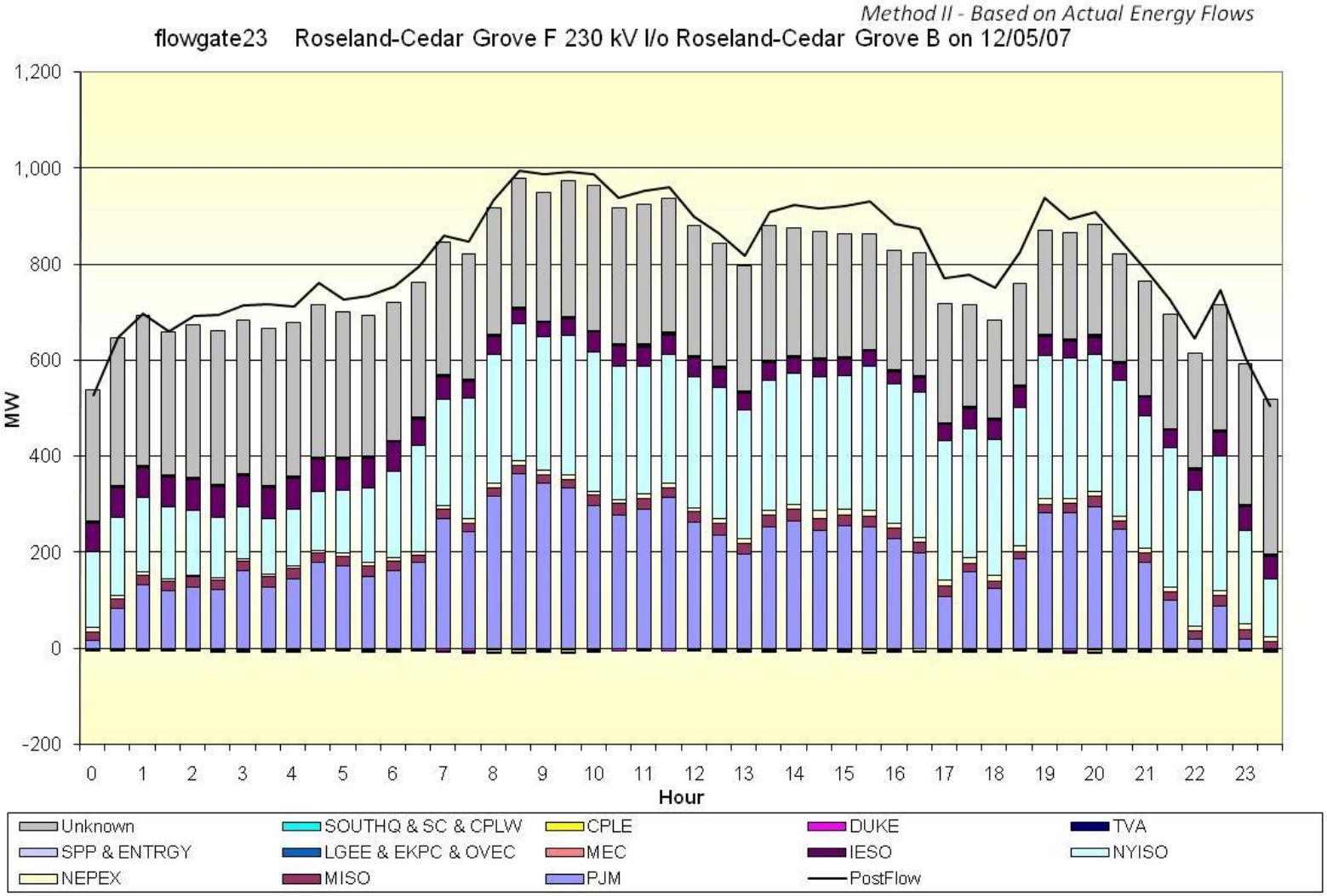
Flowgate23 Roseland-Cedar Grove F 230 kV I/o Roseland-Cedar Grove at 08:30 on 12/05/07

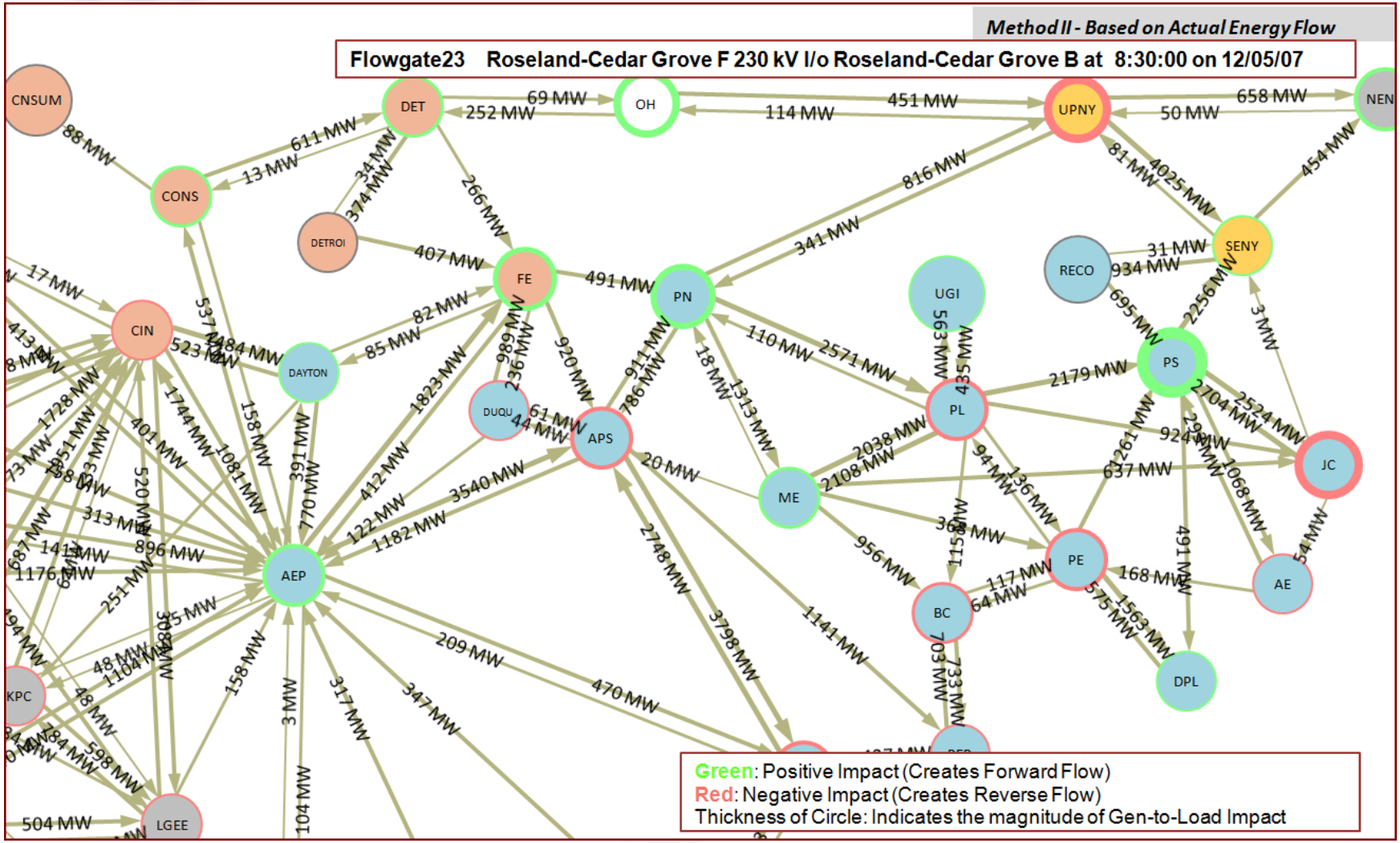


* Due to insuffcient data, this value is calculated based on inputs to the simulation. The type of impact also can not be determined.

** Only the Contracts between PJM and other entities are known

*** The Market Transfer Impact is only calculated for PJM and Midwest ISO (MISO)


Method II - Based on Actual Energy Flows
flowgate23 Roseland-Cedar Grove F 230 kV l/o Roseland-Cedar Grove B on 12/05/07
1,200
1,000
800
600
400
200
0
-200
MW
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
Hour
Unknown
SOUTHQ & SC & CPLW
CPLE
DUKE
TVA
SPP & ENTRGY
LGEE & EKPC & OVEC
MEC
IESO
NYISO
NEPEX
MISO
PJM
PostFlow


Method II - Based on Actual Energy Flow
Flowgate23 Roseland-Cedar Grove F 230 kV l/o Roseland-Cedar Grove B at 8:30:00 on 12/05/07
CNSUM
DET
OH
UPNY
NEN
CONS
DETROI
FE
PN
UGI
RECO
SENY
CIN
DAYTON
DUQU
APS
PL
PS
JC
ME
AEP
BC
PE
AE
DPL
KPC
LGEE
Green: Positive Impact (Creates Forward Flow)
Red: Negative Impact (Creates Reverse Flow)
Thickness of Circle: Indicates the magnitude of Gen-to-Load Impact

Analysis Results by Region

PJM/Midwest ISO Central Seam

100	**Kammer #200 765/500 kV xfmr l/o Belmont-Harrison 500**
122	Wylie Ridge #7 tx l/o Wylie #5 tx (SPS in-service)
141	Elrama-Mitchell 138 kV l/o Sammis-Wylie Ridge 345 kV
2470	Ashtabula-Erie West 345 (flo) Sammis-Wylie Ridge 345
3270	State Line-Wolf Lake 138 flo Burnham-Sheffield 345
2352	PRNTY-MTSTM500/BLACKO-BEDNGT500
2353	BLACKO-BEDNGT500-PRNTY-MTSTM500
2517	Northeast Ohio Interface
2519	Ohio Eastern Interface

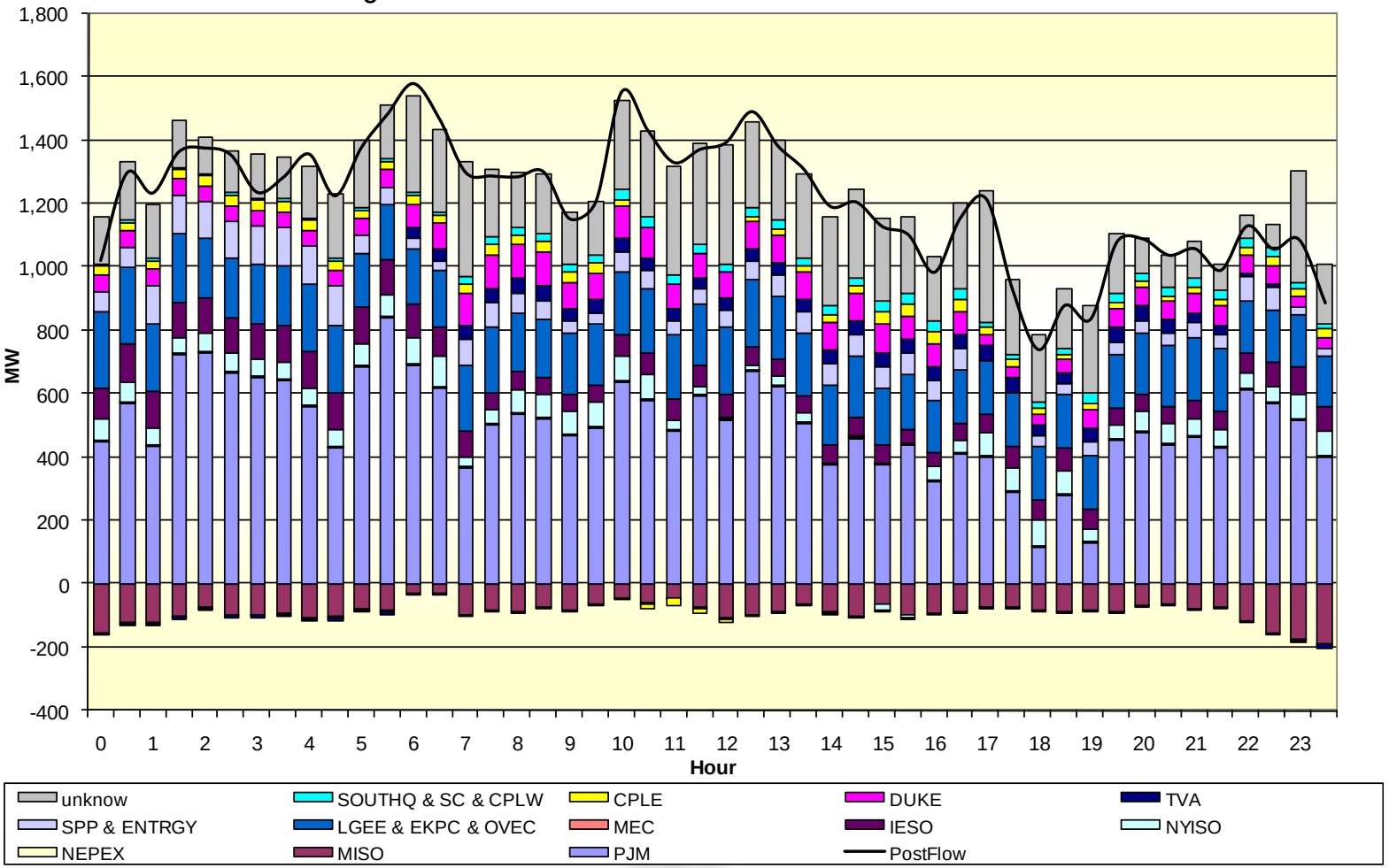
- The Kammer flowgate was selected because it is in the middle of the Midwest ISO/PJM RTO seam and is a reciprocal flowgate

Flowgate 100 Kammer #200 765/500kV xfmr I/o Belmont-Harrison 500

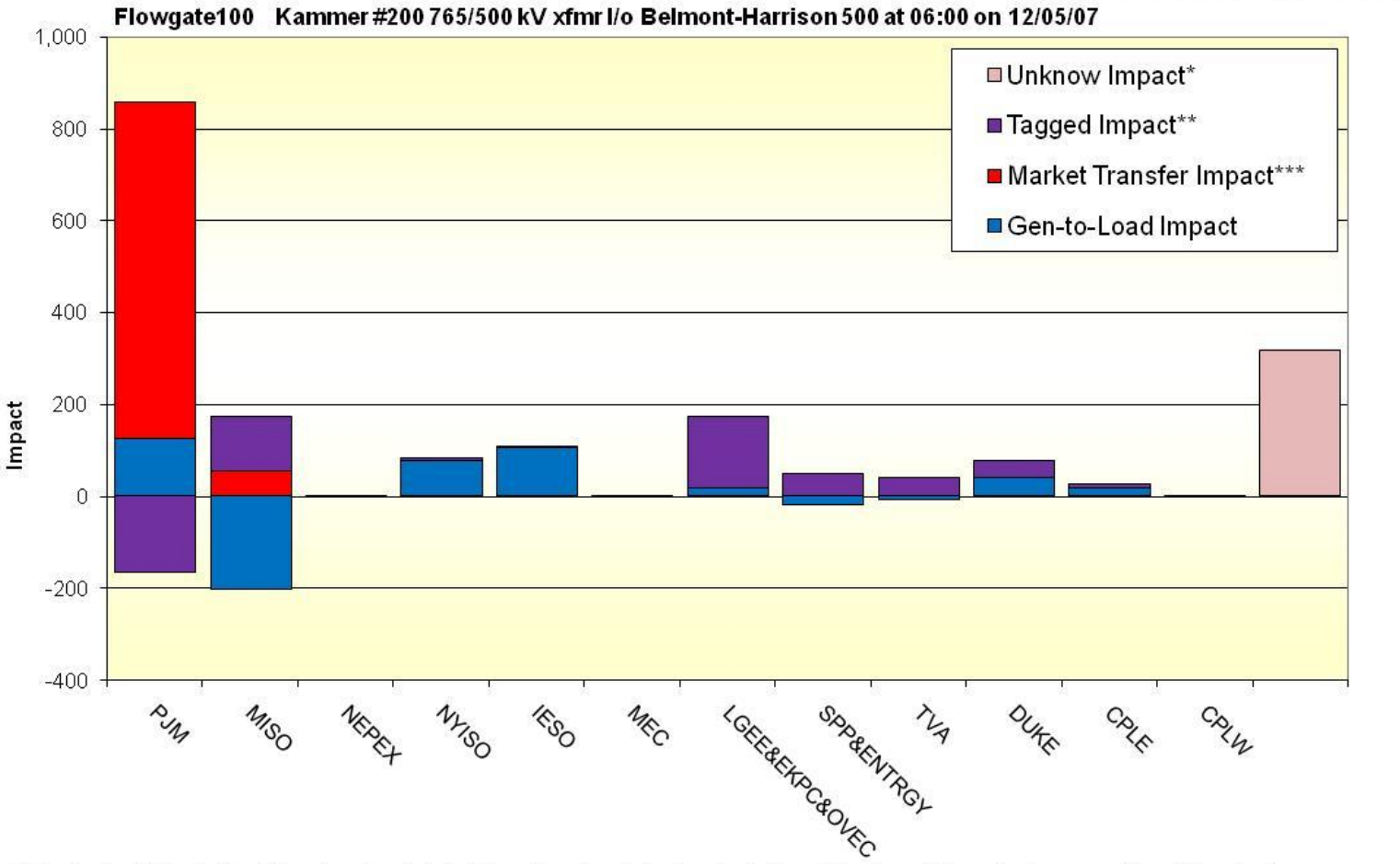
- The Kammer flowgate shows the impacts from many entities other than the Midwest ISO and PJM

- Summary of results at 06:00 on 12/05/2007
  - Major flowgate impact is from PJM's market flows
    - ComEd to APS, MIDATL, and DOM
  - Generation to load impacts from the Midwest ISO zones have a reverse flow impact of 100 MW
  - Schedules from OVEC to PJM have a positive flow impact of 157 MW
  - Schedules from TVA to PJM have a positive flow impact of 41 MW

Method I - Based on Contract Path



Method I - Based on Contract Path



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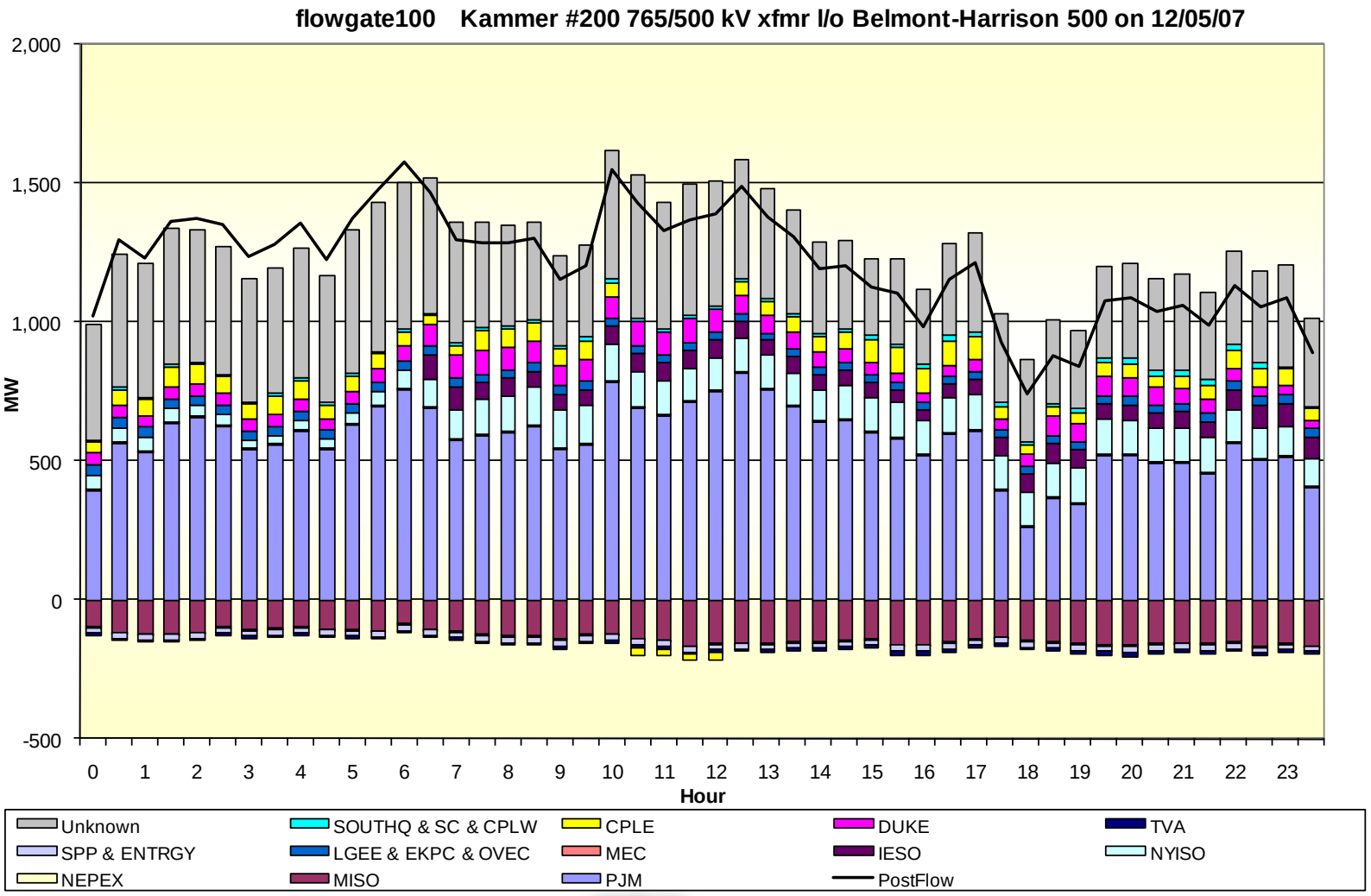
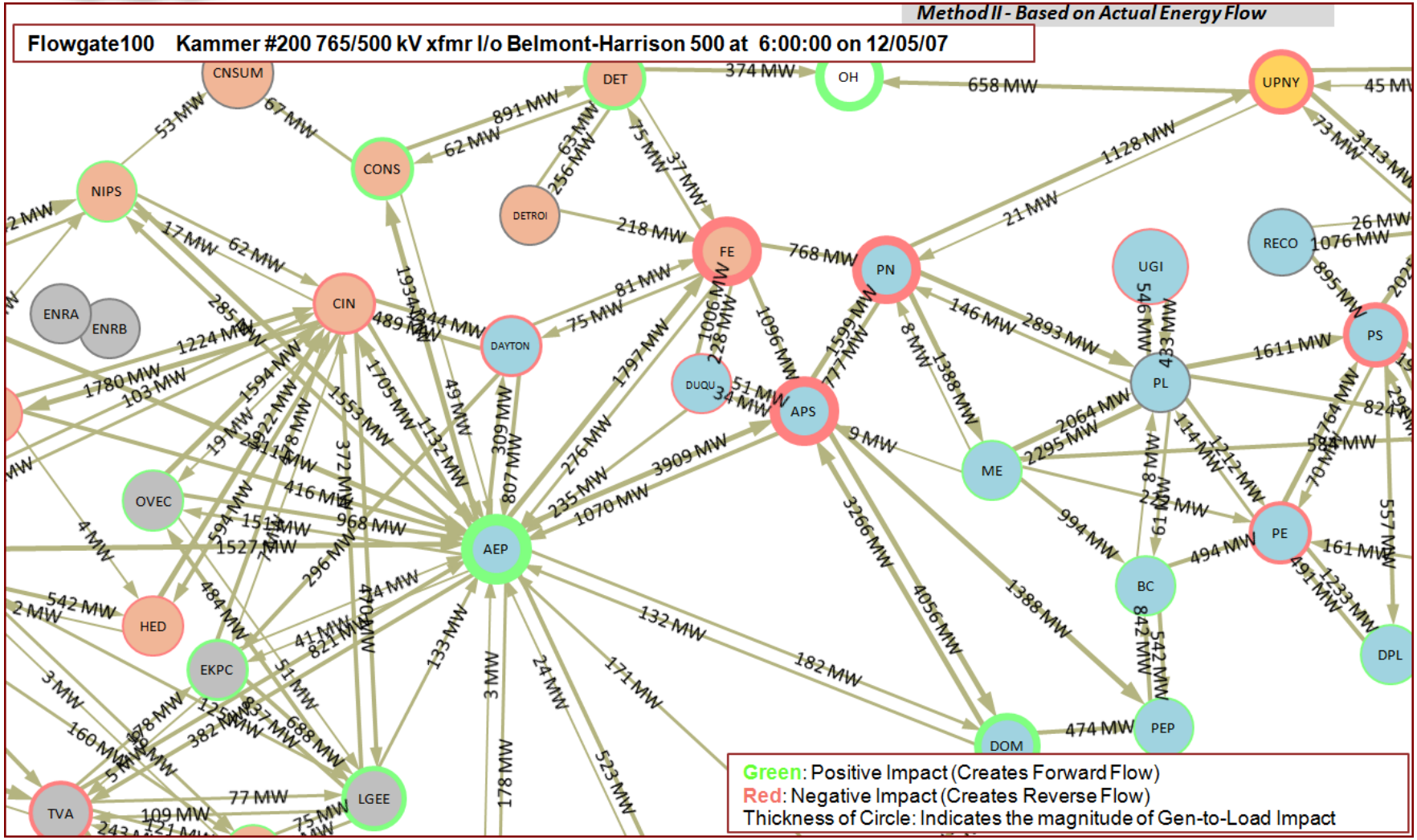
*** The Market Transfer Impact is only calculated for PJM and Midwest ISO (MISO)

Method II - Based on Actual Energy Flows




Method II - Based on Actual Energy Flow
Flowgate100 Kammer #200 765/500 kV xfmr l/o Belmont-Harrison 500 at 6:00:00 on 12/05/07
CNSUM
DET
OH
UPNY
NIPS
CONS
DETROI
FE
PN
RECO
UGI
ENRA
ENRB
CIN
DAYTON
DUQU
APS
PL
PS
OVEC
AEP
ME
PE
HED
EKPC
BC
DPL
TVA
LGEE
DOM
PEP
Green: Positive Impact (Creates Forward Flow)
Red: Negative Impact (Creates Reverse Flow)
Thickness of Circle: Indicates the magnitude of Gen-to-Load Impact

Analysis Results by Region

Southeast Region

310	Person-Halifax 230 kV line l/o Wake-Carson 500 kV

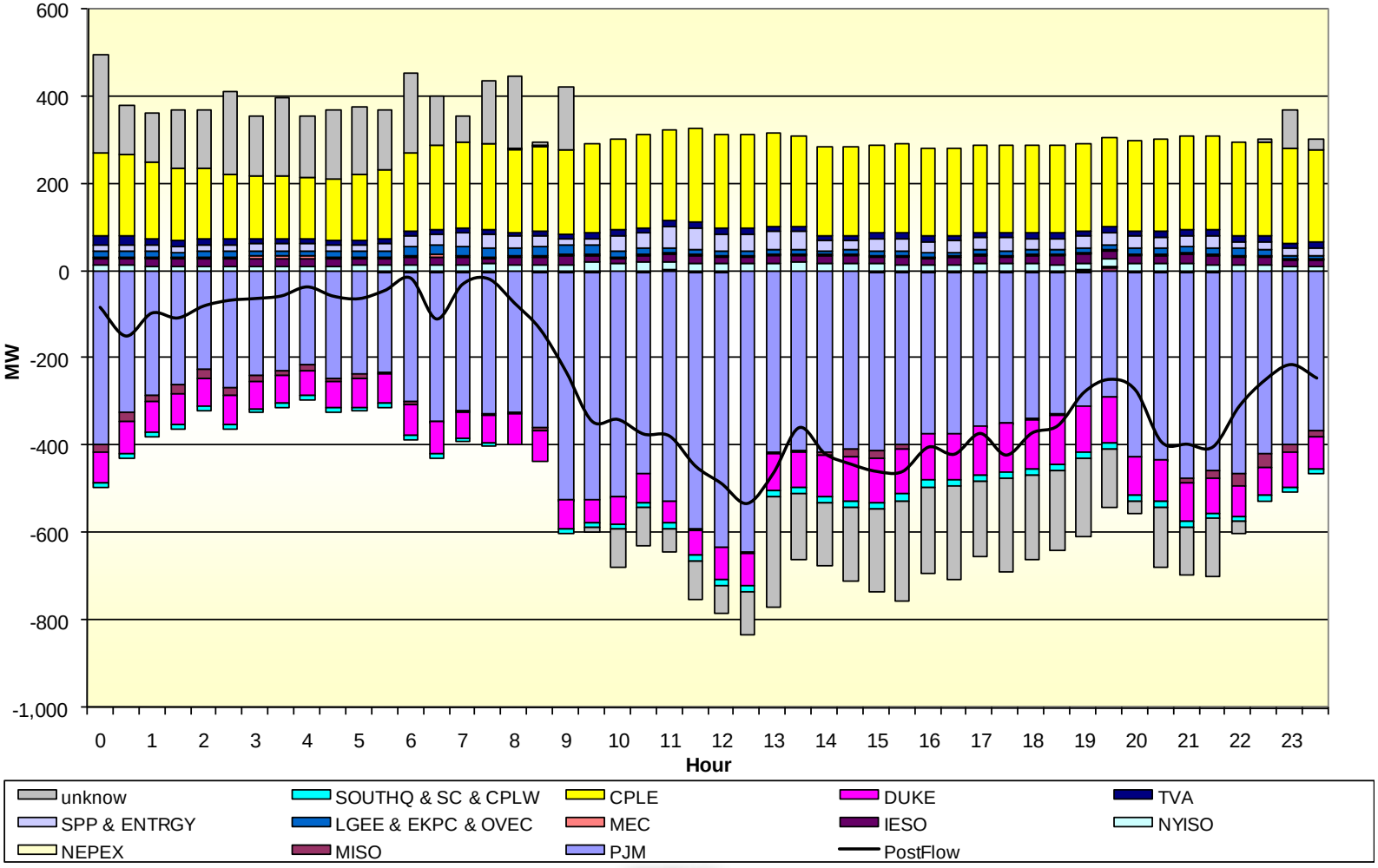
- The Person-Halifax flowgate is on the PJM/Progress Energy interface
  - Negatively impacted by large volumes of loop flows
  - TLRs unsuccessful in effectively managing loop flows in late August and early December of 2007

Flowgate310 Person-Halifax 230kV line l/o Wake-Carson 500 kV

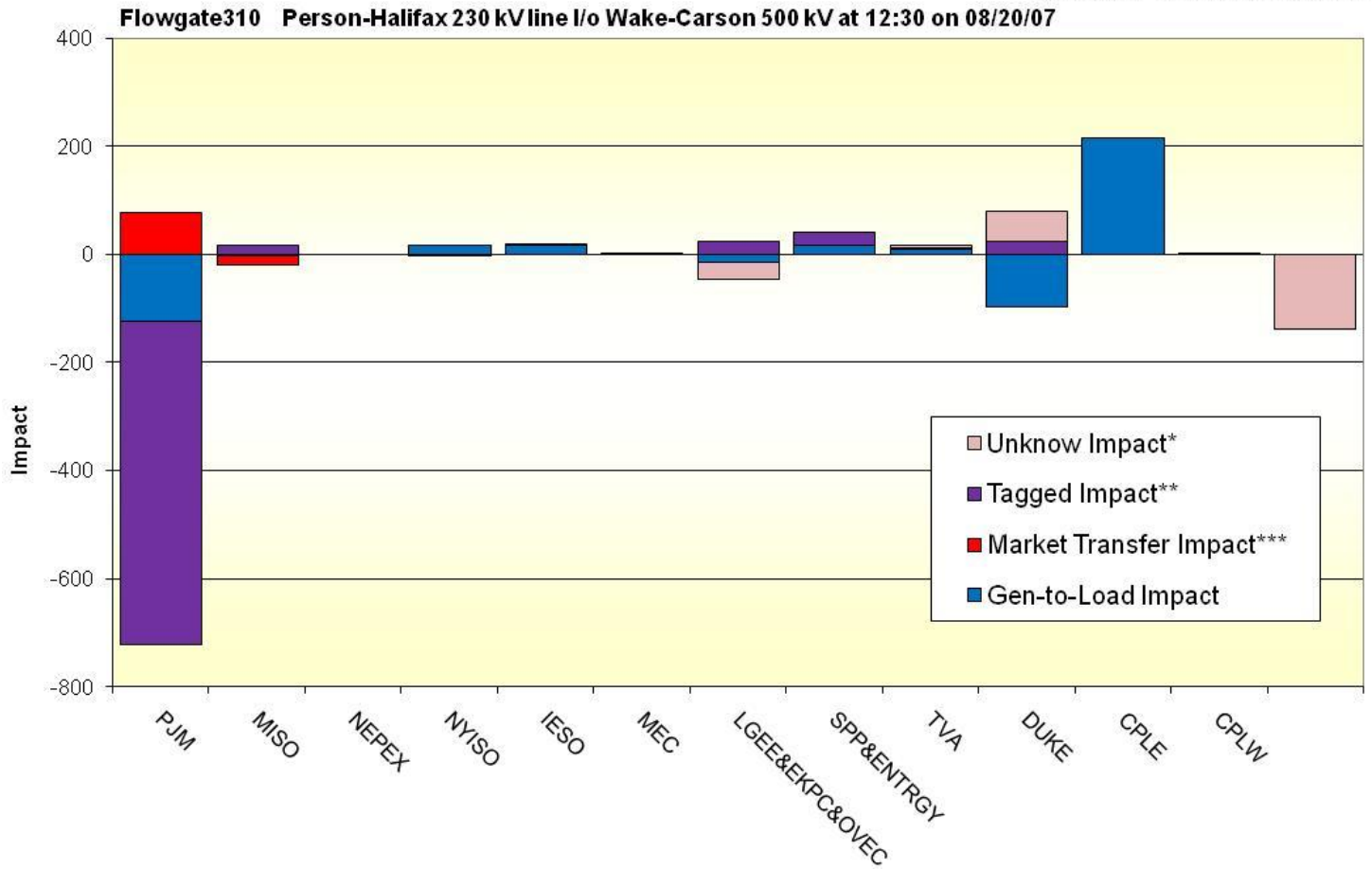
- Summary of results at 12:30 on 08/20/2007
  - Actual tie flows were from north to south
    - Schedules from PJM to southern entities were about 4,000 MW
      - Created 400 MW of north-to-south flow impact on this flowgate
    - PJM generation-to-load is north-to-south due to Clover generation location relative to this flowgate
    - PJM market transfer impact is south-to-north as a result of ComEd and AEP generation looping through CPLE
    - Duke generation-to-load impacts flowgate 310 in a north-to-south direction by about 100 MW
    - CPLE generation-to-load impacts flowgate 310 in a south-to-north direction by about 200 MW

Method I - Based on Contract Path

flowgate310 Person-Halifax 230 kV line l/o Wake-Carson 500 kV on 08/20/07



Method I - Based on Contract Path



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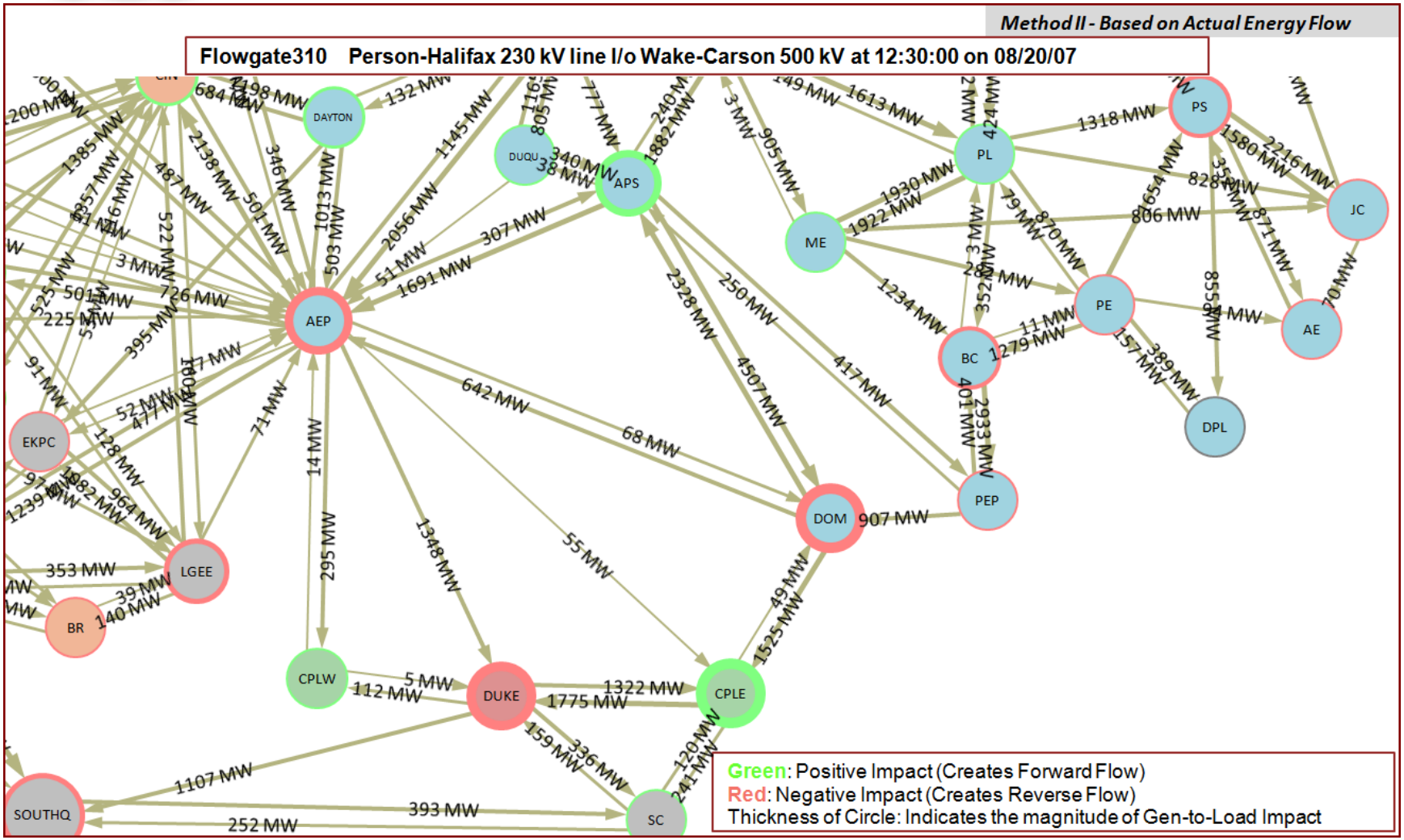
*** The Market Transfer Impact is only calculated for PJM and Midwest ISO (MISO)

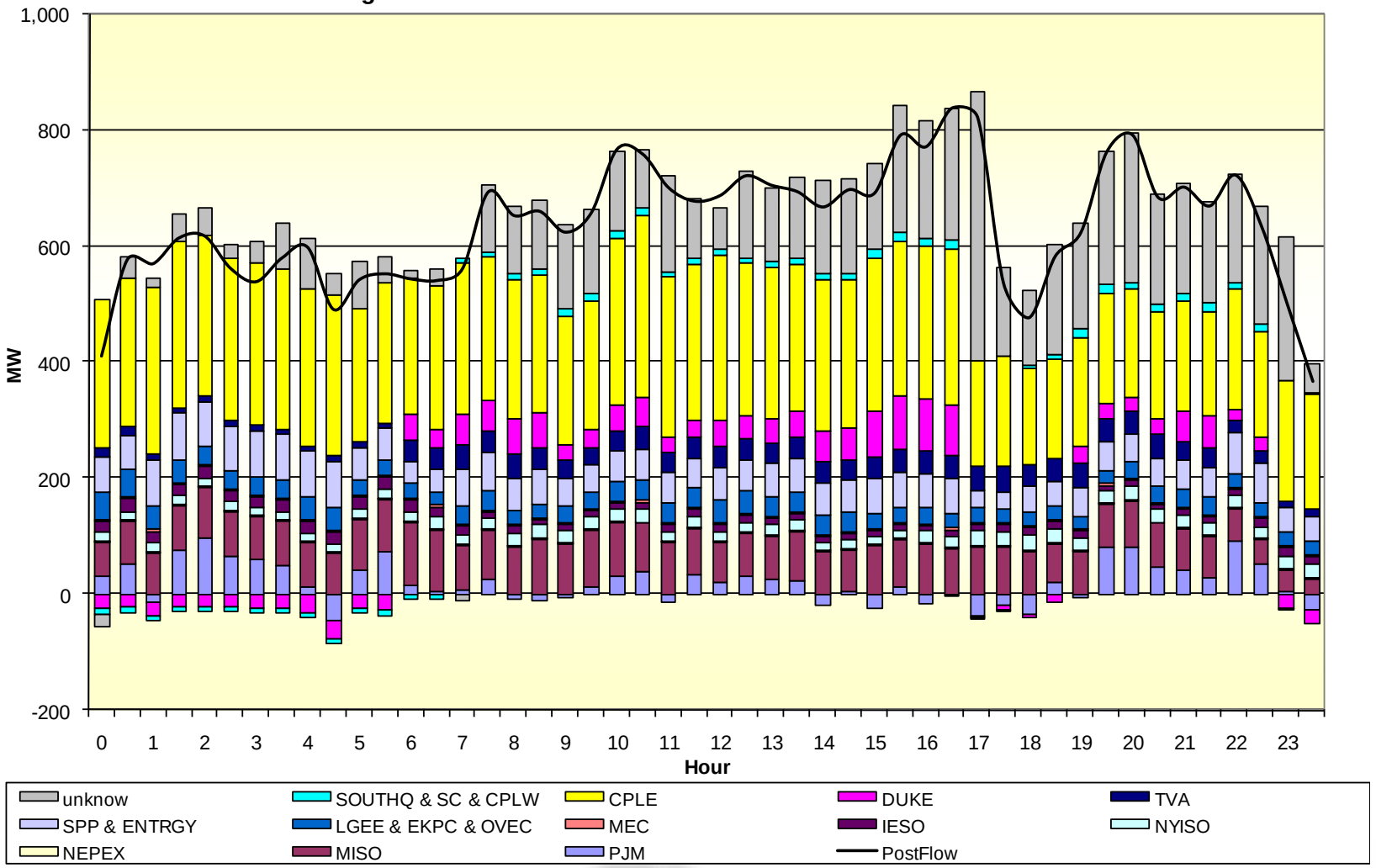

Method II - Based on Actual Energy Flow
Flowgate310 Person-Halifax 230 kV line l/o Wake-Carson 500 kV at 12:30:00 on 08/20/07
AEP
DAYTON
DUQU
APS
ME
PL
PS
JC
PE
AE
BC
DPL
PEP
DOM
EKPC
LGEE
BR
CPLW
DUKE
CPLE
SOUTHQ
SC
907 MW
Green: Positive Impact (Creates Forward Flow)
Red: Negative Impact (Creates Reverse Flow)
Thickness of Circle: Indicates the magnitude of Gen-to-Load Impact

Flowgate310 Person-Halifax 230kV line l/o Wake-Carson 500 kV

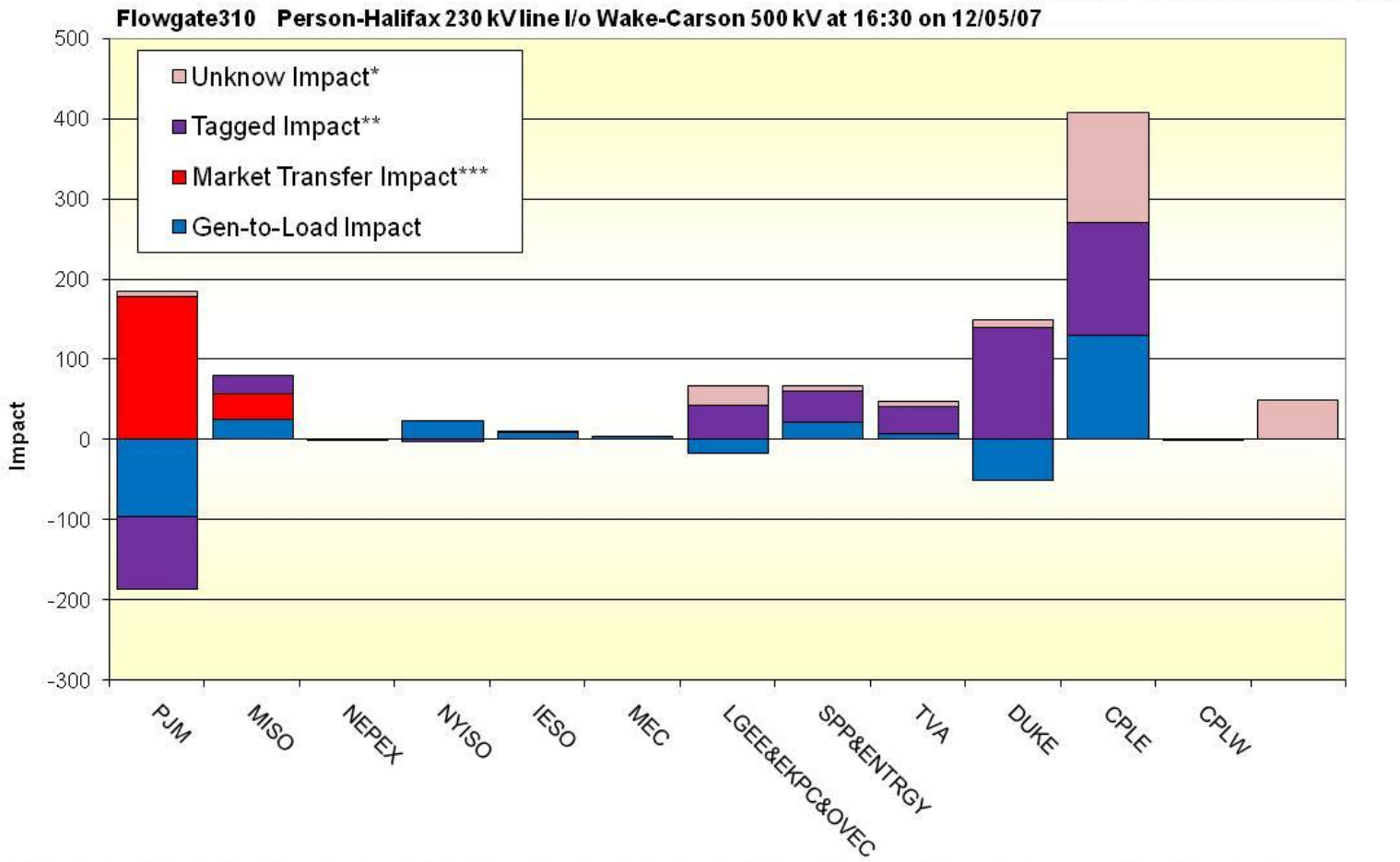
- Summary of results at 16:30 on 12/05/2007
  - Actual tie flows were from south to north
    - Schedules into PJM from southern entities was about 3,000 MW
      - Created 350 MW of south-to-north flow impact on this flowgate
    - PJM generation-to-load is north-to-south due to Clover generation location relative to this flowgate
    - PJM market transfer impact is south-to-north as a result of ComEd and AEP generation looping through CPLE
    - Duke generation-to-load impacts flowgate 310 in a north-to-south direction by about 60 MW
    - CPLE generation-to-load impacts flowgate 310 in a south-to-north direction by about 120 MW

Method I - Based on Contract Path

flowgate310 Person-Halifax 230 kV line l/o Wake-Carson 500 kV on 12/05/07



Method I - Based on Contract Path



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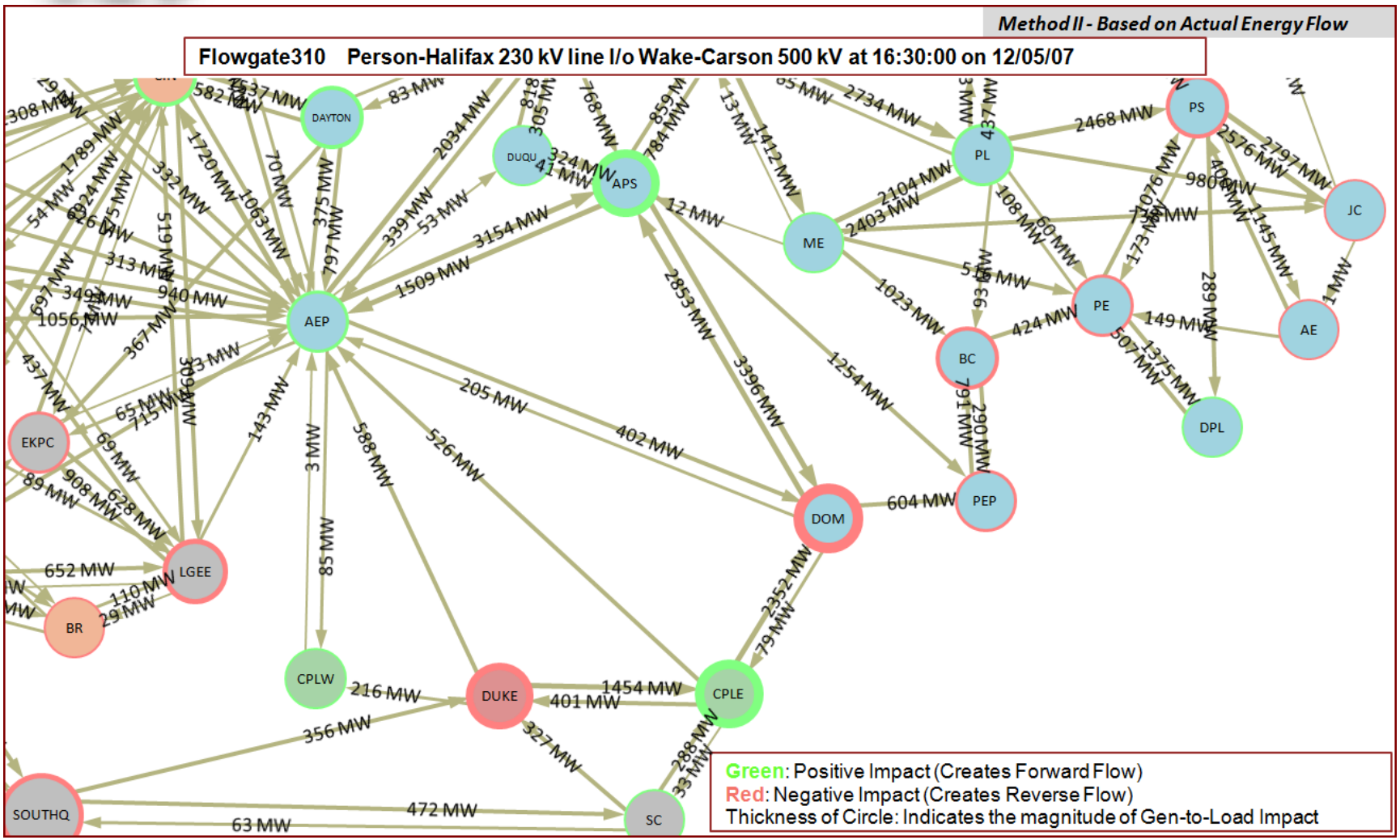
Method II - Based on Actual Energy Flow
Flowgate310 Person-Halifax 230 kV line I/o Wake-Carson 500 kV at 16:30:00 on 12/05/07
DAYTON
DUQU
APS
PS
PL
JC
ME
AEP
PE
AE
BC
DPL
EKPC
DOM
PEP
LGEE
BR
CPLW
DUKE
CPLE
SOUTHQ
SC
Green: Positive Impact (Creates Forward Flow)
Red: Negative Impact (Creates Reverse Flow)
Thickness of Circle: Indicates the magnitude of Gen-to-Load Impact