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INDIANA UTILITY
REGULATORY COMMISSION

44893

VERIFIED DIRECT TESTIMONY

OF

JAMES A. SADTLER

ON BEHALF OF

INDIANAPOLIS POWER & LIGHT COMPANY

INCLUDING IPL WITNESS JAS ATTACHMENTS 1, 2, AND 3

**VERIFIED DIRECT TESTIMONY OF JAMES A. SADTLER
ON BEHALF OF
INDIANAPOLIS POWER & LIGHT COMPANY**

Q1. Please state your name, employer and business address.

A1. My name is James A. Sadtler. I am employed by Indianapolis Power & Light Company ("IPL" or "Company"), One Monument Circle, Indianapolis, Indiana 46204.

Q2. What is your position with IPL?

A2. I am currently the Director of Transmission Field Operations.

Q3. Please describe your duties as Director of Transmission Field Operations.

A3. As Director of Transmission Field Operations, I oversee the real time operations for the IPL transmission and distribution systems, the operation and maintenance of all IPL substations and the downtown electrical network. This includes the operation and maintenance of the protective relaying schemes, and supervisory control and data acquisition systems. The real time operation of the transmission system requires coordination with the Midcontinent Independent System Operator, Inc. ("MISO").

Q4. Please summarize your educational and professional qualifications.

A4. I received a Bachelor of Science Degree in Electrical Engineering Technology from Purdue University. I am a Registered Professional Engineer in the State of Indiana.

Q5. Please summarize your prior work experience.

A5. I have been employed by IPL or one of IPALCO Enterprises, Inc. subsidiaries (Mid America Capital Resources) since 1980, assuming my current role in December, 2011. Previously, I have held a number of management and staff positions at IPL, including overseeing the IPL Power Supply organization, leading the Supply Coordination Office, managing the Eagle Valley Generating Station, managing Transmission Operation and Generation Dispatch, overseeing the Transmission Planning, Supply Chain, and Fuel Procurement functions, Business Development, and engineering support roles in Power Supply and Transmission & Distribution.

Q6. Have you testified previously before the Indiana Utility Regulatory Commission ("Commission") or other regulatory agencies?

A6. Yes, I have submitted testimony on behalf of IPL in some of its previous FAC proceedings (FAC55 through FAC67), and in IPL's FAC89 and FAC90 proceedings. I also testified in Cause No. 44339 which concerned the Eagle Valley Combined Cycle Gas Turbine and Harding Street Units 5 & 6 refueling project and in Cause No. 44576/44602 in which the Commission approved IPL's current basic rates and charges.

Q7. What is the purpose of your testimony in this proceeding?

A7. My testimony supports IPL's used and useful Transmission and Distribution ("T&D") plant in service. I also support IPL Witness Sanchez's testimony by describing IPL's electric service reliability statistics.

Q8. Are you sponsoring any attachments to your testimony?

A8. Yes. My testimony includes the following attachments: IPL Witness JAS Attachment 1, which is a copy of the Indiana Utility Regulatory Commission Electric Utility Reliability Report: 2002-2015; IPL Witness JAS Attachment 2, which is a copy of the Institute of Electrical and Electronics Engineers ("IEEE") Benchmark Year 2016 Results for 2015 Data, and IPL Witness JAS Attachment 3 which is a graphical representation of Page 6 of the Indiana Utility Regulatory Commission Electric Utility Reliability Report: 2002 – 2015.

Q9. Were the attachments you are sponsoring prepared or assembled by you or under your direction or supervision?

A9. Yes. I prepared or assembled the attachments for inclusion with my testimony. IPL Witness JAS Attachment 1 is publicly available at the URL address: http://www.in.gov/iurc/files/2015_Electric_IOU_Reliability_Report.pdf. IPL Witness JAS Attachment 2 was prepared by IEEE staff and presented at the 2016 General Meeting Distribution Reliability Working Group in Boston, Massachusetts and is publicly available at http://grouper.ieee.org/groups/td/dist/sd/doc/Benchmarking-Results-2015.pdf. I prepared IPL Witness JAS Attachment 3 from the data presented in the Indiana Utility Regulatory Commission Electric Utility Reliability Report: 2002-2015.

ELECTRIC PLANT IN SERVICE – TRANSMISSION AND DISTRIBUTION

Q10. Please provide an overview of IPL's electric transmission system as it existed on June 30, 2016.

A10. The IPL transmission system consists of approximately 458 circuit miles of lines at 345,000 volts ("345 kV"), 377 miles of line at 138,000 volts ("138 kV") lines and associated substations. There is a 345 kV ring around Marion County with multiple lines that interconnect into the ring at four different locations. Inside of the 345 kV ring is a 138 kV ring/grid. These two rings are connected through 345 kV to 138 kV auto-transformers at six locations. This allows power to flow from the 345 kV transmission system to the 138 kV system. The customers IPL serves are connected to the 138 kV system.

IPL has generation connected to the 345 kV system at the Petersburg ("Pete") Generating Station and generation connected to the 138 kV system at Harding Street Station ("HSS") Station, Eagle Valley ("EV") Generating Station once the EV Combined Cycle Gas Turbine ("CCGT") plant is placed in service, and the Georgetown Generating Station.

IPL's transmission system also includes a 20 megawatt Energy Storage Array, referred to as the HSS Battery Energy Storage System ("HSS BESS") that was placed in service in May 2016. As discussed by IPL Witness Holtsclaw, IPL's Hanna Substation was upgraded in July 2015 and a Static Var Compensator ("SVC") was placed in service in May 2016 at the Southwest Substation.

Q11. Please explain how IPL's transmission system is interconnected with the transmission systems of other electric utilities.

A11. The IPL transmission system operates as part of a larger integrated network system, commonly referred to as the Eastern Interconnection. The IPL transmission system is directly connected to the transmission systems of Duke Energy Indiana ("Duke"), American Electric Power ("AEP"), Vectren, and Hoosier Energy ("HE"). Through the interconnections with these other utilities, power can flow into and out of the IPL transmission system. The IPL transmission system is connected at both the 345 kV and 138 kV level with the other utilities. At the Petersburg Generation Station there are 345 kV level interconnections with Duke and AEP and 138 kV level interconnections with Duke, Vectren, and HE. In the Indianapolis area IPL's Transmission System has 345 kV level interconnections with Duke and AEP and 138 kV level interconnections with Duke.

Q12. Please provide an overview of IPL's electric distribution system as it existed on June 30, 2016.

A12. The distribution system used to serve our customers as of June 30, 2016, consisted of utility properties customarily used for such purposes, including 71 substations feeding the 472 distribution circuits, 62 additional substations dedicated to transmission or specific customers, towers, poles, conductors, transformers, station structures and equipment, meters and overhead distribution wire of approximately 6,123 miles and underground cable distribution lines of approximately 4,912 miles plus the street lighting facilities which include 1,014 miles of overhead and 762 miles of underground.

Q13. You stated above that IPL's transmission system includes the HSS BESS placed in service in May 2016. Please describe this facility.

A13. The $24.8 million HSS BESS is a grid-scale, lithium ion Battery Energy Storage System. The storage system is located on the southwest side of Indianapolis at the IPL Harding Street Station and is interconnected with the IPL 138 kV transmission system. The HSS BESS is a 20 MW or flexible 40 MW lithium ion battery system currently designed to automatically respond to frequency deviations outside of a preset dead band above or below ±60 Hz to assist in the arrest of the frequency deviation. The term "flexible 40 MW" means the battery can inject up to 20 MWs of stored energy or withdraw up to 20 MWs of energy for a total range of 40 MWs. The HSS BESS has the capacity to inject 20 MWs for one hour or withdraw 20 MWs for hour. The HSS BESS automatically responds to deviations based on the North American Electric Reliability Corporation ("NERC") standards for frequency control by either injecting or withdrawing energy to support the return of the Bulk Electric System frequency to 60 Hz. Frequency can be considered the pulse of the electric grid and is a fundamental indicator of the health of the power system. Frequency Control is a set of defined services across a time continuum known as the "control continuum". Frequency control services may be provided automatically and others may be centrally dispatched by a Balancing Authority. The control continuum includes four stages: 1) Primary Control, 2) Secondary Control, 3) Tertiary Control, and 4) Time Control.

The HSS BESS does not participate in the MISO co-optimized energy and ancillary services market and is therefore not dispatched by the market. It provides frequency control services by automatically reacting within a second to system frequency deviations regardless of cause. It is set to automatically contribute to frequency control, reacting whenever system frequency deviates from 60 Hz by more than +/-0.036 Hz. If frequency is low relative to the standard, the device injects; if frequency is too high relative to the standard, the device withdraws. Automatic provision of frequency control services is the most expedient means to maintain system stability. Chart 1 provides a summary of the Frequency Control Continuum Services and the NERC standard for each. The technical document prepared by the NERC Resources Subcommittee on Balancing and Frequency Control is a good resource to gain further insight to frequency control concepts.[1]

[1] http://www.nerc.com/docs/oc/rs/NERC%20Balancing%20and%20Frequency%20Control%20040520111.pdf

Chart 1 – Control Continuum Summary

Control	Ancillary Service	Dispatched/ Automatic	Purpose	How is it accomplished?	NERC STANDARD[2]
Primary Control	Frequency Response	Automatic	To arrest in 10-60 seconds the degradation of frequency following an event such as a generator tripping or a weather related transmission outage.	All generators with active governors installed automatically react to deviations in system frequency by increasing or decreasing their output minimally sharing the responsibility with all generators on the system	FRS-CPS1
Secondary Control	Regulation, Spinning & None Spinning Reserves	Dispatched	To manage the difference between scheduled generation and load with actual. his is called Area Control Error (ACE is for a balancing area and includes a frequency deviation and frequency bias components).	Resources are dispatched by the Balancing Authority/ RTO adjusting their output in an attempt to balance real time generation, load, and scheduled interchange. Response required in up to 10 minutes in most RTOs	CPS1-CPS2-DCS-BAAL
Tertiary Control	Imbalance / Reserves	Manual and Dispatched	Actions taken to get resources in place to handle current and future contingencies.	Reliability Coordinator can re-dispatch on line generating resources, mandate load schedule/curtailment and/or dispatch resources not already online. This process can take 10 minutes to hours depending upon the event	BAAL-DCS
Time Control	Time Error Correction	Automatic	To regulate system frequency in a manner that keeps synchronous machines/clocks running accurately.	RTOs set system frequency to a level that will elicit a response from generators with governors or other resources capable of automatically responding. .	TEC

The HSS BESS lithium ion battery is housed in a large building with racks and environmental controls including HVAC and looks similar to a data center. The HSS BESS is a modular design comprised of eight (8) two and a half (2.5) MW Cores, each with thirty or more (30+) nodes. There are a total of 244 nodes. A node is a rack of battery trays and invertors. The system is monitored and controlled through Supervisory

[2] http://www.nerc.com/pa/Stand/Reliability%20Standards%20Complete%20Set/RSCompleteSet.pdf

Control and Data Acquisition ("SCADA") and Human Machine Interface ("HMI") monitors over 20,000 data points in each Core. Each node contains 20 battery trays with 20 wafer batteries in each tray for a total of 97,600 lithium ion batteries.

Q14. Why was the HSS BESS added to IPL's system?

A14. In the normal course of IPL's transmission and resource planning process, we plan for the provision of Essential Reliability Services[3], as defined by NERC, (frequency and voltage control), so our customers continue to receive reliable electricity service. As the resource mix in the Eastern Interconnection changes to include more wind, solar and gas fired generation with less flexibility to respond to grid disturbance conditions than coal-fired generation, IPL sought state-of-the-art solutions to provide both frequency and voltage control that are physically and economically efficient to provide benefits to our customers. IPL chose to build a Static Var Compensator for voltage control and the HSS BESS for frequency control. IPL Witness Holtsclaw provides detailed information about the Static Var Compensator in his testimony.

While the category of "energy storage" includes many technologies with varying operating characteristics and benefits, lithium ion battery storage is a leading technology for mitigating the diminishing supply of resources providing Essential Reliability Services. The HSS BESS can inject or withdraw energy as required in a second to contribute to maintaining system stability to mitigate the challenges related to the integration solar PV, wind, and variable frequency drive motor loads.

At this time, no other device has as much flexibility, efficiency, or adaptability to future changes for grid frequency control as lithium ion battery storage systems. The Eastern

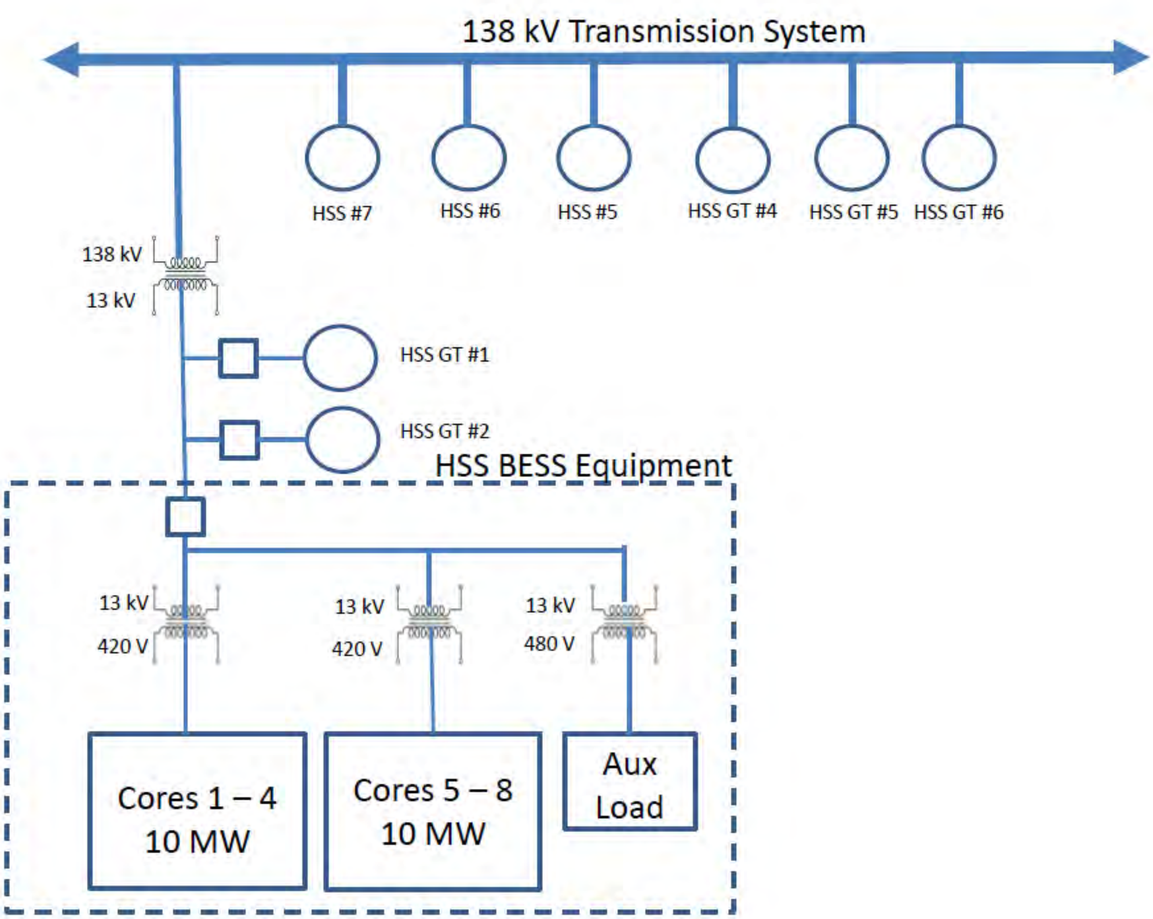
[3] http://www.nerc.com/comm/Other/essntlrlbltysrvcstskfrcDL/Scope_ERSTF_Final.pdf

Interconnection experiences approximately 25 events per year which require primary frequency control to arrest the deviation. Since the HS BESS has been placed in service it has contributed to the arrest of the frequency deviations. There is a provision in the contract to return the batteries to the supplier at the end of their useful life for proper recycling of the various components and materials.

Q15. How is the HSS BESS interconnected to the transmission system?

A15. The HSS BESS is interconnected at the IPL 138 kV sharing the common bus with Harding street generators. See Figure 1 below.

Figure 1



Q16. Please explain further what frequency control is and how the BESS is used to provide it.

A16. Frequency control is an Essential Reliability Service. If frequency is not controlled within the parameters set by the NERC, it can cause generators to trip offline and damage end use equipment. If not mitigated quickly the excursion can lead to load shedding by under frequency relaying.

Q17. Can the HSS BESS provide other benefits to IPL's system?

A17. Yes. The HSS BESS could provide 5 MWs of capacity credit toward meeting IPL's resource adequacy requirement. Even though the MISO tariff does not yet permit energy storage devices to receive capacity credit, because the HSS BESS tested successfully to provide 5 MWs of capacity over the four hours of the peak and could be accounted for administratively as "behind-the-meter." IPL can use those MWs as a Load Modifying Resource ("LMR") in the MISO capacity construct.[4] Additionally, the HSS BESS can perform all the ancillary services defined by FERC according to the criterion included in the MISO tariff. However at this time, neither the MISO tariff nor the market dispatch design facilitates provision of the other ancillary services by batteries.

Q18. What is the function of this facility in MISO?

A18. MISO plans to include the HSS BESS as part of their compliance with NERC Standard BAL003-1. BAL003-1 assigns the responsibility for provision of Primary Frequency Response ("PFR") to MISO as the Balancing Authority. BAL003-1 requires the

[4] IPL registered the 5 MW LMR capability of the HSS BESS with MISO, along with its demand response programs and Conservation Voltage Reduction program which account for 58 MW of LMR capacity credit in planning year 2016/2017.

resources within the footprint to contribute to MISO's provision of PFR according to a frequency bias standard.

Q19. How is this beneficial to IPL and its customers?

As discussed in the November 2015 publication entitled "Essential Reliability Services Task Force Measures Framework Report"[5] and the December 2015 NERC publication entitled "2015 Long-Term Reliability Assessment,"[6]

> "The North American electric power system is undergoing a significant transformation with ongoing retirements of fossil-fired and nuclear capacity as well as growth in natural gas, wind, and solar resources. This shift is caused by several drivers, such as existing and proposed federal, state, and provincial environmental regulations as well as low natural gas prices, in addition to the ongoing integration of both distributed and utility-scale renewable resources. The resource mix changes are directly impacting the behavior of the North American BPS. These developments will have important implications on system planning and operations, as well as how NERC and the industry assess reliability. In order to maintain an adequate level of reliability through this transition, generation resources need to provide sufficient voltage control, frequency support, and ramping capability as essential components to the reliable operations and planning of the BPS. It is necessary for policy makers to recognize the need for essential reliability services provided by the current and future mix of resources. Analyses of this transformation must be done to allow for effective planning and to provide System Operators the flexibility to modify realtime operations and future planning of the BPS."

A19. While the environmental benefits of this change in the generation mix have been endlessly studied for years, the impact on grid reliability due to a reduction in ancillary services capability has just recently been elevated as an associated risk by NERC. In December 2015, NERC recommended steps to gather data and study/forecast the needs going forward. While today on a regional basis, only California Independent System Operator ("CAISO") is experiencing a material shortage of the ancillary services that

[5] http://www.nerc.com/comm/Other/essntlrlbltysrvcstskfrcDL/ERSTF%20Framework%20Report%20-%20Final.pdf
[6] http://www.nerc.com/pa/RAPA/ra/Reliability%20Assessments%20DL/2015LTRA%20-%20Final%20Report.pdf

support grid reliability, (voltage and frequency control services) the other RTOs are expected to begin seeing shortages of ancillary services as coal-fired generation retires and additional renewable resources and gas-fired generation are interconnected. In fact MISO recently recognized a decline in frequency response in its own footprint.[7] The NERC "Reliability Considerations for Clean Power Plan Development" issued in January 2016[8] states:

> "Essential Reliability Services – Changes to the generation resource mix and the way in which resources are dispatched and controlled can impact system operations. In order to maintain an adequate level of reliability through this transition, generation resources need to provide sufficient voltage control, frequency support, and ramping capability—essential components to the reliable operation of the BPS. It is necessary for policy makers to recognize the need for these services by ensuring that interconnection requirements, market mechanisms, or other reliability requirements provide sufficient means of adapting the system to accommodate large amounts of variable and/or distributed energy resources. Whereas distinct market mechanisms and wholesale services are regulated by FERC, states plan for policies on resource mix and establishing Reserve Margin requirements."

This NERC report corroborates the benefit the HSS BESS provides to the Bulk Power System. IPL must meet NERC standards. The obligation includes compliance with NERC Standard BAL003-1 for frequency bias, the resource obligation to contribute to frequency response. While the obligation to provide a prescribed amount of primary frequency response under this standard is MISO's, they neither own nor control the assets. IPL and other generation owners must contribute for MISO to meet its obligation. For IPL and other utilities with an obligation to serve end use customers reliably, Frequency Control is essential to meeting our obligation to our customers. As do other

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[7] https://www.misoenergy.org/Library/Repository/Meeting%20Material/Stakeholder/IPTF/2016/20160310/20160310%20IPTF%20Item%2002%20Frequency%20Response.pdf

[8] http://www.nerc.com/pa/RAPA/ra/Reliability%20Assessments%20DL/Reliability%20Considerations%20for%20State%20CPP%20Plan%20Development%20Baseline%20Final.pdf

utility members of MISO, IPL plans for all elements needed to continue to serve our customers reliably. Components of that planning include generation, transmission and the provision of all ancillary services required for system reliability.

Planning for Mercury Air Toxic Standards ("MATS") compliance focused our attention on the potential grid challenges of fewer resources providing Essential Reliability Services across the Eastern Interconnection, in part due to the increase of renewable resources. As part of the normal transmission planning process and given the renewable resource business environment IPL sought solutions to the provision of both frequency and voltage control services that are more efficient and beneficial to our customers than when served by traditional generators. As noted above, IPL chose to build a SVC for state of the art voltage control and the HSS BESS for state of the art frequency control.

Early on, IPL identified through rigorous study the reactive needs of our system and have built a Static VAR Compensator placed in service in May 2016 to manage local voltage control issues. IPL selected a lithium ion battery, the HSS BESS, to assist with frequency control issues, an Eastern Interconnection-wide challenge. Both technologies are part of an industry trend to design devices specifically to efficiently provide essential reliability and other ancillary services.

Q20. Please describe the overall condition of IPL's transmission and distribution plant.

A20. In my opinion, the T&D plant is well maintained, in good condition and reasonably necessary for IPL's provision of electric service. The T&D plant is included in the electric plant in service shown on <u>IPL Financial Exhibit IPL-RB, Schedule RB3</u>, which is discussed by IPL Witness Tornquist.

SERVICE RELIABILITY

Q21. How do the Commission and IPL monitor the reliability of utility Transmission & Distribution systems?

A21. The Commission and IPL use the following standard industry key performance indicators to measure electric system reliability:

- System Average Interruption Frequency Index ("SAIFI"): the average number of interruptions per customer. It is calculated by dividing the total number of customer interruptions by the total number of customers.
- System Average Interruption Duration Index ("SAIDI"): the average minutes of interruption per customer. It is calculated by dividing the sum of all customer interruptions (in minutes) by the total number of customers.
- Customer Average Interruption Duration Index ("CAIDI"): the average duration of interruptions or the time to restore service to interrupted customers. It is calculated by dividing SAIDI by SAIFI.

Q22. Are the IPL electric system reliability key performance indicator indices benchmarked?

A22. Yes. IPL Witness JAS Attachments 1 and 2 are two recent external benchmarks available for the IPL electric system.

Q23. In your opinion, how do the IPL electric system reliability key performance indices compare in the external benchmarks provided in IPL Witness JAS Attachment 1?

A23. In IPL Witness JAS Attachment 1, the annual reliability key performance indices (SAIFI, SAIDI, & CAIDI) for the Indiana investor-owned utilities for the fourteen year time period 2002 through 2015 are provided including and excluding major events. As stated in the report, "It is important to note that the same definition of "major event" is not the used by all utilities. However, Indiana IOUs define a major event day (MED) using a standard provided by the IEEE Standard 1366. It involves the calculation of a threshold in terms of SAIDI minutes based on data from the previous five years. Any day the threshold is exceeded is a MED. The provision of indices that exclude major events normalizes the data by eliminating interruptions over which the utilities have little or no control. In addition, there can be great variation in major events (e.g. tornadoes, floods, ice storms), the resulting damage, and the time necessary to make repairs." Since all the Indiana IOUs have adopted the IEEE 1366 Standard it is appropriate to use the information found on Page 6 of IPL Witness JAS Attachment 1 "Electric Reliability Not Including Major Events." As shown in IPL Witness JAS Attachment 3, a graphical representation of Page 6 of the Indiana Utility Regulatory Commission Electric Utility Reliability Report: 2002 – 2015. IPL Witness JAS Attachment 3 page 1 is the SAIFI relative benchmark graph, page 2 is the SAIDI relative benchmark graph, and page 3 is the CAIDI relative benchmark graph. From inspection of the data and the graphs, IPL's electric system reliability is a top performer for this peer group for the fourteen year time period from 2002 through 2015.

Q24. Please describe the type of information reflected in the 96 total entries that are included in the IEEE benchmarking presented in IPL Witness JAS Attachment 3.

A24. IPL Witness JAS Attachment 3, pages 4, 5, and 6 provide information on the participants for IEEE benchmarking. See Table 1.

Table 1

Page	Information Presented	IPL's segment	Count
4	Count by Geographical region	Midwest Region	19
5	Count by NERC Region	RF	29
6	Classification by number of customers	Size - Medium	57

Q25. In your opinion, how does the IPL electric system reliability compare in the external benchmark provided in IPL Witness JAS Attachment 2?

A25. The key pages in IPL Witness JAS Attachment 2 are identified in the table below along with IPL's position compared to 93 participating electric distribution utilities. See Table 2 below.

Table 2

Metric	IEEE 1366 Method	Quartile
SAIDI	Page 15 – IPL's position 8th	First
SAIFI	Page 20 – IPL's position 10th	First
CAIDI	Page 24 – IPL's position 8th	First

On the charts presented on the referenced pages in IPL Witness JAS Attachment 2, you will notice that the each participate on the X axis has a unique identifying code to maintain confidentiality. In this report, IPL's code is U196. IPL's 2015 electric system reliability is in the 1st Quartile for all three of the key performance metrics (SAIDI, SAIFI, & CAIDI) using the IEEE 1366 Standard Methodology.

Q26. Does this conclude your verified pre-filed direct testimony?

A26. Yes.

VERIFICATION

I, James A. Sadtler, Director of Transmission Field Operations for Indianapolis Power& Light Company, affirm under penalties of perjury that the foregoing representations are true and correct to the best of my knowledge, information and belief.

James A. Sadtler

James A. Sadtler

Dated: December 22, 2016

Indiana Utility Regulatory Commission
Electric Utility Reliability Report: 2002 – 2015

Each investor-owned electric utility (IOU) in Indiana is required to file a reliability report annually with the Indiana Utility Regulatory Commission (IURC) in compliance with 170 IAC 4-1-23(e). This document serves as a compilation of the reports filed for 2015 and provides historical data beginning in 2002. The data is provided in summary tables early in the report and in complete tables at the end. Also included is a written summary and graph for each IOU illustrating the trends from 2002 to 2015.

The utilities provide the following three reliability indices in their reports:

- System Average Interruption Frequency Index (SAIFI): the average number of interruptions per customer. It is calculated by dividing the total number of customer interruptions by the total number of customers.
- System Average Interruption Duration Index (SAIDI): the average minutes of interruption per customer. It is calculated by dividing the sum of all customer interruption durations (in minutes) by the total number of customers.
- Customer Average Interruption Duration Index (CAIDI): the average duration of interruptions or the time to restore service to interrupted customers. It is calculated by dividing SAIDI by SAIFI.

Each utility reports its indices with and without major events. Major events are weather-related storms that are more destructive than normal weather-related storm patterns. It is important to note that the same definition of "major event" is not used by all utilities. However, Indiana IOUs define a major event day (MED) using a standard provided by the Institute of Electrical and Electronics Engineers (IEEE Standard 1366). It involves the calculation of a threshold in terms of SAIDI minutes based on data from the previous five years. Any day the threshold is exceeded is a MED. The provision of indices that exclude major events normalizes the data by eliminating interruptions over which the utilities have little or no control. In addition, there can be great variation in major events (e.g., tornadoes, floods, ice storms), the resulting damage, and the time necessary to make repairs.

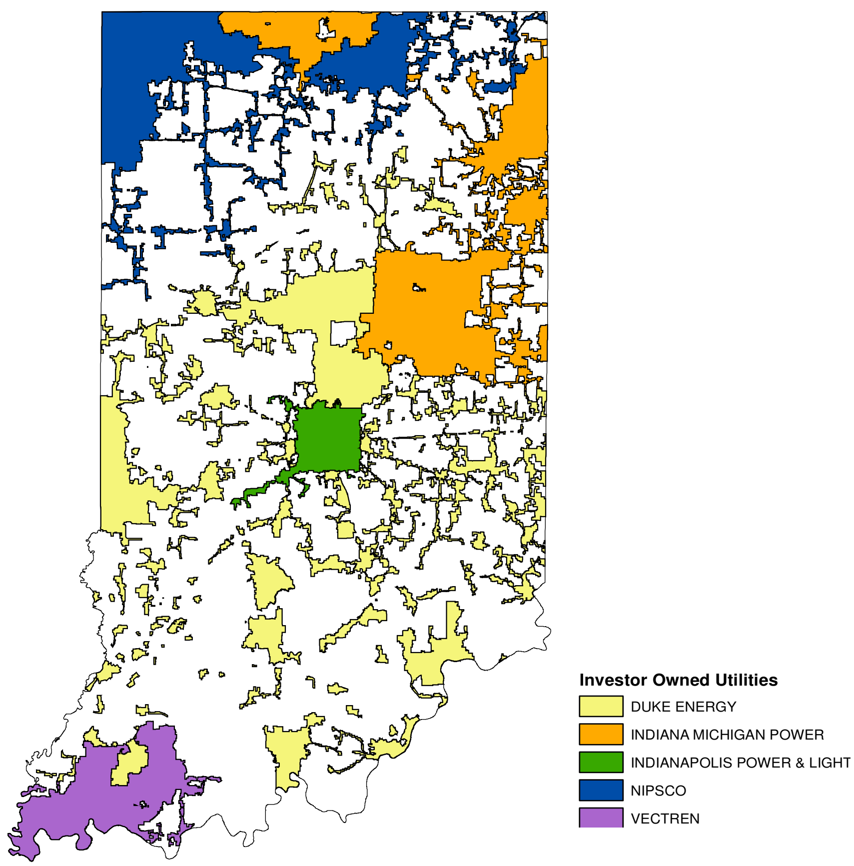
The following table summarizes the number of major event days each IOU reported for 2015. Although not required, four of the IOUs also provided the number of major events. This demonstrates how one weather-related storm can potentially cause multiple major event days.

Utility Company	Major Event Days	Major Events
Duke Energy Indiana	6	5
Indiana Michigan Power	4	4
Indianapolis Power & Light	6	not provided
NIPSCO	10	4
Vectren	2	1

Causes of interruptions other than MEDs can include equipment failures, accidents, and weather events that do not meet the MED threshold. As an example, NIPSCO stated it experienced an additional 76 severe weather events; however, they did not meet the MED threshold.

The reliability indices should only be used to evaluate the performance of an individual utility company over time. Direct comparisons of the utilities' indices should be avoided. The size and geography of service territories and the distribution of customers within them can vary greatly among the utilities, complicating direct comparison of the indices. A map showing the service territories of the Indiana IOUs is shown below. All other factors being equal, IOUs with compact service areas like Vectren and Indianapolis Power and Light (IPL) should be able to respond to interruptions faster and restore a greater number of customers at a time. This may partially explain Vectren's and IPL's lower numbers for the duration of the SAIDI and CAIDI indices.

Service Territories of Indiana Investor Owned Utilities



The following tables provide the 2015 reliability indices for the Indiana IOUs and a comparison of the 2015 indices with their averages for the years 2002 through 2014. Details for 2002 through 2014 are provided in the tables on pages 6 and 7.

Comparison of 2015 Indices to 2002-2014 Average Indices (With Major Events)				
	2015	2002-2014 Avg	Variance 2015 - Avg	% Variance 2015 - Avg
Duke				
SAIFI	1.27	1.66	-0.39	-23%
SAIDI	211	289	-78	-27%
CAIDI	166.1	166.31	0	0%
I&M				
SAIFI	1.243	1.26	-0.02	-1%
SAIDI	390.3	543	-153	-28%
CAIDI	313.9	407.67	-94	-23%
IPL				
SAIFI	0.94	0.99	-0.05	-5%
SAIDI	219.45	123	97	79%
CAIDI	233.12	117.77	115	98%
NIPSCO*				
SAIFI	1.16	1.47	-0.31	-21%
SAIDI	248	496	-248	-50%
CAIDI	214	320.81	-107	-33%
Vectren				
SAIFI	0.9	1.68	-0.78	-46%
SAIDI	81.3	535	-454	-85%
CAIDI	90.6	251.68	-161	-64%

*NIPSCO's 2007 report updated values for 2004-2006 based on accepted industry standard IEEE Std 1366. The averages above reflect those revisions.

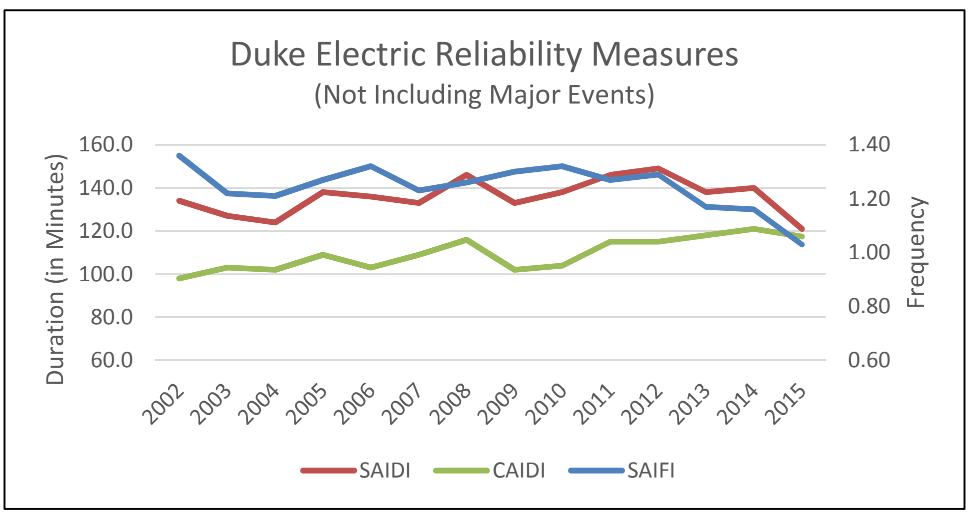
Comparison of 2015 Indices to 2002-2014 Average Indices (Without Major Events)				
	2015	2002-2014 Avg	Variance 2015 - Avg	% Variance 2015 - Avg
Duke				
SAIFI	1.03	1.24	-0.21	-17%
SAIDI	121	136	-15	-11%
CAIDI	118	109	8	7%
I&M				
SAIFI	1.05	0.98	0.07	7%
SAIDI	160	143	18	12%
CAIDI	153	146	7	4%
IPL				
SAIFI	0.66	0.85	-0.19	-22%
SAIDI	49	66	-18	-27%
CAIDI	74	78	-4	-5%
NIPSCO*				
SAIFI	0.87	1.03	-0.16	-15%
SAIDI	110	165	-55	-33%
CAIDI	127	155	-28	-18%
Vectren				
SAIFI	0.85	1.21	-0.36	-30%
SAIDI	71	107	-36	-34%
CAIDI	83	87	-4	-4%

*NIPSCO's 2007 report updated values for 2004-2006 based on accepted industry standard IEEE Std 1366. The averages above reflect those revisions.

The individual IOU summaries for the indices without major events follow.

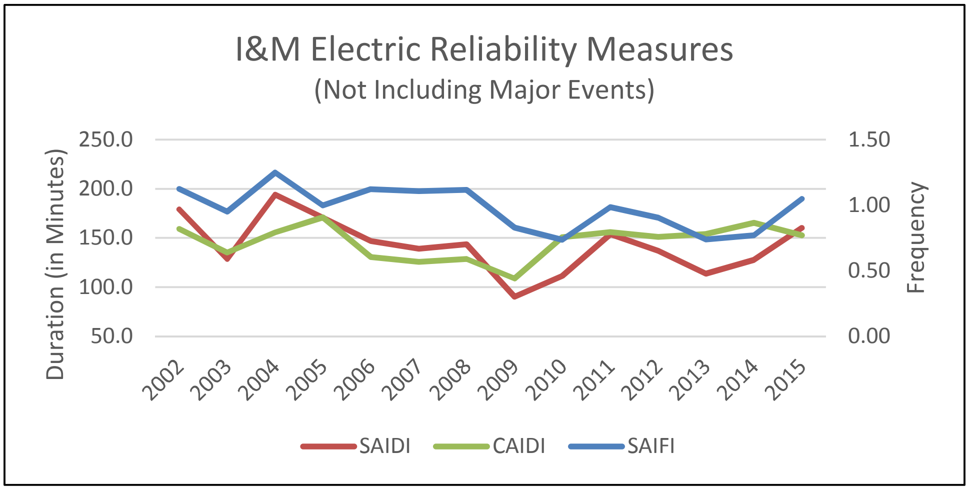
Duke Energy Indiana (Duke)

Duke's interruptions per customer (SAIFI) and length of interruption per customer (SAIDI) were both lower in 2015 compared to the 2002-2014 averages. Since 2012, the trend for both indices has been downward. Duke's 2015 average interruption length (CAIDI) was slightly higher than the 2002-2014 average, but its trend has been relatively flat since 2011.



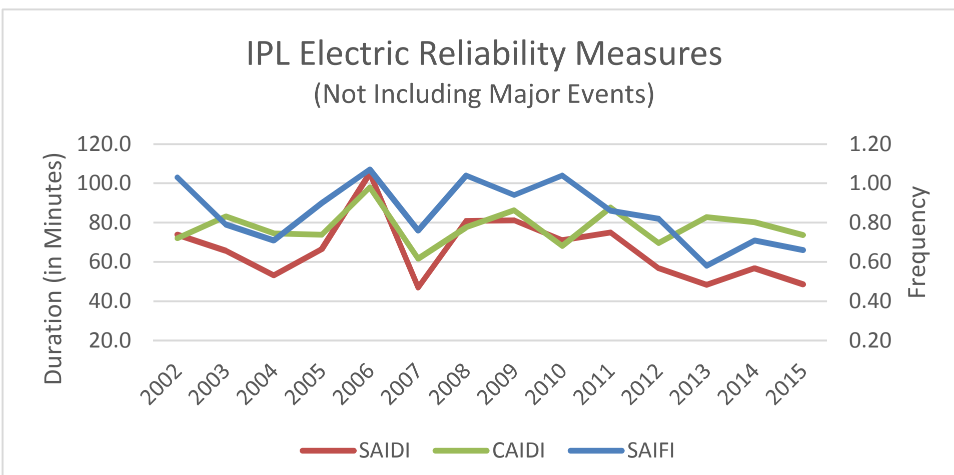
Indiana Michigan Power (I&M)

All 2015 measures for I&M were above their respective 2002-2014 averages. The number of interruptions per customer (SAIFI) and duration of interruption per customer (SAIDI) exhibited a downward trend through 2013, but both have increased in the last two years. The average interruption duration (CAIDI) has remained relatively steady during the entire period.



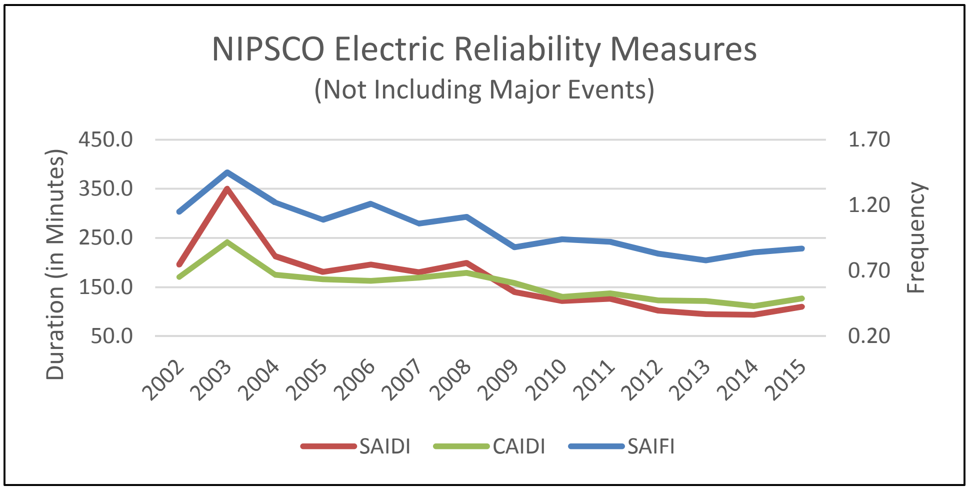
Indianapolis Power and Light (IPL)

IPL's 2015 measures were all below their 2002-2014 averages, with the number (SAIFI) and duration of interruptions per customer (SAIDI) 22% and 27% below their averages, respectively. These two particular per-customer measures have trended downward since 2008. The average interruption duration (CAIDI) has been relatively flat since 2007.



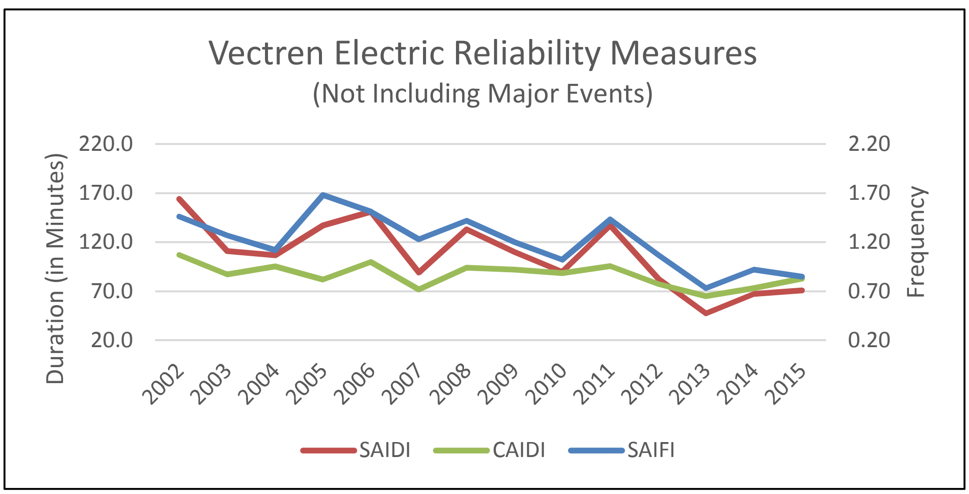
Northern Indiana Public Service Company (NIPSCO)

All 2015 measures for NIPSCO were below their 2002-2014 averages, with duration of interruption per customer (SAIDI) 33% below average. An overall downward trend has been experienced for all three measures since 2003; however, since 2013 trending is slightly upward.



Vectren Energy Delivery of Indiana (Vectren)

The three measures for Vectren in 2015 were all below their 2002-2014 averages. The number (SAIFI) and duration of interruptions per customer (SAIDI) were 30% and 34% below their averages, respectively. Those two measures show a downward trend for the period while the average interruption duration remains relatively flat.



Electric Reliability Not Including Major Events*

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Duke														
SAIFI	1.36	1.22	1.21	1.27	1.32	1.23	1.26	1.3	1.32	1.27	1.29	1.17	1.16	1.03
SAIDI	134.0	127.0	124.0	138.0	136.0	133	146	133	138	146	149	138	140	121
CAIDI	98.0	103.0	102.0	109.0	103.0	109	116	102	104	115	115	118	121	117.5
I&M														
SAIFI	1.12	0.95	1.25	1.00	1.123	1.107	1.117	0.83	0.74	0.99	0.91	0.739	0.771	1.049
SAIDI	179.1	128.5	194.1	170.7	146.7	139.1	143.7	90	111	154	137	113.7	127.5	160.1
CAIDI	159.3	135.0	155.6	171.1	130.6	125.6	128.6	109	151	156	151	154	165.4	152.6
IPL														
SAIFI	1.03	0.79	0.71	0.90	1.07	0.76	1.04	0.94	1.04	0.86	0.82	0.58	0.71	0.66
SAIDI	73.8	65.7	53.2	66.5	105.2	46.99	80.84	81	71	75	57	48.33	56.71	48.7
CAIDI	72.0	83.2	74.5	73.9	98.0	61.7	77.68	86	68	88	70	82.78	80.24	73.7
NIPSCO														
SAIFI	1.15	1.45	1.22	1.09	1.21	1.06	1.11	0.88	0.94	0.92	0.83	0.78	0.84	0.87
SAIDI	196.2	350.4	213	181	196	180	199	140	122	126	102	95	94	110
CAIDI	170.6	241.7	175	166	163	169	179	158	130	137	123	122	111	127
Vectren														
SAIFI	1.46	1.27	1.12	1.68	1.51	1.23	1.42	1.2	1.02	1.43	1.07	0.73	0.92	0.85
SAIDI	164.0	111.0	106.8	137.0	151.0	89	133	110	90	137	83	47.5	67.2	70.9
CAIDI	107.0	87.0	95.4	82.0	100.0	72	94	92	88	96	78	65.1	73	82.9

Notes

SAIFI: System Average Interruption Frequency Index; (# of customers who experience outage) / (total # of customers)

SAIDI: System Average Interruption Duration Index; (duration or time of service interruptions) / (total # of customers)

CAIDI: Customer Average Interruption Duration Index; (SAIDI) / (SAIFI)

*Major events are storms or weather events that are more destructive than normal storm patterns. The same definition of "major event" is not used by all utilities.

**NIPSCO's 2007 report updated values for 2004-2006 based on accepted industry standard IEEE Std 1366 - however, the above values reflect the original reports.

Electric Reliability Including Major Events*

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Duke														
SAIFI	1.57	1.58	1.66	1.59	1.63	1.41	2.48	1.76	1.58	2.07	1.520	1.38	1.31	1.27
SAIDI	170.0	201.0	255.0	282.0	203.0	178	689	293	195	630	216.000	257	186	211
CAIDI	109.0	128.0	153.0	177.0	125.0	126	278	166	124	304	143.000	187	142	166.1
I&M														
SAIFI	1.68	1.56	1.42	1.31	1.242	1.237	1.633	0.91	0.98	1.12	1.387	0.955	0.963	1.243
SAIDI	930.6	594.2	291.4	1,131.6	222.0	199.4	1164.3	122	392	258	1071.200	374.5	305.9	390.3
CAIDI	553.5	380.2	204.7	863.0	178.7	161.2	712.8	133	400	230	772.500	392	317.8	313.9
IPL														
SAIFI	1.17	0.90	0.81	0.90	1.07	0.76	1.54	1.1	1.04	0.86	1.040	0.71	0.96	0.94
SAIDI	132.9	98.0	76.7	66.5	105.2	46.99	358.98	158	71	75	124.920	92.3	189.98	219.45
CAIDI	113.3	108.4	94.1	73.9	98.0	61.7	232.96	145	68	88	119.660	130.01	198.63	233.12
NIPSCO														
SAIFI	1.41	1.65	1.38	1.24	1.40	2.23	1.8	0.88	1.36	1.38	1.440	1.45	1.53	1.16
SAIDI	542.4	498.0	317	258	317	1073	882	140	505	371	428.000	520	603	248
CAIDI	384.7	301.8	229	208	227	480	490	158	372	269	297.000	359	395	214
Vectren														
SAIFI	1.46	1.27	2.36	2.05	1.87	1.23	2.33	2.56	1.02	2.16	1.240	0.78	1.47	0.9
SAIDI	164.0	111.0	932.4	376.0	241.0	89	859	2,889	90	711	117.300	60.1	314.3	81.3
CAIDI	107.0	87.0	394.7	185.0	128.0	72	369	1,126	88	330	94.900	76.6	213.5	90.6

Notes

SAIFI: System Average Interruption Frequency Index; (# of customers who experience outage) / (total # of customers)

SAIDI: System Average Interruption Duration Index; (duration or time of service interruptions) / (total # of customers)

CAIDI: Customer Average Interruption Duration Index; (SAIDI) / (SAIFI)

*Major events are storms or weather events that are more destructive than normal storm patterns. The same definition of "major event" is not used by all utilities.

**NIPSCO's 2007 report updated values for 2004-2006 based on accepted industry standard IEEE Std 1366 - however, the above values reflect the original reports.

IEEE Benchmark Year 2016
Results for 2015 Data

Follow up to 2016 General Meeting

Distribution Reliability Working Group

Boston, Massachusetts

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Background to IEEE DRWG Benchmark Study

1. *Initiated in 2003, conducted annually*
2. *Participants are anonymous with key identifier to retain anonymity*
3. *Participation list is not revealed to anyone*
4. *Each participant can choose to share their results*
5. *No inference is made about good or bad reliability*
6. *Intended to provide information for users to assess their performance relative to peers*
7. *Called the 2016 Study (for 2015 Results)*

Benchmarking

- Using annual key metrics (SAIDI, SAIFI and CAIDI) to assess performance of a system may be useful, however, needs to be tempered
- DRWG Study attempts to identify various aspects that could cause a difference in reported metrics
- Data may not be directly comparable, since
  - Data collection & system differences exist
  - Certain exclusion differences can occur
- IEEE 1366-2003/2012
  - addresses data basis issues by clearly defining the rules.
  - It DOES NOT address the data collection issues
  - Companies may not report all forms of outages, due to data collection issues or other reasons

Regions represented by the participants 2016 Benchmark Study

Region 0: Spans States or Unknown

Region 1: Northeast

Region 2: Mid-Atlantic

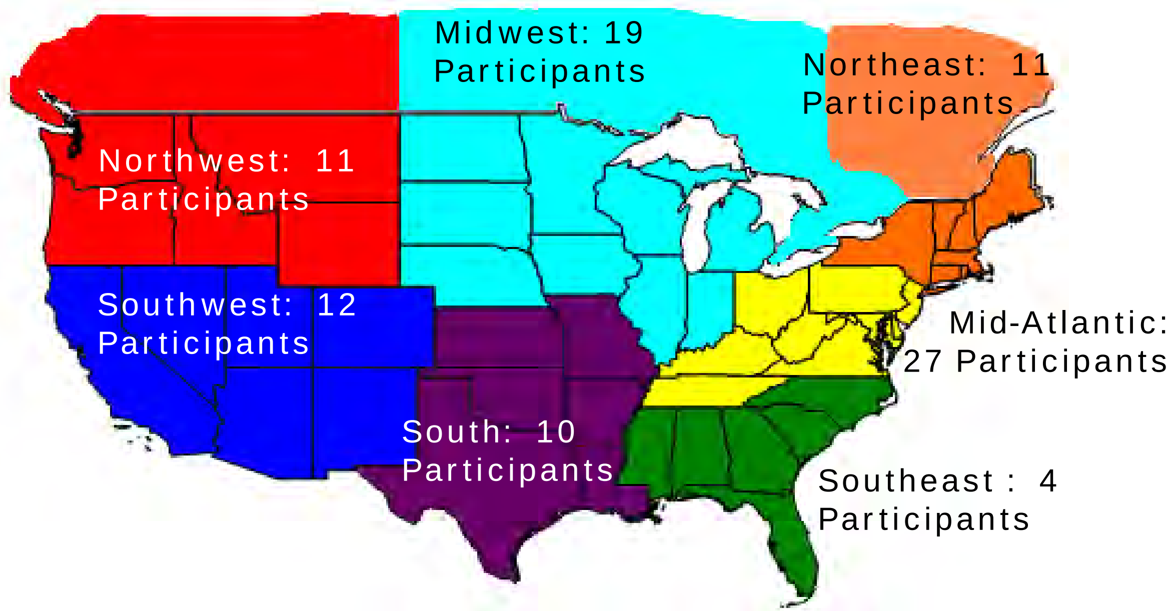
Region 3: Southeast

Region 4: Midwest

Region 5: Southwest

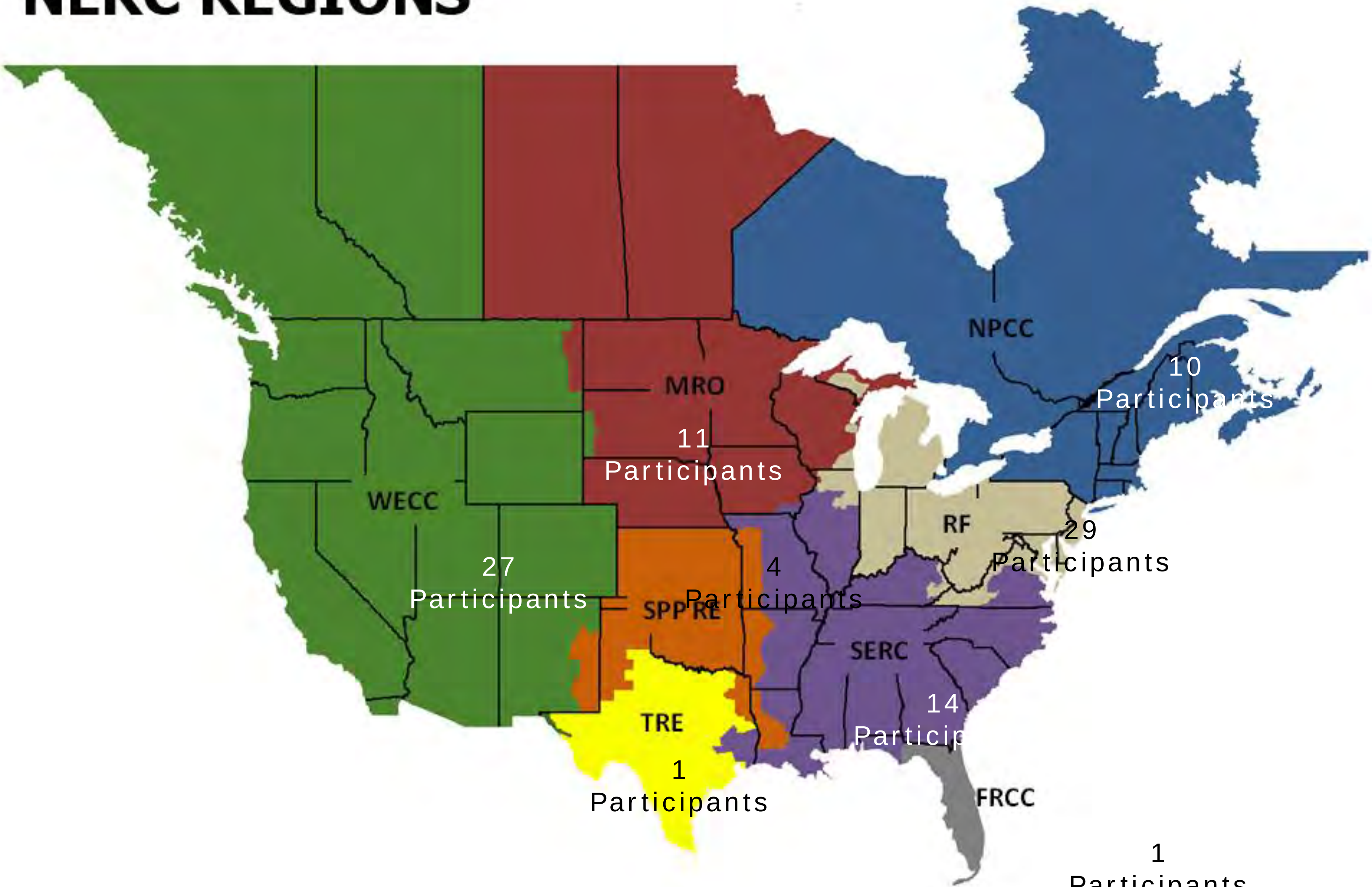
Region 6: South

Region 7: Northwest



Spans States or Other: 2

NERC REGIONS



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Classification of Respondents

- 90,284,244 customers represented in North America
- Small, Medium, Large
  - Small =< 100,000 customers
  - Medium >100,000 and <1,000,000 customers
  - Large >= 1M customers
- 2016 Survey
  - 7 Small
  - 57 Medium
  - 32 Large
- Circuit Mileage Reported by all entrants
  - 2.35 million miles, for which about 2/3 reported on overhead (64%) versus underground (42%)

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Respondents

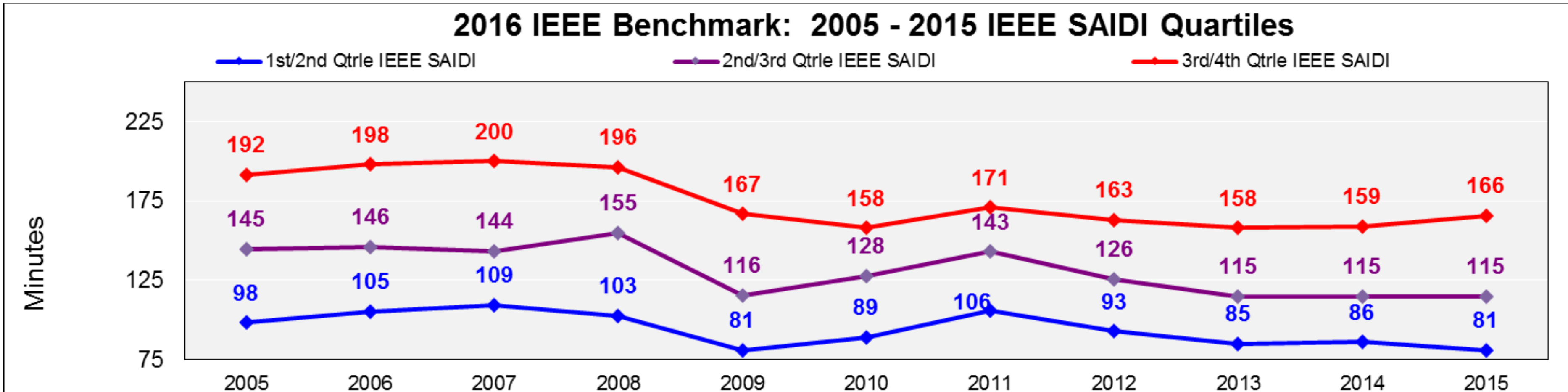
- About 240 companies have responded at some time
- 2015 Survey: 94 unique entries responded, 96 total entries

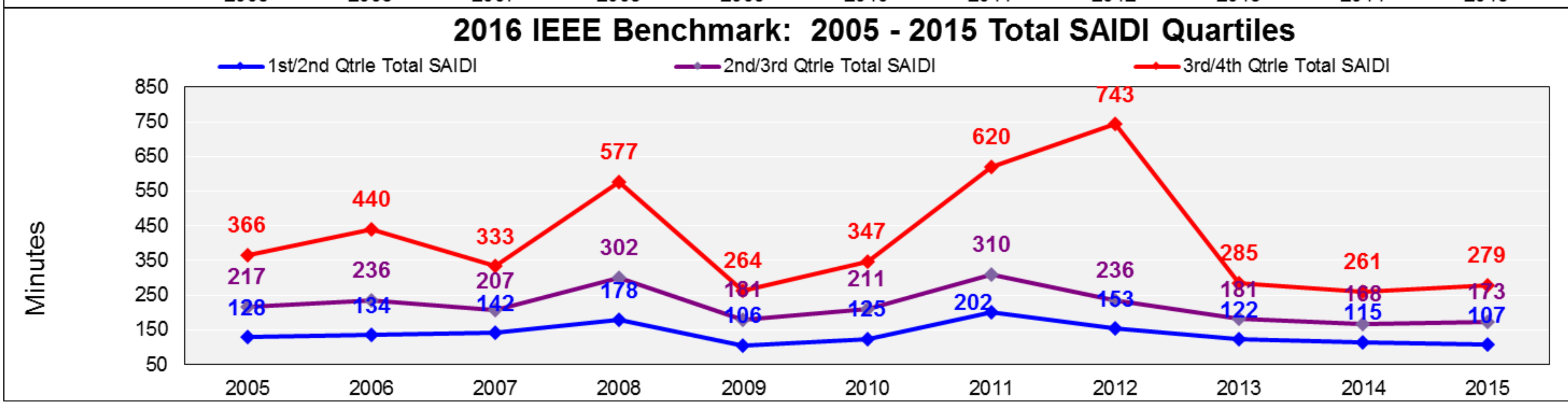
	SAIDI ALL	SAIDI IEEE	SAIDI WOF	SAIDI WOP	SAIFI ALL	SAIFI IEEE	SAIFI WOF	SAIFI WOP	CAIDI ALL	CAIDI IEEE	CAIDI WOF	CAIDI WOP
MIN	24	24	24	23	0.33	0.31	0.31	0.29	62	22	23	22
Q1	107	81	79	74	0.93	0.86	0.75	0.69	109	94	98	96
MEDIAN	173	115	102	98	1.20	1.04	0.93	0.84	137	111	116	116
Q3	279	166	150	129	1.56	1.32	1.16	1.05	183	127	136	136
MAX	1372	555	456	509	6.78	5.23	4.25	4.36	634	211	215	228

Respondents by Utility Size

7 Small	SAIDI ALL	SAIDI IEEE	SAIDI WOF	SAIDI WOP	SAIFI ALL	SAIFI IEEE	SAIFI WOF	SAIFI WOP	CAIDI ALL	CAIDI IEEE	CAIDI WOF	CAIDI WOP
MIN	24	24	24	24	0.33	0.33	0.33	0.33	66	66	62	61
Q1	75	75	76	70	0.92	0.92	0.88	0.69	78	78	83	85
MEDIAN	138	138	129	113	1.22	1.22	0.94	0.84	134	106	109	117
Q3	423	277	169	131	2.58	2.22	1.23	1.06	160	126	140	142
MAX	1263	555	375	509	6.78	5.23	3.46	4.36	186	134	169	175
57 Medium	**SAIDI ALL**	**SAIDI IEEE**	**SAIDI WOF**	**SAIDI WOP**	**SAIFI ALL**	**SAIFI IEEE**	**SAIFI WOF**	**SAIFI WOP**	**CAIDI ALL**	**CAIDI IEEE**	**CAIDI ALL**	**CAIDI IEEE**
MIN	31	24	24	23	0.33	0.31	0.31	0.29	62	22	23	22
Q1	118	81	74	75	0.94	0.87	0.72	0.69	108	95	97	96
MEDIAN	188	118	106	103	1.25	1.14	0.97	0.86	137	112	117	116
Q3	281	156	149	126	1.56	1.32	1.17	1.06	183	126	133	135
MAX	1372	468	456	417	4.79	4.47	4.25	4.23	634	195	194	209
32 Large	**SAIDI ALL**	**SAIDI IEEE**	**SAIDI WOF**	**SAIDI WOP**	**SAIFI ALL**	**SAIFI IEEE**	**SAIFI WOF**	**SAIFI WOP**	**CAIDI ALL**	**CAIDI IEEE**	**CAIDI ALL**	**CAIDI IEEE**
MIN	81	54	53	50	0.69	0.53	0.52	0.51	80	80	80	78
Q1	102	89	86	75	0.93	0.84	0.80	0.69	114	98	100	97
MEDIAN	140	101	97	92	1.07	0.98	0.88	0.84	136	111	115	116
Q3	257	164	152	132	1.39	1.21	1.12	1.03	183	137	141	139
MAX	759	442	418	382	2.35	2.14	1.94	1.67	372	211	215	228

Historic SAIDI Quartiles-Total & IEEE





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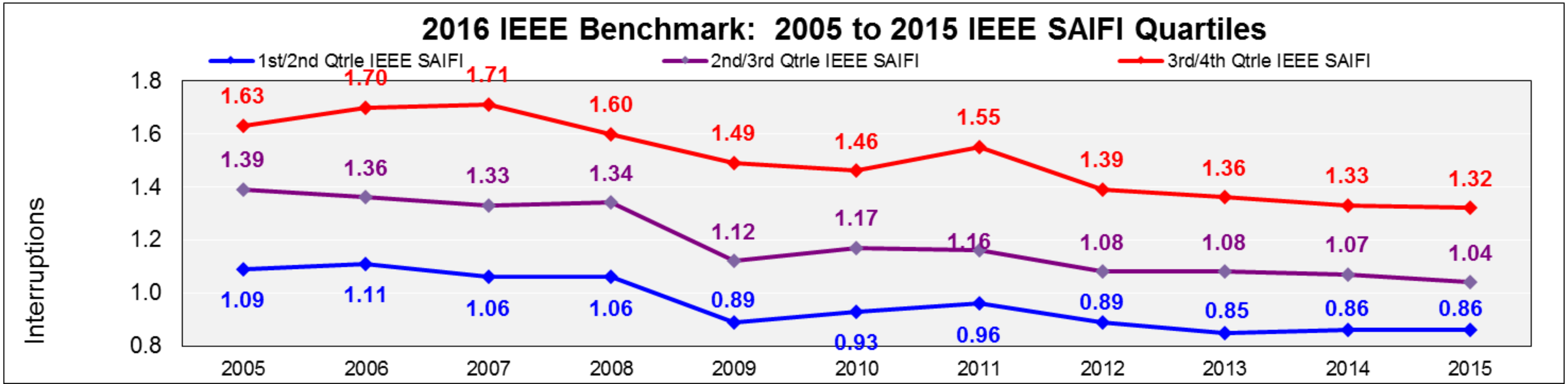
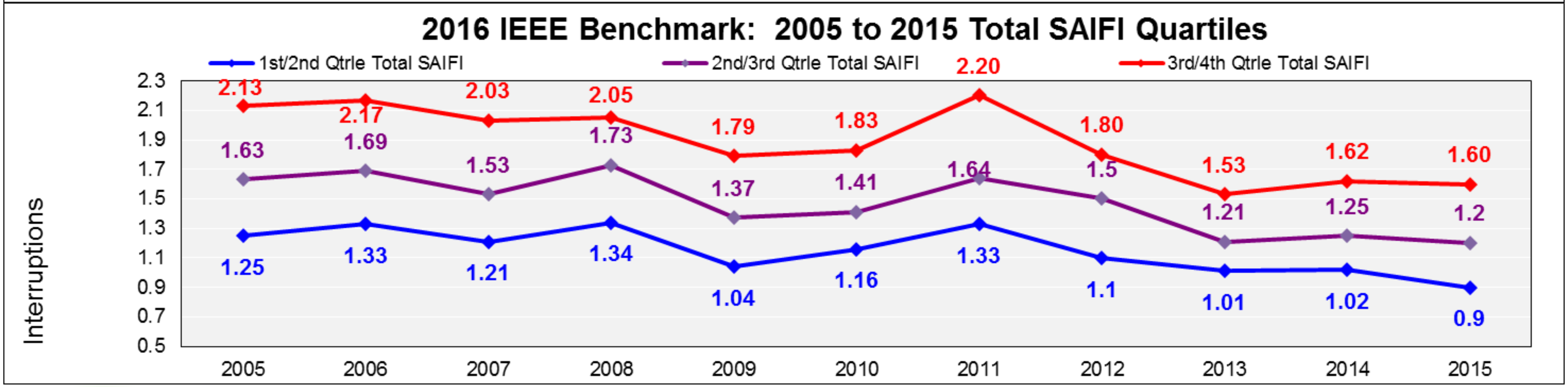
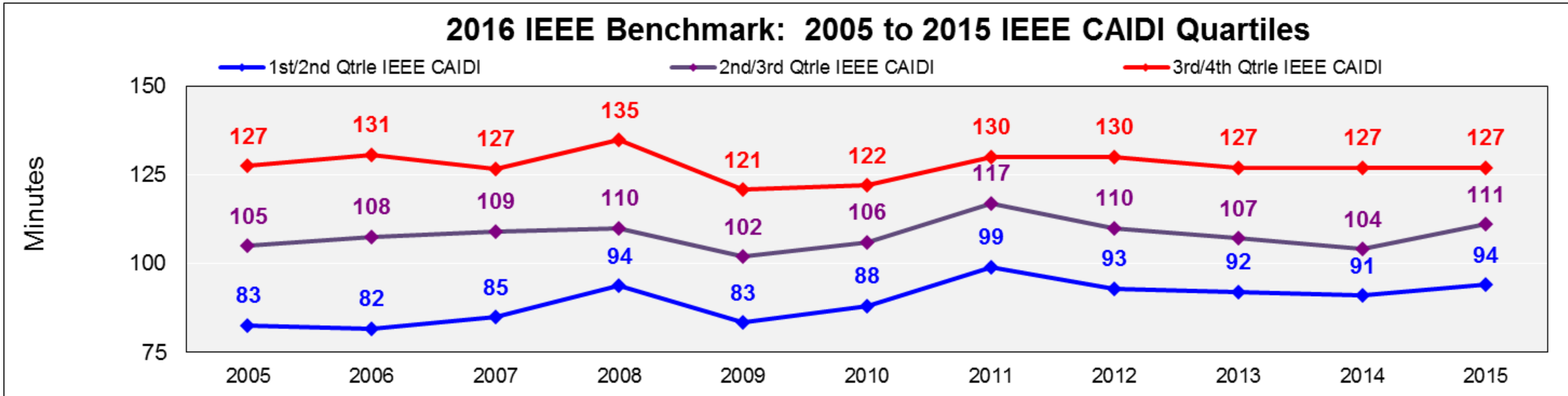
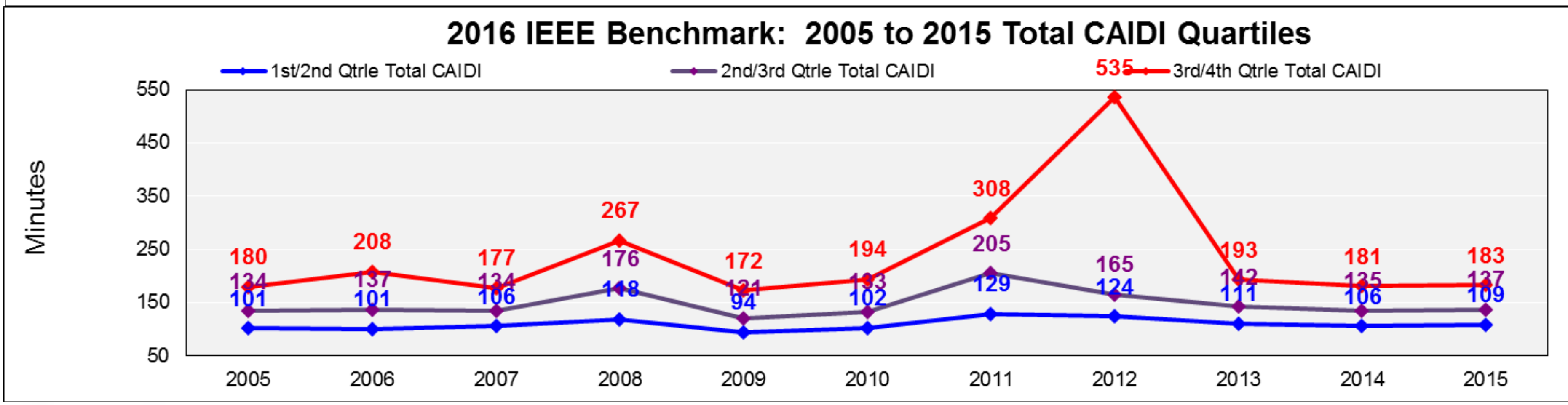
Historic SAIFI Quartiles-Total & IEEE





Historic CAIDI Quartiles-Total & IEEE

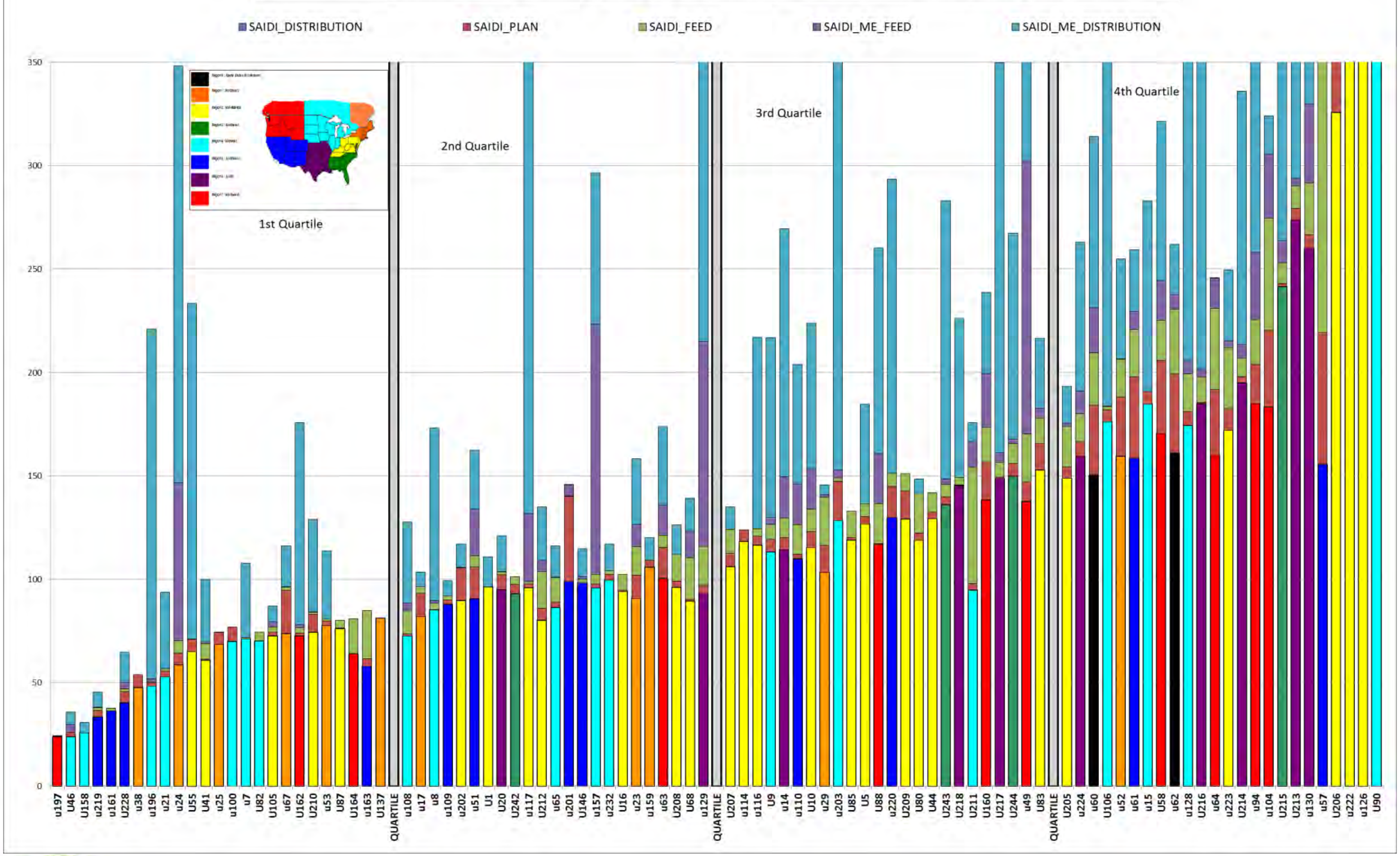




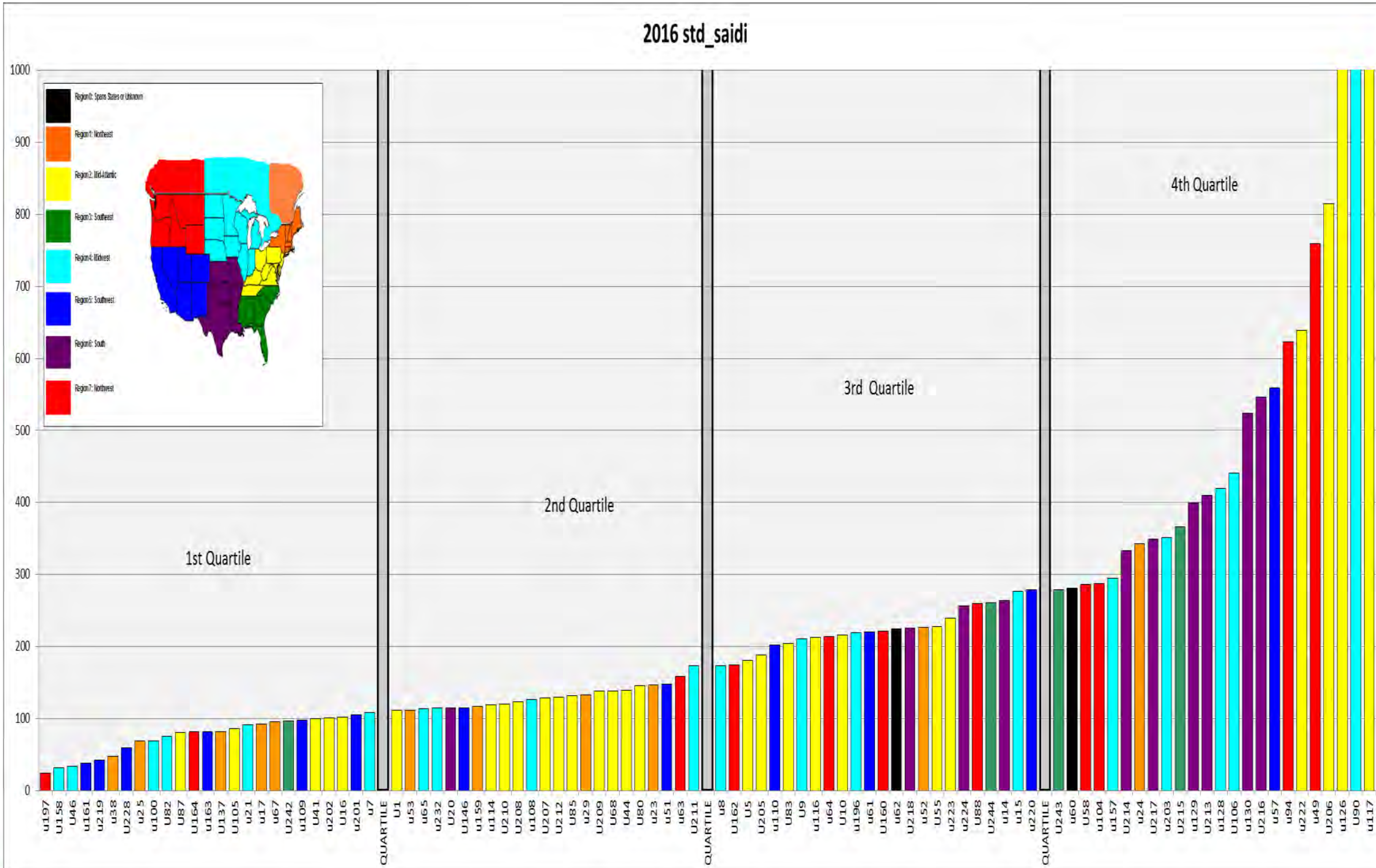
The following slides…

- Show company performance using the IEEE 2.5 Beta method to segregate data into:
  - Day-to-Day operating Indices vs.
  - Performance considering the whole customer experience (All)
  - Separate data collected to evaluate impact of transmission (WOF) and both transmission and planned outages (WOP)
  - Segregation by transmission (feed), planned and distribution
- To date more than 240 companies have participated in our benchmarking at sometime.

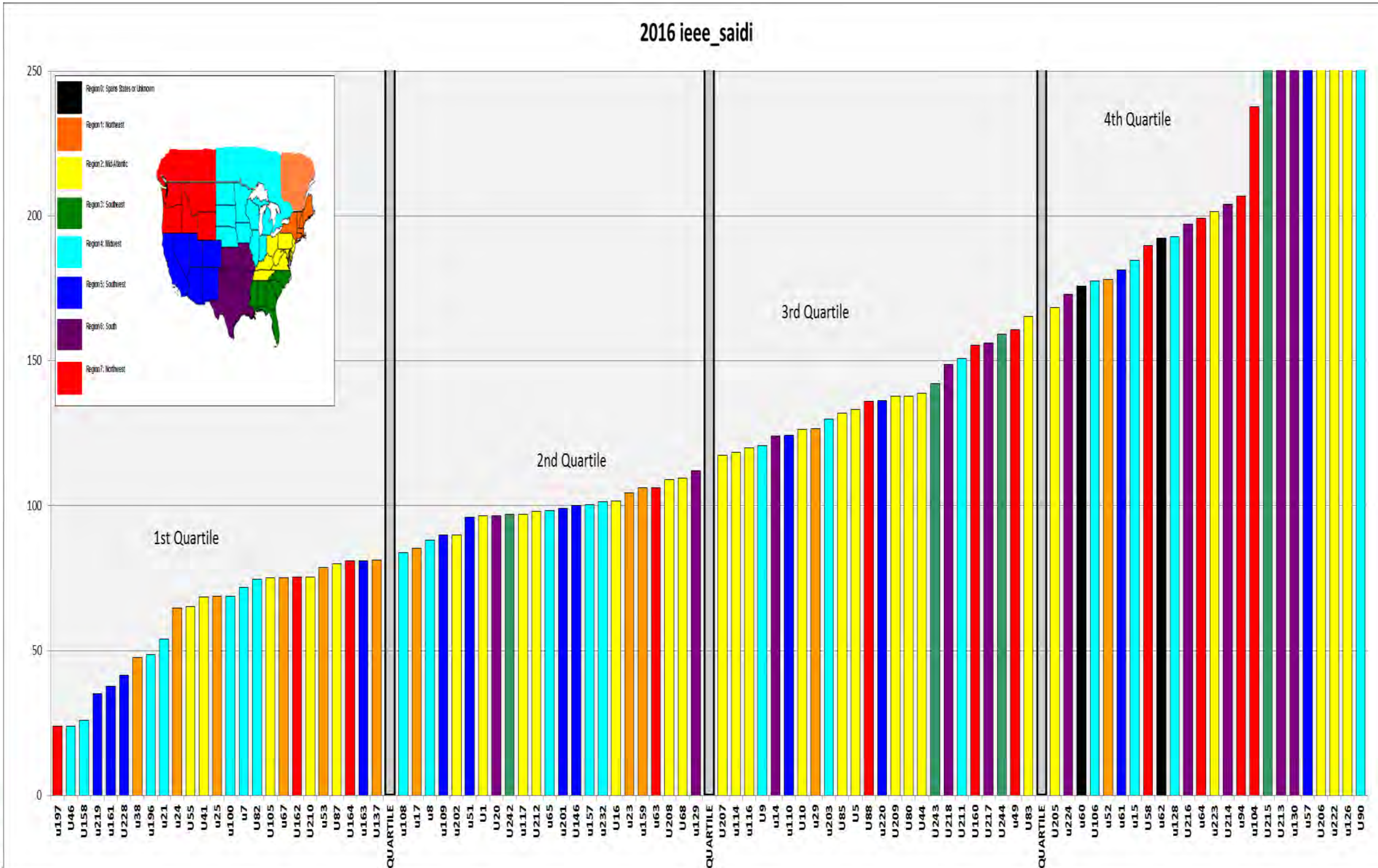
2016 SAIDI by Benchmark Area Segment by SAIDI IEEE; Distribution, Feed (Trans) and Planned



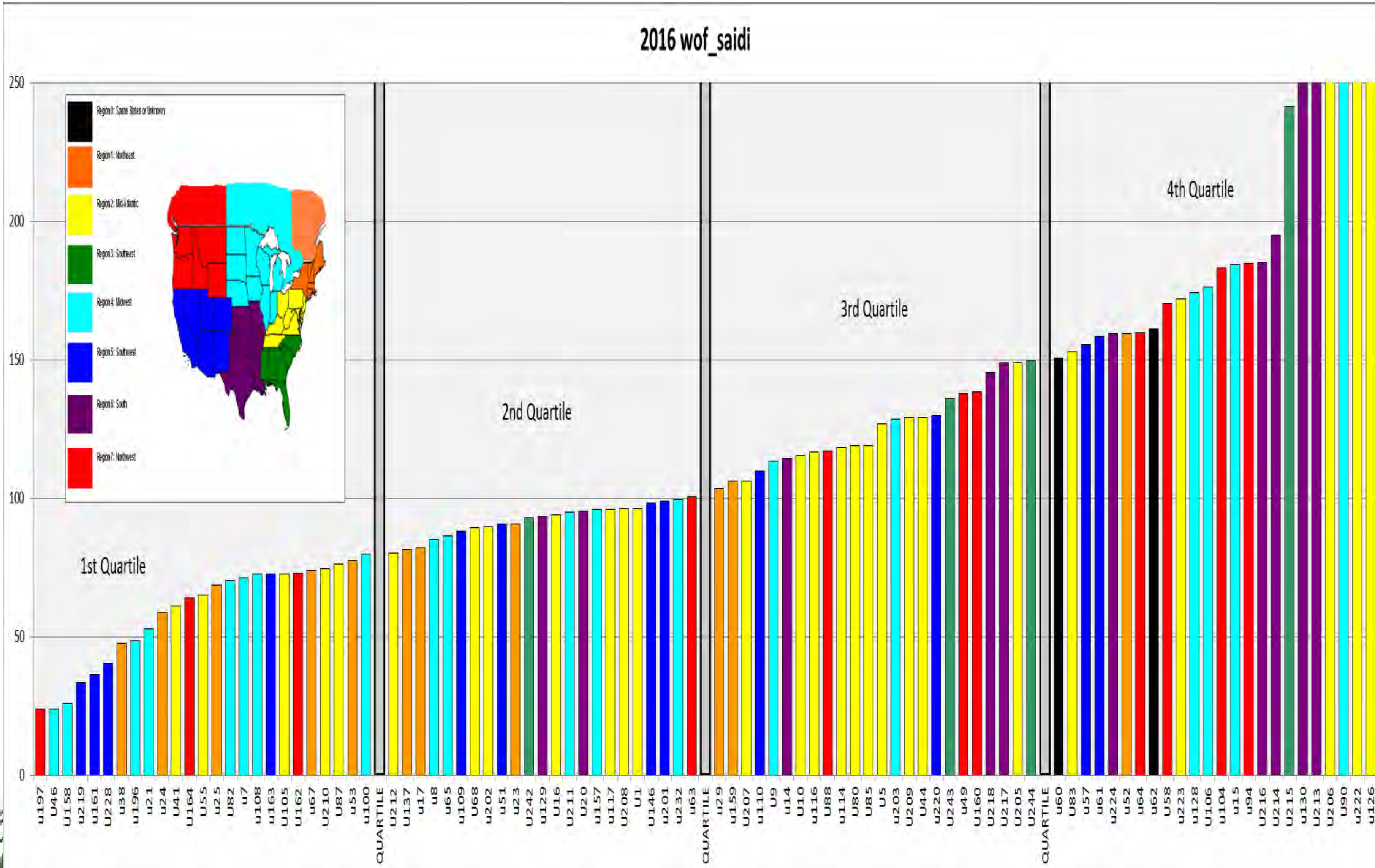
2016 Total SAIDI



2016 IEEE SAIDI



2016 WOF SAIDI



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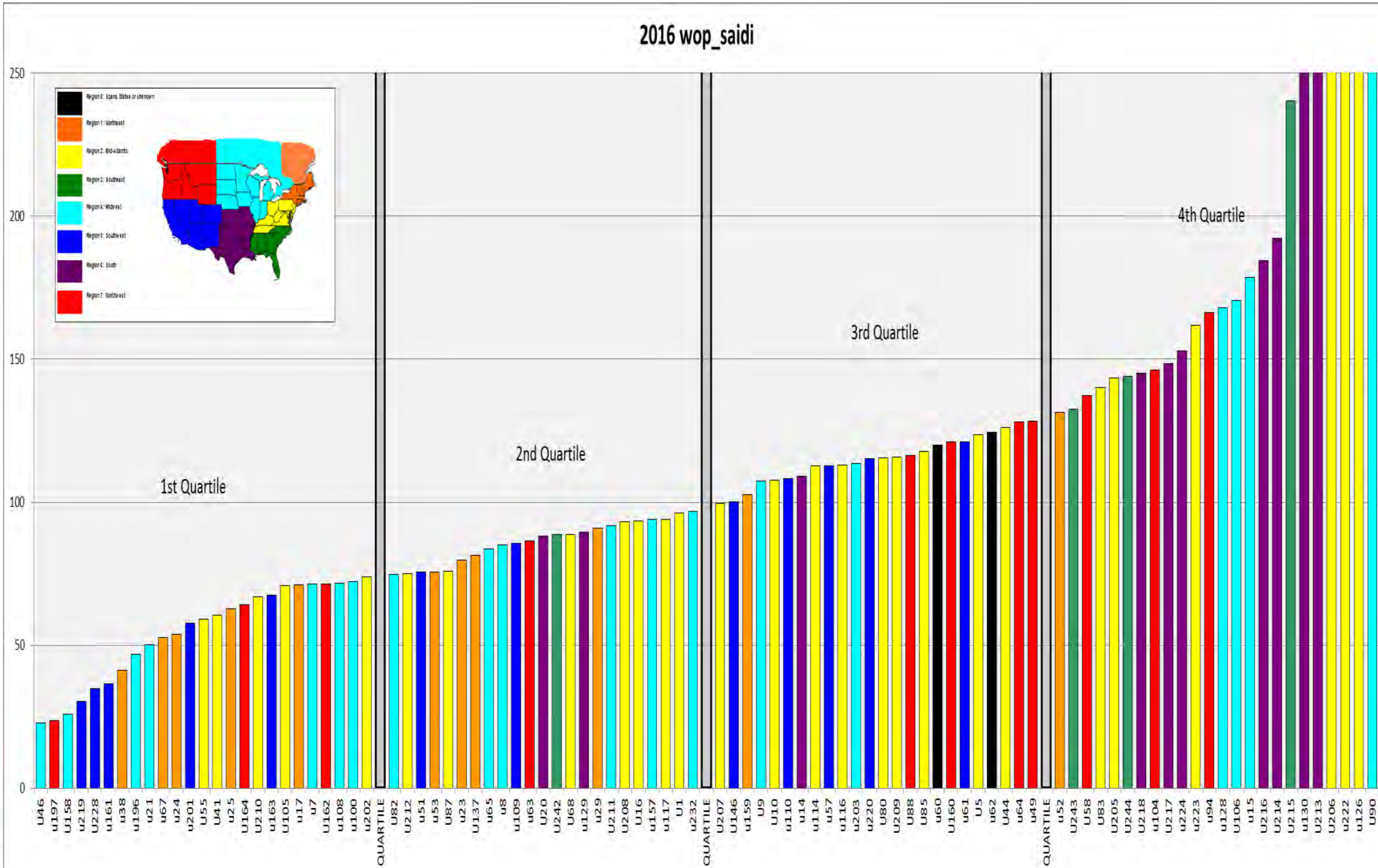
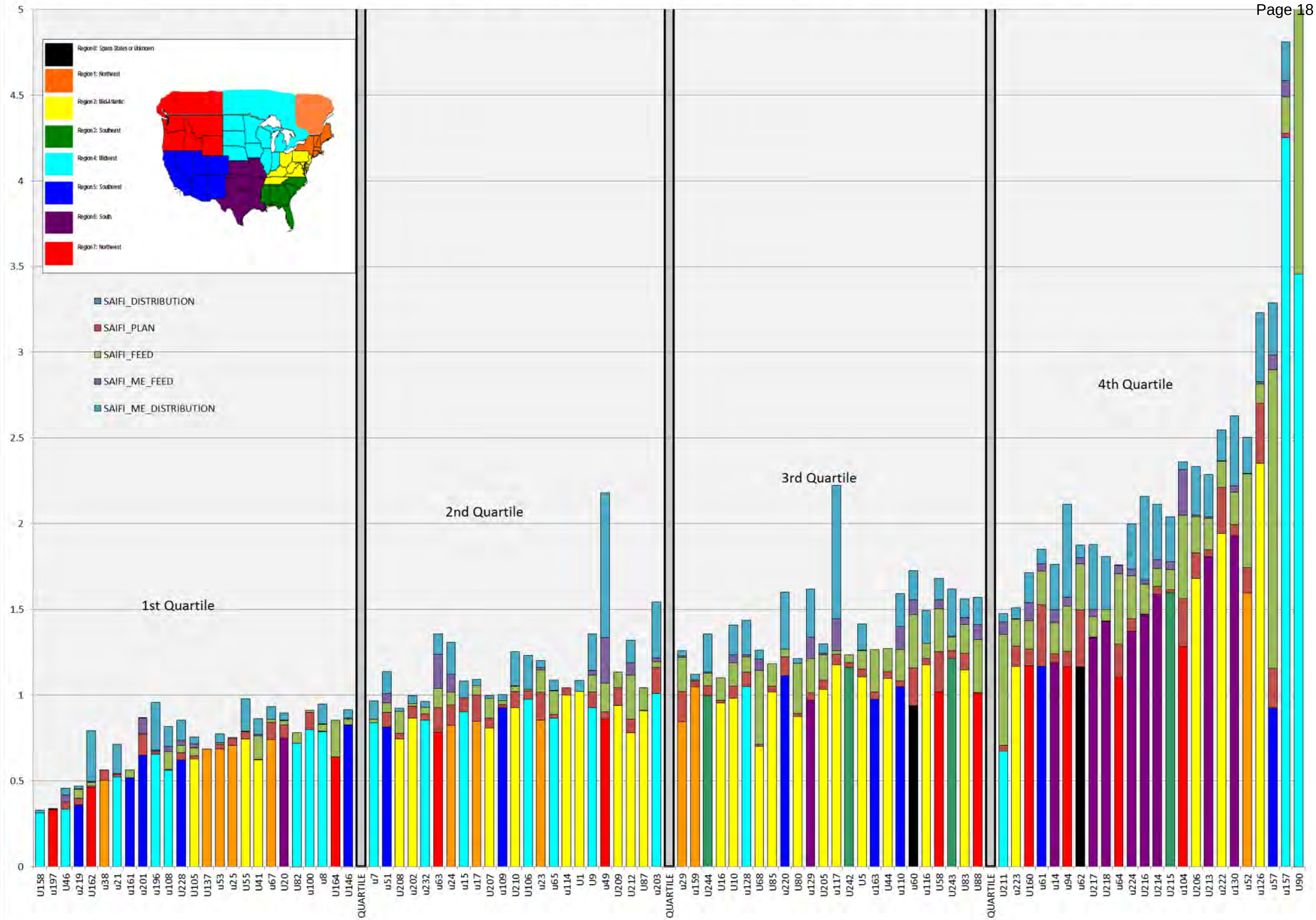
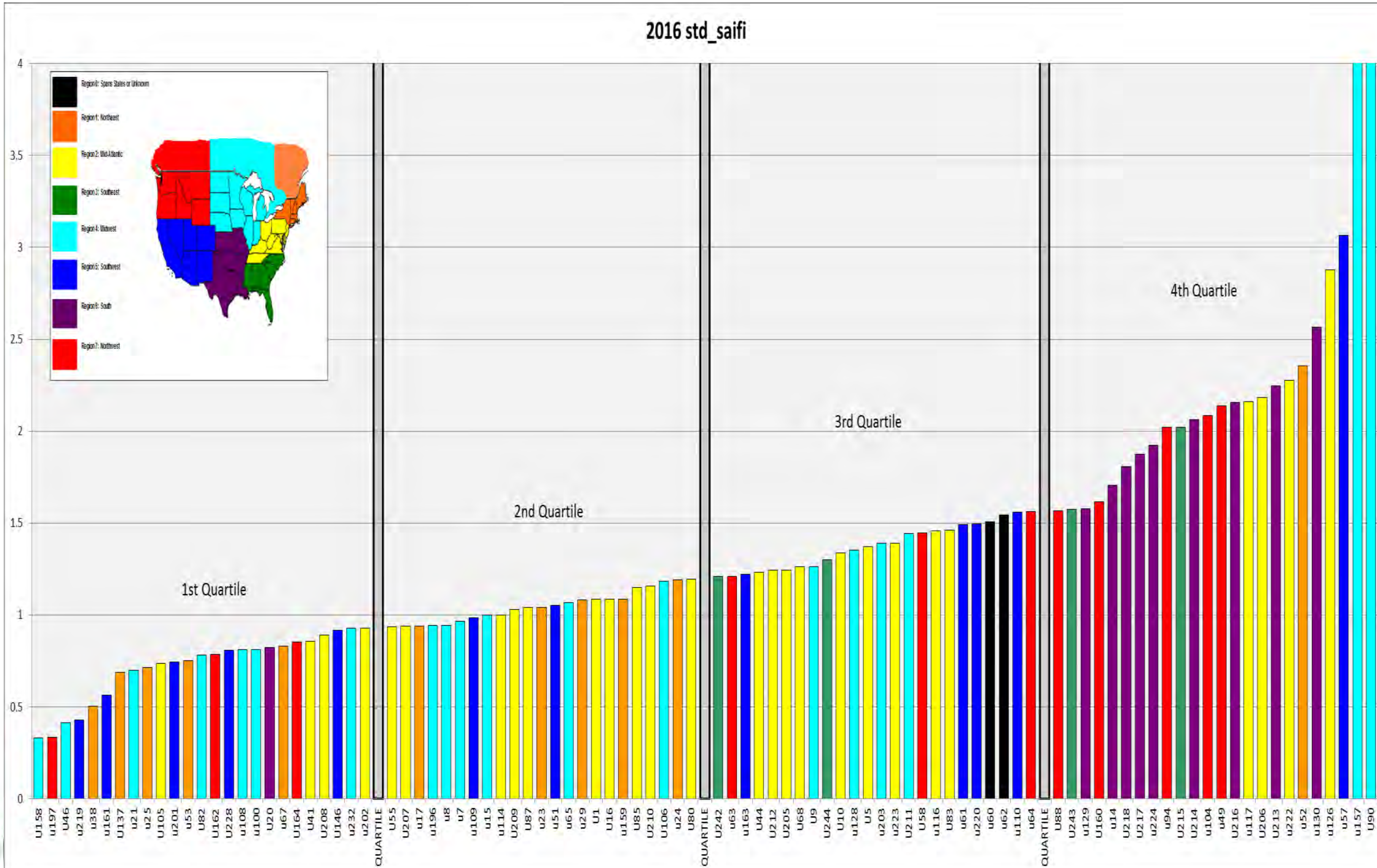
2016 WOP SAIDI



2016 SAIFI by Benchmark Area Segment by SAIFI IEEE; Distribution, Feed (Trans) and Planned



2016 Total SAIFI



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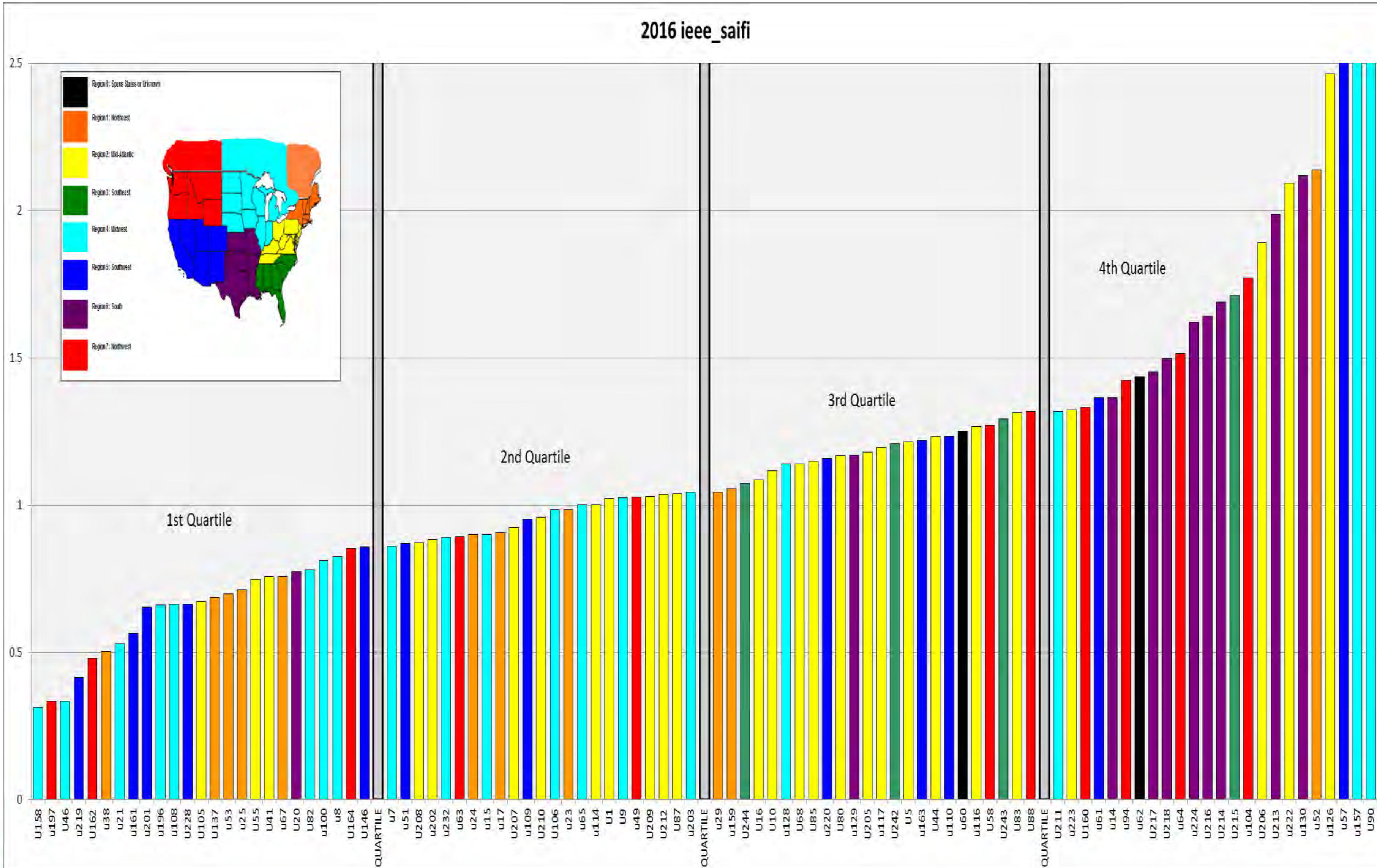
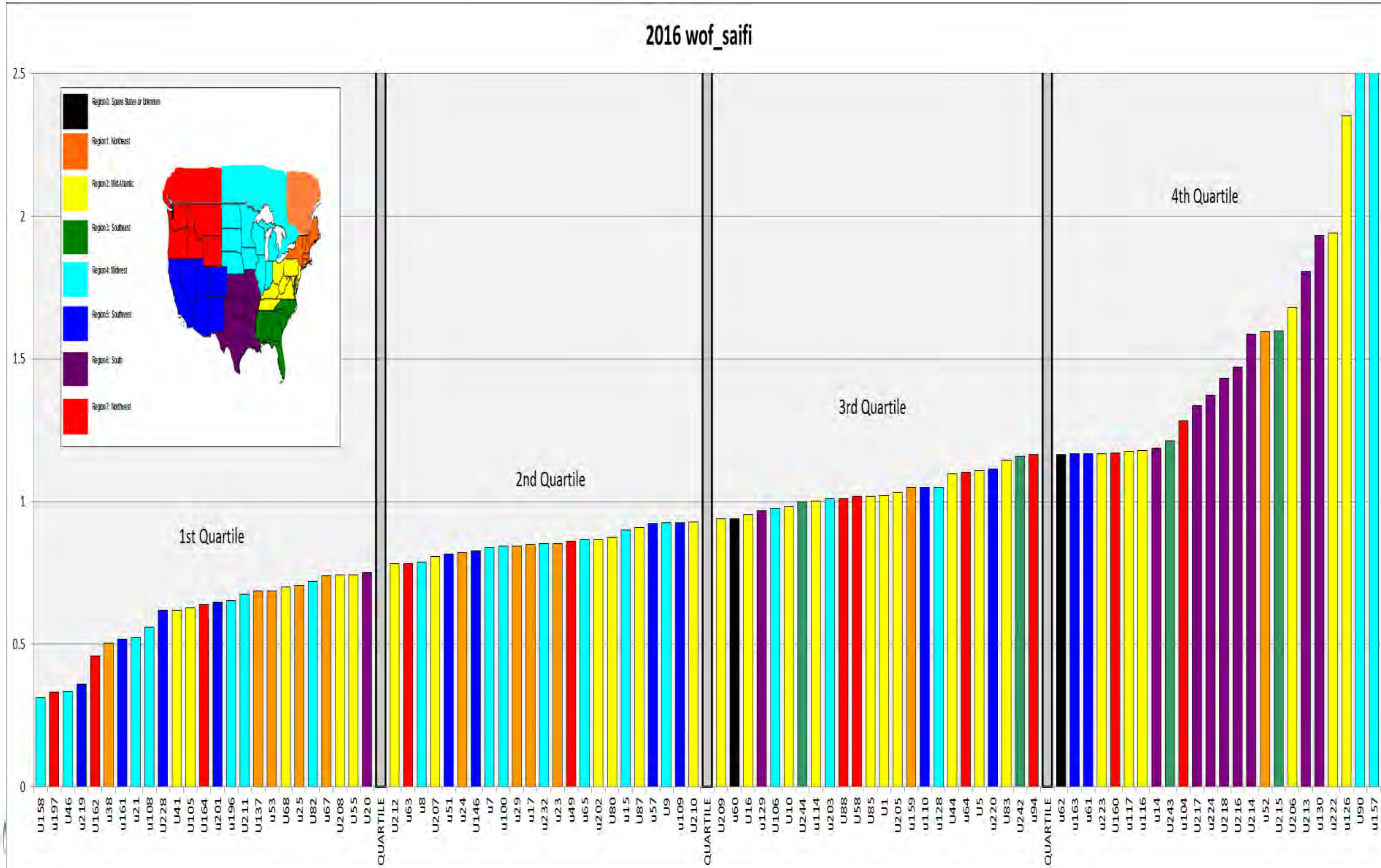
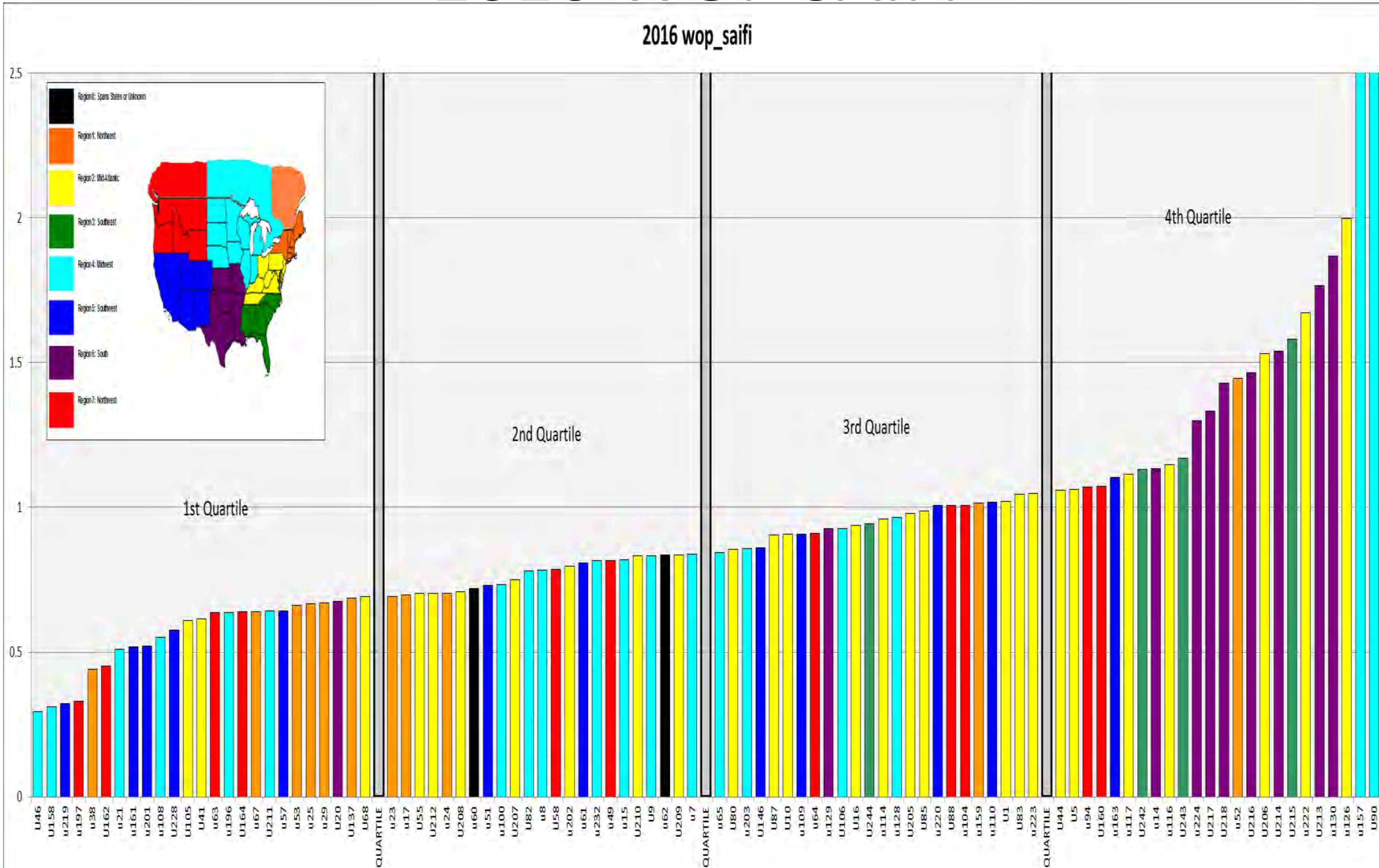
2016 IEEE SAIFI



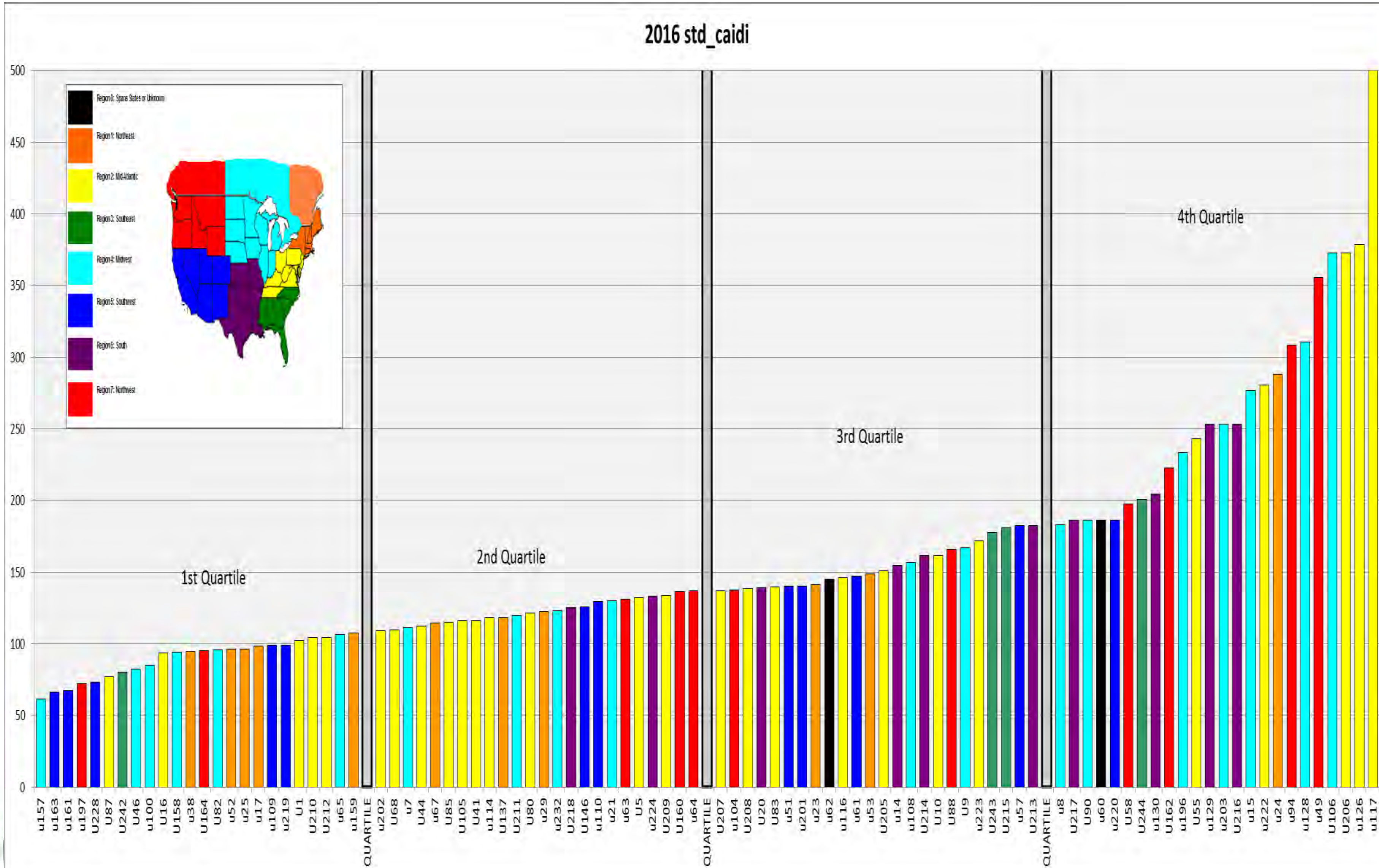
2016 WOF SAIFI



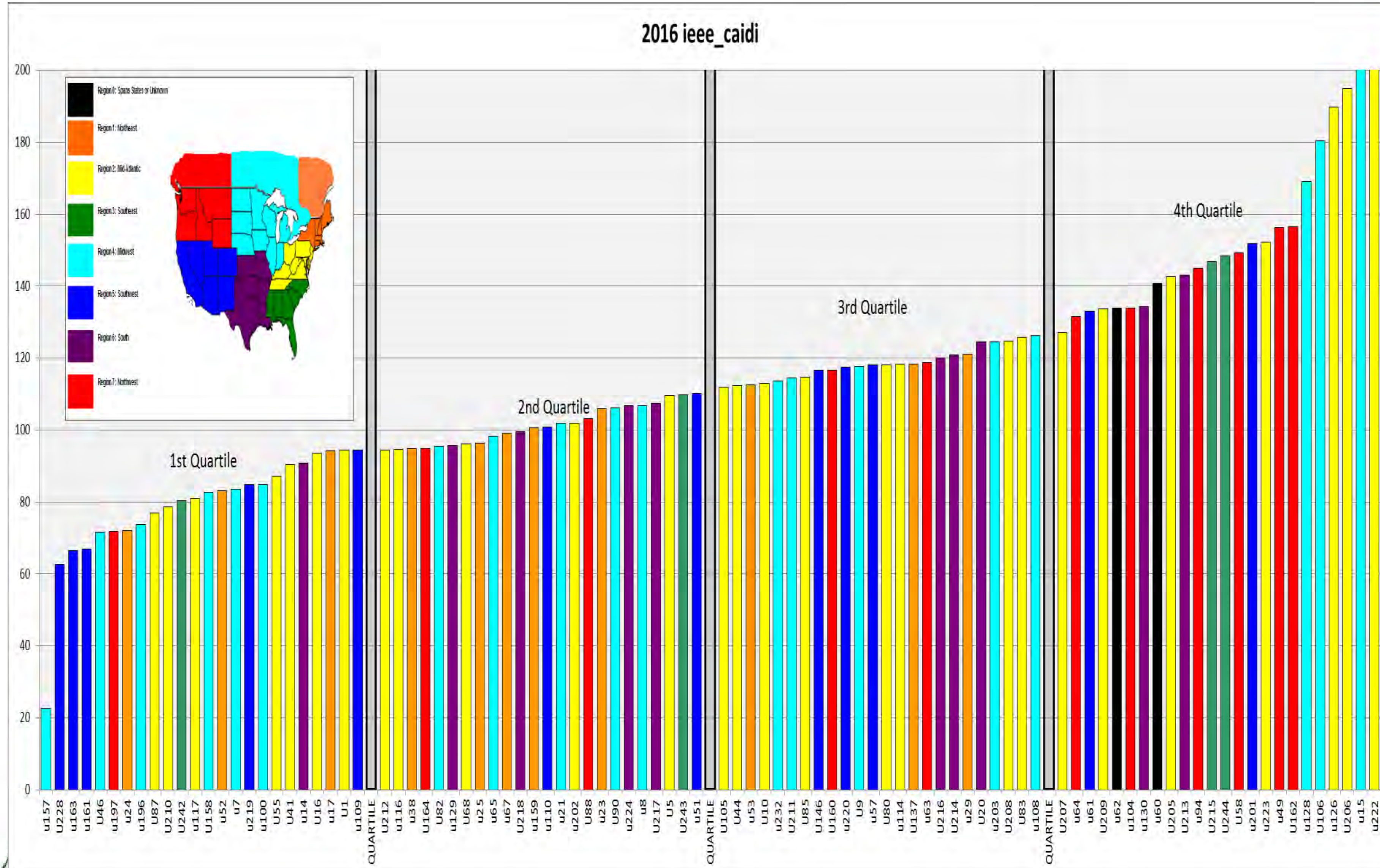
2016 WOP SAIFI



2016 Total CAIDI



2016 IEEE CAIDI



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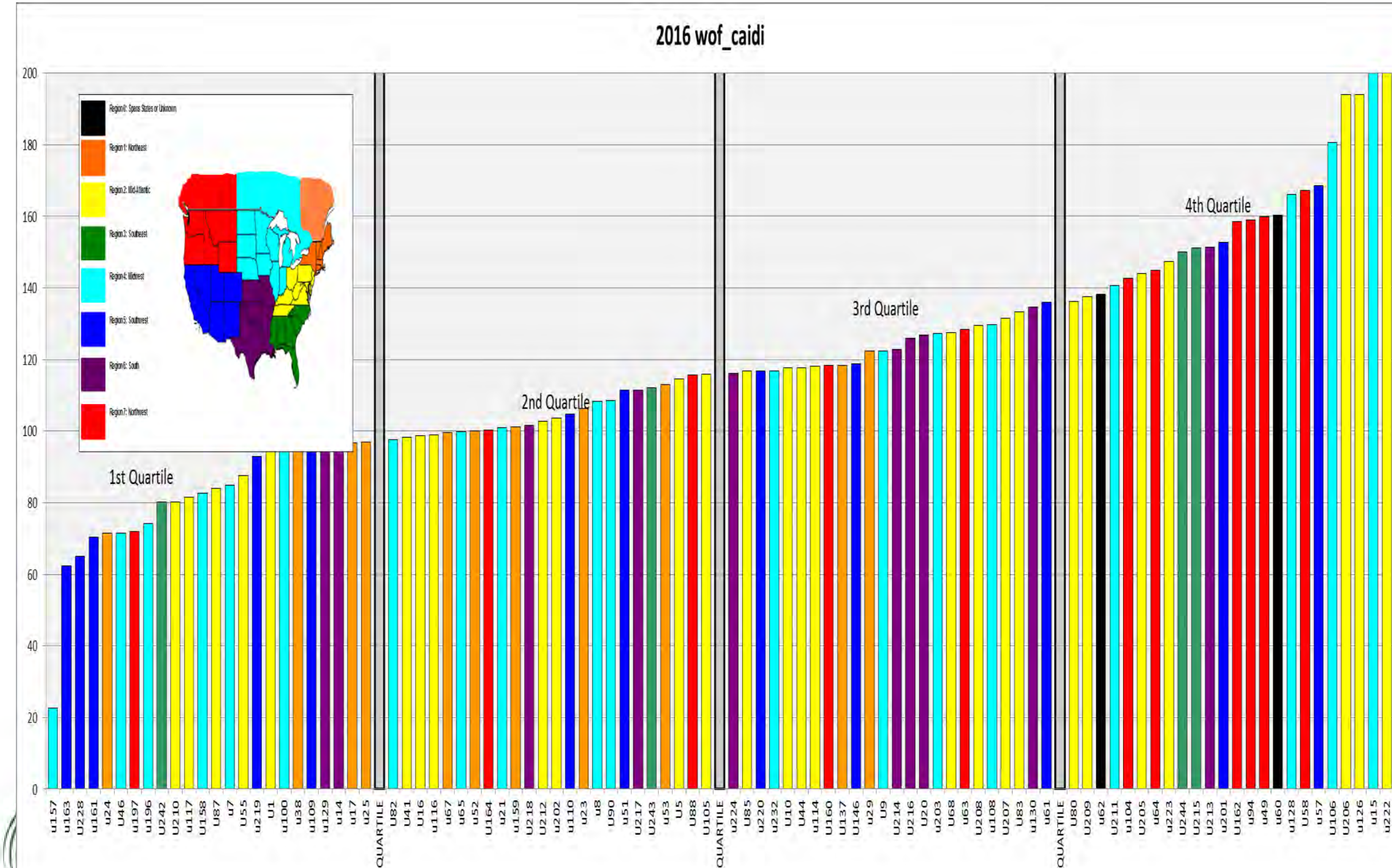
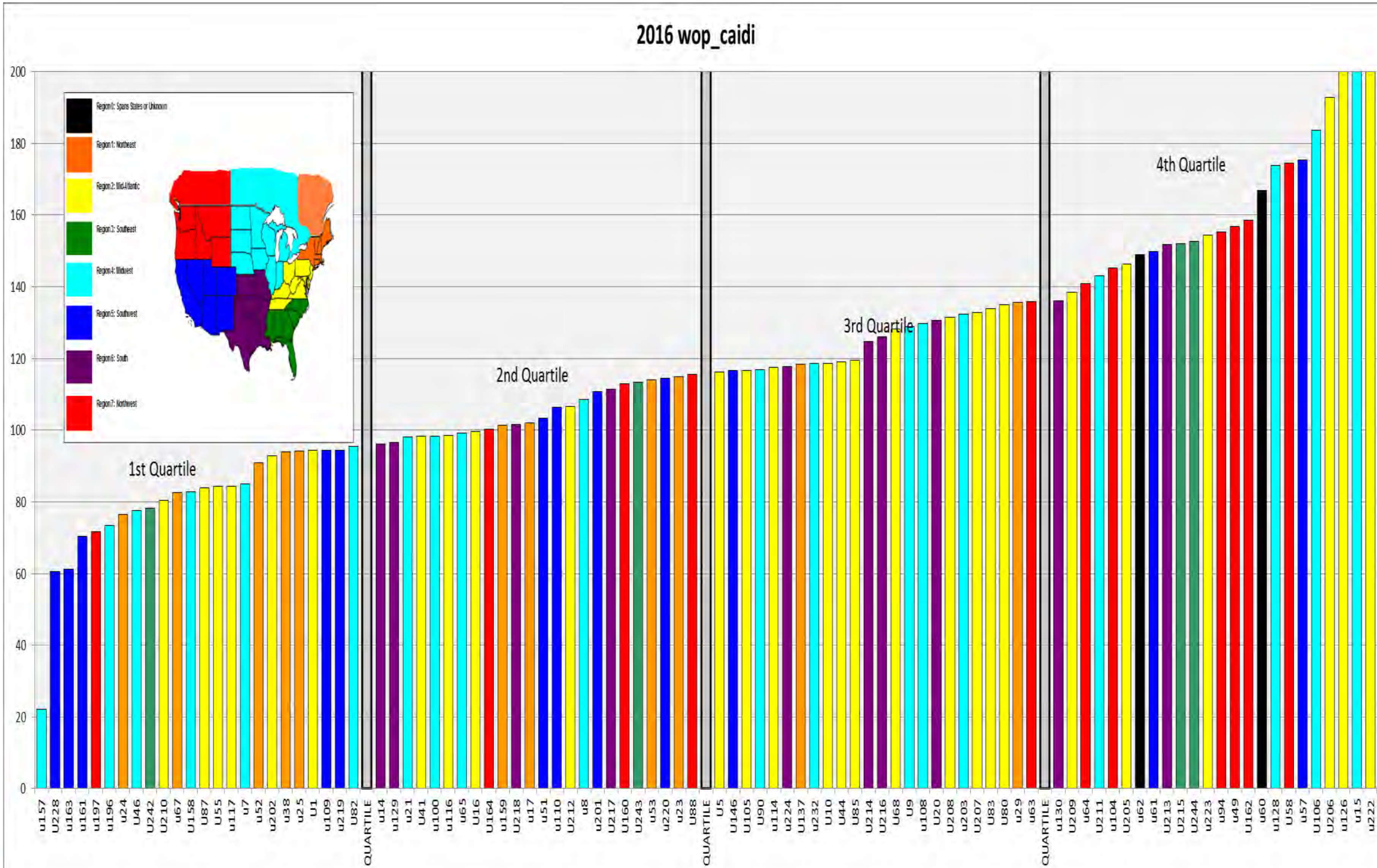
2016 WOF CAIDI



2016 WOP CAIDI



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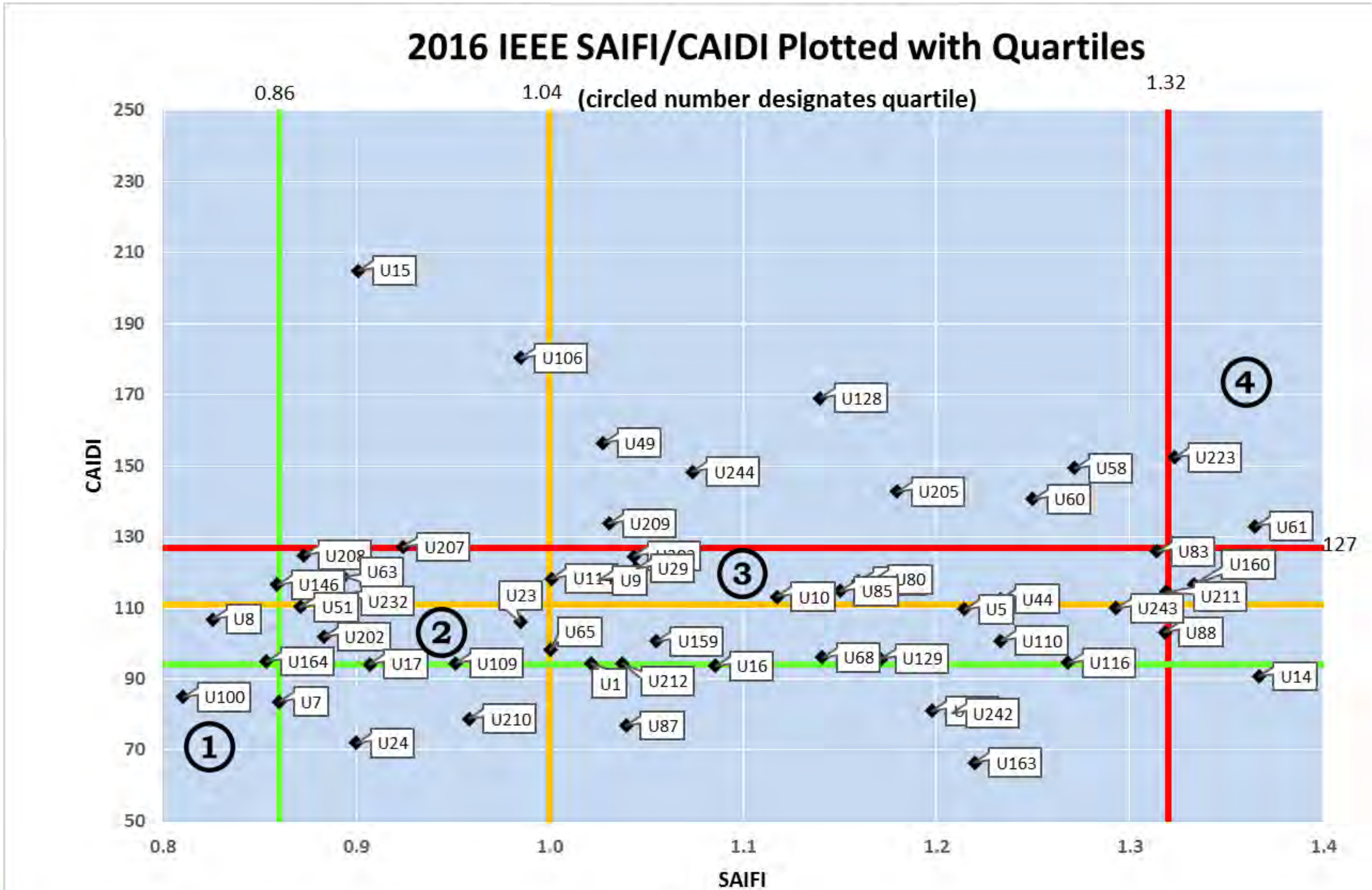
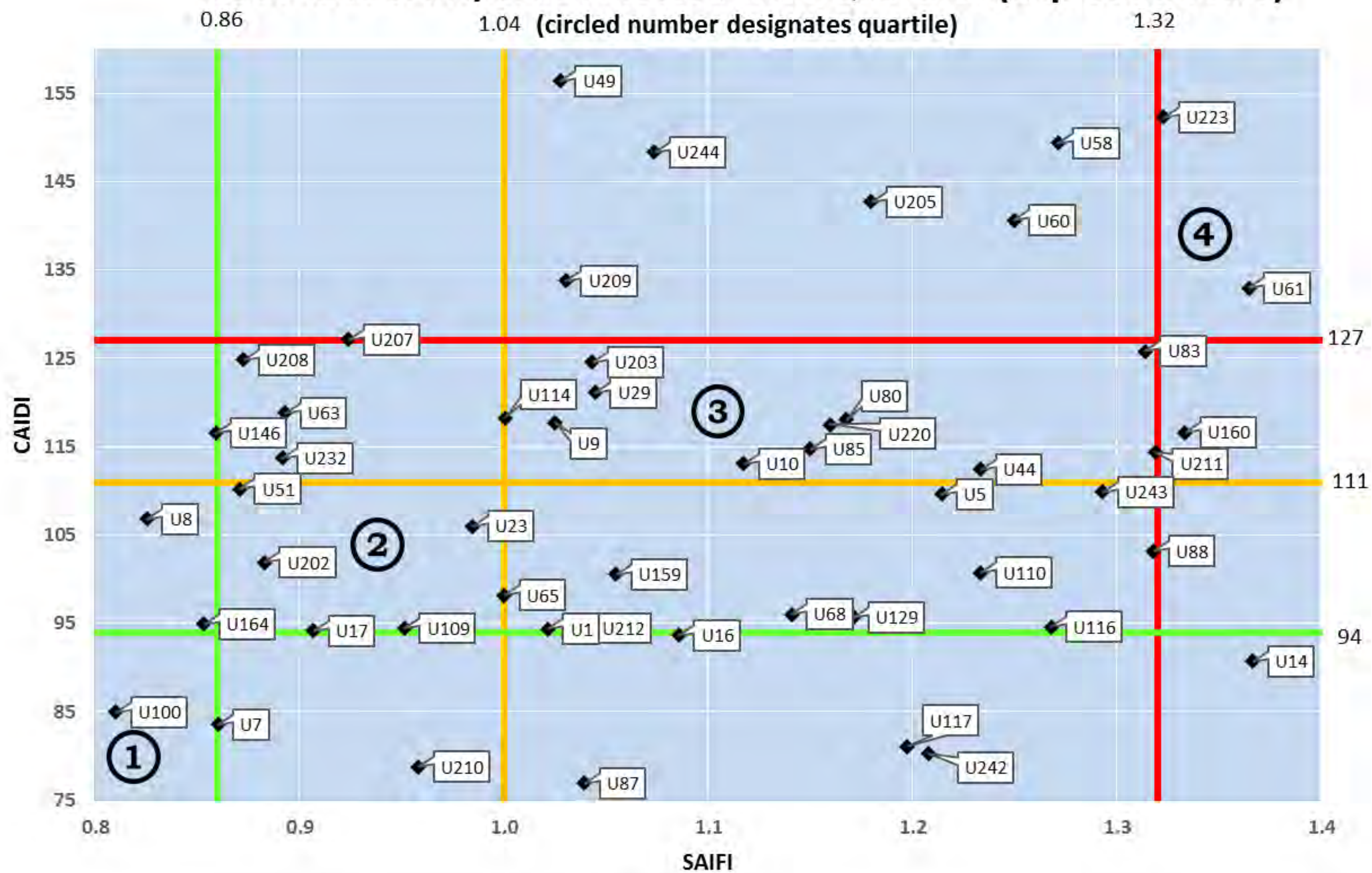
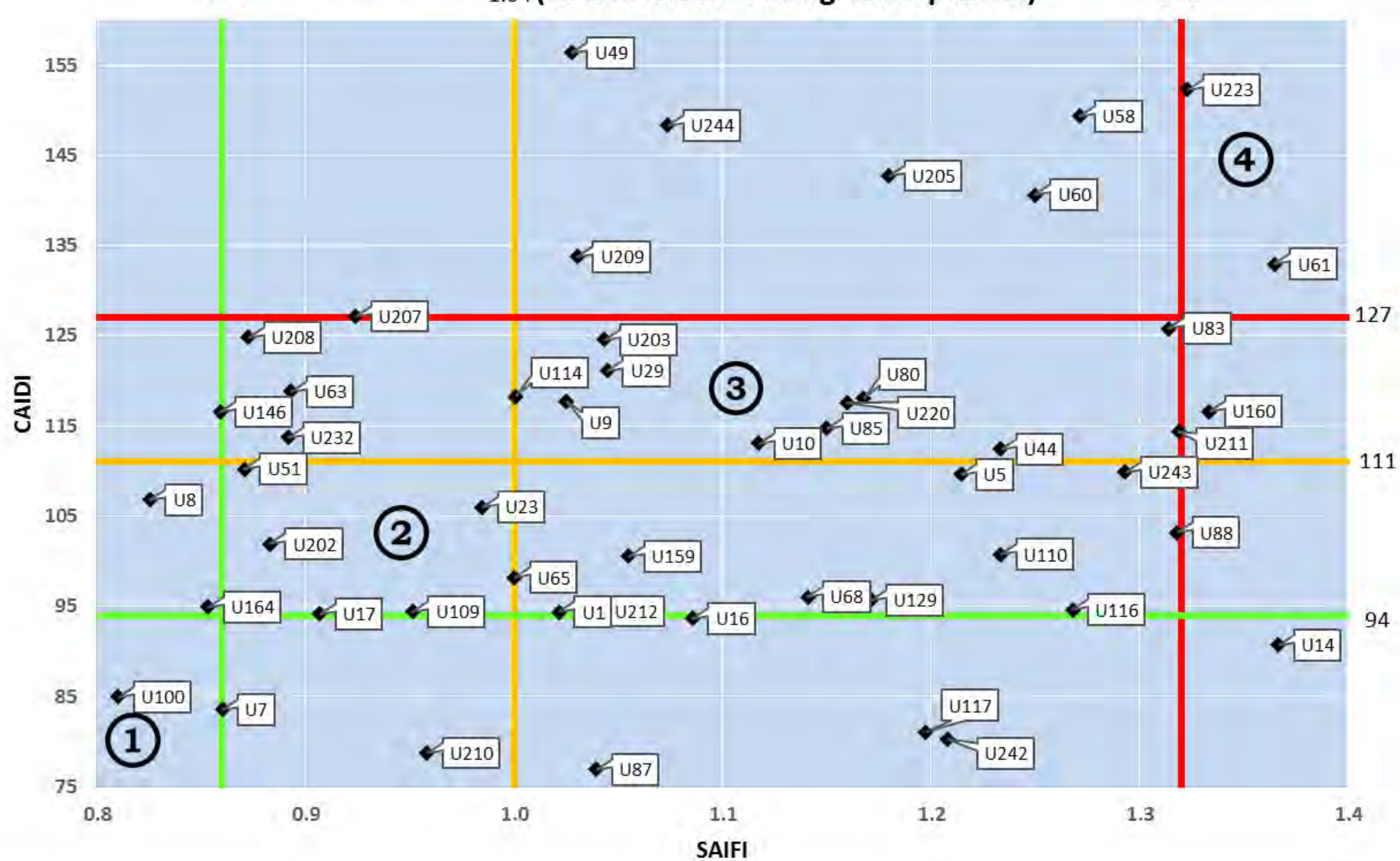

2016 IEEE SAIFI/CAIDI Plotted with Quartiles
(circled number designates quartile)
0.86
1.04
1.32
127
CAIDI
SAIFI
250
230
210
190
170
150
130
110
90
70
50
0.8
0.9
1.0
1.1
1.2
1.3
1.4
1
2
3
4
U15
U106
U128
U49
U244
U223
U58
U205
U60
U209
U61
U207
U208
U83
U63
U29
U9
U160
U146
U23
U85
U10
U44
U211
U51
U232
U5
U243
U8
U202
U65
U159
U110
U88
U164
U17
U109
U1
U212
U16
U68
U129
U116
U14
U100
U7
U210
U87
U242
U24
U163

2016 IEEE SAIFI/CAIDI Plotted with Quartiles (Exploded Scale)



2016 IEEE SAIFI/CAIDI Plotted with Quartiles (More Exploded Scale)

(circled number designates quartile)



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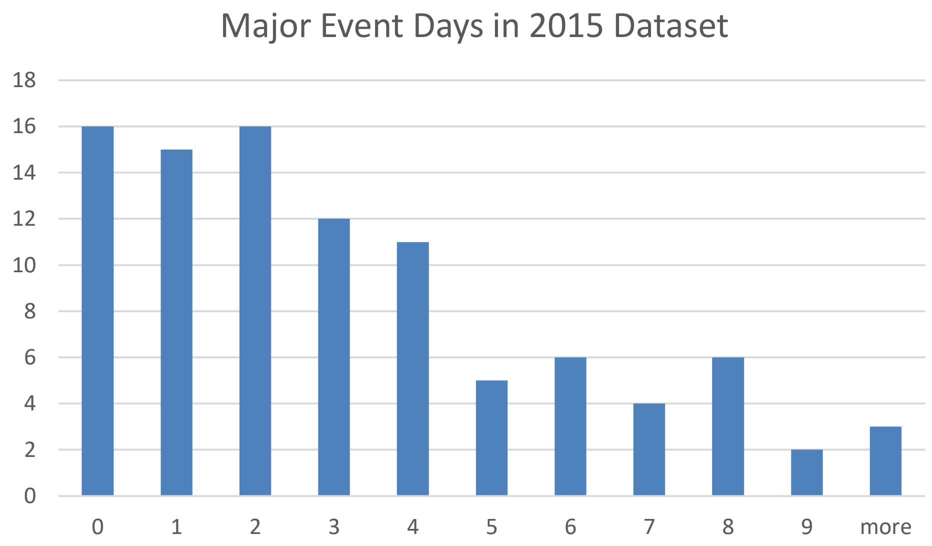
Major Event & Zero Days

2016 ME & Zero Days Results	Major Event Days	Zero Days
median	3	0
average	3.26	1.48
max	11	91
0	16	89
1	15	1
2	16	1
3	12	0
4	11	0
5	5	1
6	6	1
7	4	0
8	6	0
9	2	0
more	3	0



Questions?

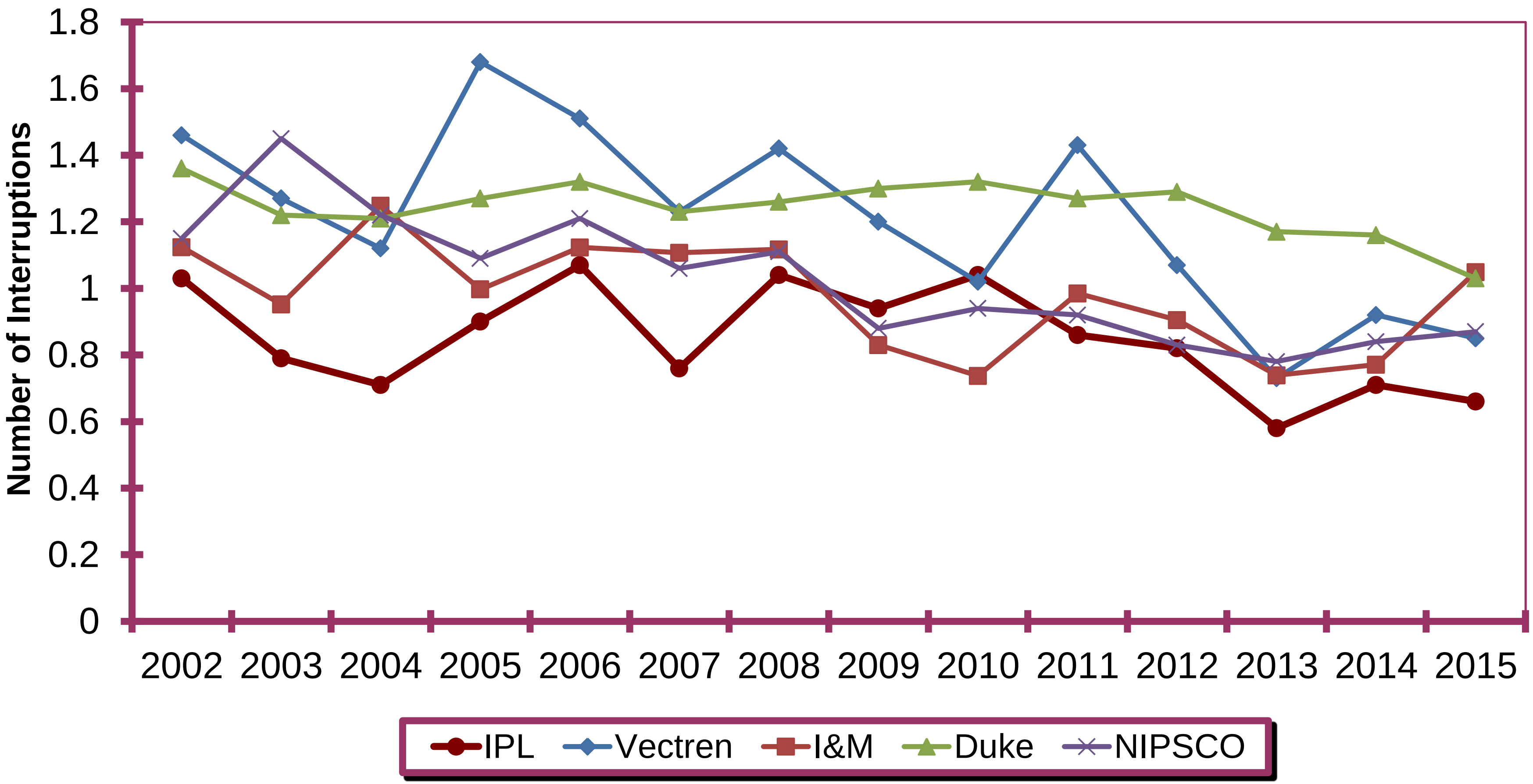
Areas for Further Investigation?

1) Gain information about planned data reporting by separate survey
2) Attempt to differentiate source (WOF) performance between BES and non-BES reliability metrics
3) Evaluate effects of urban/suburban/rural compared against reliability metrics
4) Evaluate tmed and lognormality
5) 3Φ versus 1Φ
6) Storm CAIDI

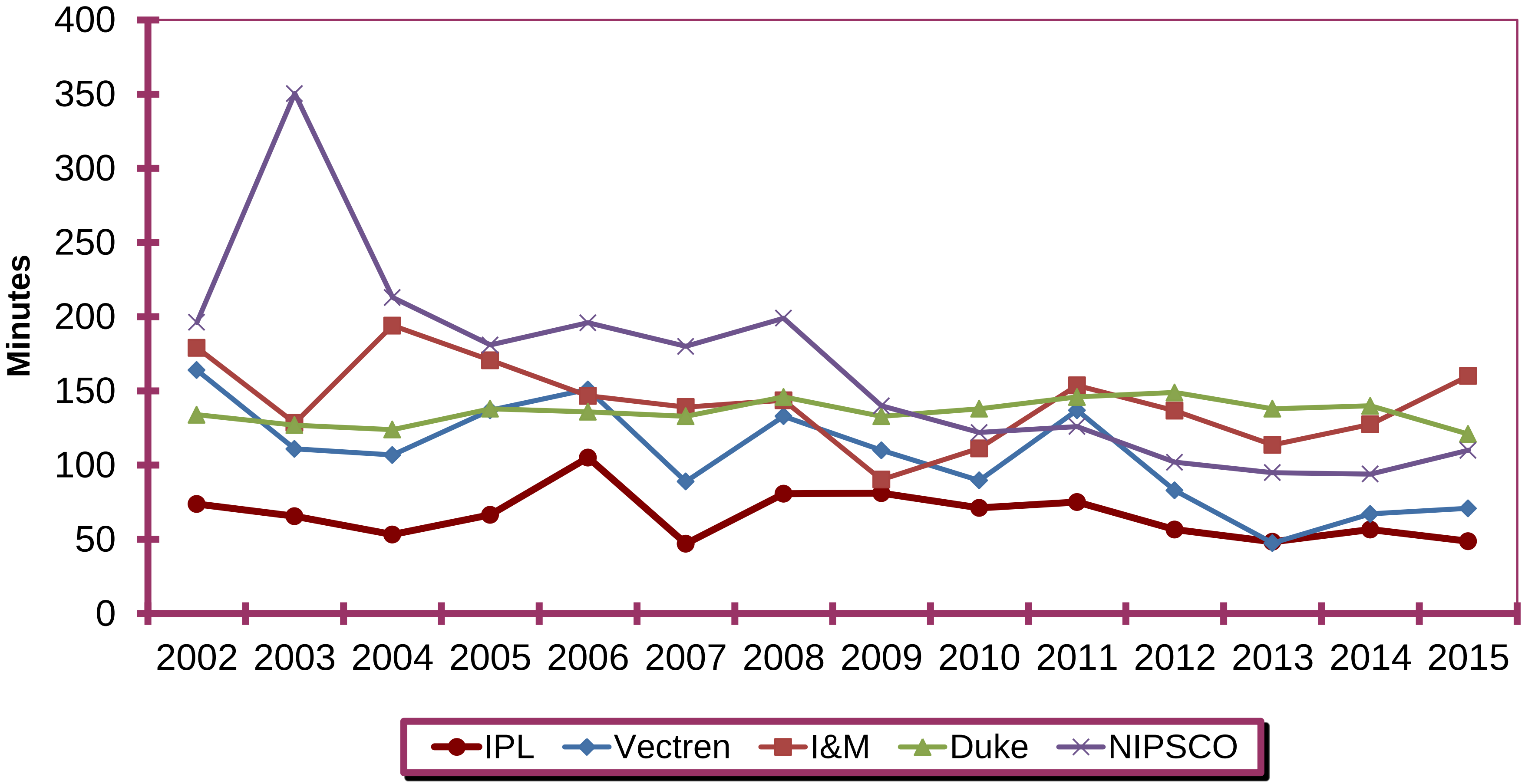
Graphical Representation of Page 6 of the

Indiana Utility Regulatory Commission Electric Utility Reliability Report: 2002 – 2015

System Average Interrruption Frequency Index
(SAIFI)
Not Including Major Events



System Average Interruption Duration Index
(SAIDI)
Not Including Major Events



Customer Average Interruption Duration Index
(CAIDI)
Not Including Major Events