DUKE ENERGY OHIO EXHIBIT________

BEFORE
THE PUBLIC UTILITIES COMMISSION OF OHIO

In the Matter of the Application of Duke Energy Ohio, Inc., for an Increase in Electric Distribution Rates.	))	Case No. 17-32-EL-AIR
In the Matter of the Application of Duke Energy Ohio, Inc., for Tariff Approval.	))	Case No. 17-33-EL-ATA
In the Matter of the Application of Duke Energy Ohio, Inc., for Approval to Change Accounting Methods.	))	Case No. 17-34-EL-AAM
In the Matter of the Application of Duke Energy Ohio, Inc., for Approval to Modify Rider PSR.	))	Case No. 17-872-EL-RDR
In the Matter of the Application of Duke Energy Ohio, Inc., for Approval to Amend Rider PSR.	))	Case No. 17-873-EL-ATA
In the Matter of the Application of Duke Energy Ohio, Inc., for Approval to Change Accounting Methods.	)	Case No. 17-874-EL-AAM
In the Matter of the Application of Duke Energy Ohio, Inc., for Authority to Establish a Standard Service Offer Pursuant to Section 4928.143, Revised Code, in the Form of an Electric Security Plan, Accounting Modifications and Tariffs for Generation Service.	))))	Case No. 17-1263-EL-SSO
In the Matter of the Application of Duke Energy Ohio, Inc., for Authority to Amend its Certified Supplier Tariff, P.U.C.O. No. 20.	)))	Case No. 17-1264-EL-ATA
In the Matter of the Application of Duke Energy Ohio, Inc., for Authority to Defer Vegetation Management Costs.	))	Case No. 17-1265-EL-AAM
In the Matter of the Application of Duke Energy Ohio, Inc., to Establish Minimum Reliability Performance Standards Pursuant to Chapter 4901:1-10, Ohio Administrative Code.	)))	Case No. 16-1602-EL-ESS

DIRECT TESTIMONY OF

RICHARD E. BROWN

ON BEHALF OF

DUKE ENERGY OHIO, INC.

IN SUPPORT OF STIPULATION

June 6, 2018

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I. INTRODUCTION

Q. PLEASE STATE YOUR NAME AND BUSINESS ADDRESS.

A. My name is Richard Eric Brown, and my business address is 1331 17th Street, Suite 515, Denver, CO 80202.

Q. BY WHOM ARE YOU EMPLOYED AND IN WHAT CAPACITY?

A. I am employed by Exponent Inc. as a Principal Engineer. Exponent is a science and engineering consulting company with approximately 1000 employees, about 25 U.S. offices and several international offices. As a Principal Engineer with Exponent, my primary role is to provide consulting services to electric utilities and related industries.

Q. PLEASE BRIEFLY DESCRIBE YOUR EDUCATION AND PROFESSIONAL EXPERIENCE.

A. I received my Bachelor of Science in Electrical Engineering, Master of Science in Electrical Engineering, and Ph.D. in Electrical Engineering from the University of Washington in Seattle. I received my Masters of Business Administration from the University of North Carolina at Chapel Hill. I am a registered professional engineer in the State of North Carolina.

I have worked chronologically at Jacob Engineering (a large design engineering firm), ABB (a large utility equipment manufacturer), KEMA (a utility consulting company), Quanta Services (a large utility construction company), WorleyParsons (a large design engineering firm) and Exponent.

During my consulting career, I have provided expert witness testimony to regulatory commissions in the states of California, Florida, Maryland, Massachusetts, Texas, and Virginia. I have also helped numerous utilities develop cost-justified reliability improvement plans. I have participated as an expert on the subject of electric power distribution reliability assessment, reliability improvement, major event assessment, major event hardening, and benefit-to-cost assessment. I am the author of over ninety peer-reviewed technical papers and the books *Electric Power Distribution Reliability* and *Business Essentials for Utility Engineers*.

In 2007, I was elected to the grade of IEEE Fellow for "contributions to distribution system reliability and risk assessment." The grade of Fellow is conferred by the IEEE Board of Directors for an "extraordinary record of industry accomplishments," and is limited to one-tenth of one percent of the total voting membership per year.

Q. HAVE YOU PREVIOUSLY TESTIFIED BEFORE THE PUBLIC UTILITIES COMMISSION OF OHIO?

A. No.

Q. WHAT IS THE PURPOSE OF YOUR TESTIMONY IN THESE PROCEEDINGS?

A. The purpose of my testimony is to discuss my opinion of the proposed reliability index targets associated with Rider DCI (Distribution Capital Investment) as described in the Stipulation and Recommendation filed on April 13, 2018 (Stipulation) by Duke Energy Ohio, Inc., (Duke Energy Ohio or the Company), the Staff of the Public Utilities Commission of Ohio (Staff), the City of

Cincinnati, the Ohio Partners for Affordable Energy, and others (Section III.E.4, "Rider DCI," pp. 10-14).

II. BACKGROUND

Q. PLEASE DESCRIBE DUKE ENERGY OHIO'S EXISTING ELECTRIC DISTRIBUTION SYSTEM AS IT RELATES TO THE RIDER DCI.

A. Duke Energy Ohio's electric delivery system provides electric service to approximately 700,000 customers located throughout southwestern Ohio. The infrastructure, management, and operations of this system are described in the direct testimony of Duke Energy Ohio's witness, Cicely M. Hart.

Q. PLEASE DESCRIBE YOUR FAMILIARITY WITH THE DUKE ENERGY OHIO'S ELECTRIC DISTRIBUTION SYSTEM.

A. I am very familiar with Duke Energy Ohio's existing electric distribution system as it relates to historical reliability performance, historical reliability programs, proposed continuations of reliability programs, new proposed reliability programs, and the setting of SAIDI and CAIDI targets. I have consulted for Duke Energy Ohio regarding its reliability performance initiatives and have assisted the Company in evaluating its programs and identifying new initiatives and best practices to maintain and improve reliability of its electric delivery system.

Q. PLEASE DESCRIBE YOUR UNDERSTANDING OF RELIABILITY TARGETS AS THEY RELATE TO DUKE ENERGY OHIO.

A. Duke Energy Ohio is a regulated electric utility in Ohio and is subject to the Ohio Administrative Code ("the Code"). Section 4901:1-10-10 of the Code addresses distribution system reliability and states the following:

<u>4901:1-10-10 Distribution system reliability.</u>

(A) General. This rule prescribes the measurement of each electric utility's service reliability, the development of minimum performance standards for such reliability, and the reporting of performance against the established standards.

(B) Service reliability indices and minimum performance standards.

(1) The service reliability indices are as follows:

"CAIDI," or the customer average interruption duration index, represents the average interruption duration or average time to restore service per interrupted customer. CAIDI is expressed by the following formula:

CAIDI equals sum of customer interruption durations divided by total number of customer interruptions

"SAIFI," or the system average interruption frequency index, represents the average number of interruptions per customer. SAIFI is expressed by the following formula:

SAIFI equals total number of customer interruptions divided by total number of customers served

(2) Each electric utility in this state shall file with the commission an application to establish company-specific minimum reliability performance standards.

…

(4) Supporting justification for the proposed methodology and each resulting performance standard.

(a) Performance standards should reflect historical system performance,

> system design, technological advancements, service area geography, customer perception survey results as defined in paragraph (B)(4)(b) of this rule, and other relevant factors.
>
> (b) Each electric utility shall periodically (no less than every three years) conduct a customer perception survey. …
>
> (c) Performance data during major events and transmission outages shall be excluded from the calculation of the indices, proposed standards, and any revised performance standards, as set forth in paragraph (B) of this rule.
>
> (E) Failure to meet the same performance standard for two consecutive years shall constitute a violation of this rule.

In summary, the Code requires Duke Energy Ohio to propose minimum performance standards with regards to SAIFI and CAIDI, to justify these minimum performance standards, and be subject to possible fines if these minimum performance standards are not met for two consecutive years. Failure to meet SAIFI or CAIDI targets exposes Duke Energy Ohio, per the Code, with a fine of up to $10,000 per day.

III. STIPULATION PROPOSAL FOR RIDER DCI

Q. PLEASE DESCRIBE RIDER DCI.

A. The purpose of Rider DCI is to allow the Duke Energy Ohio to maintain the safety and reliability of its delivery system and recover the Duke Energy Ohio's associated incremental revenue requirement. Programs within Rider DCI include work that is accounted for in FERC accounts 360 to 374.

Q. WHAT ARE THE STIPULATION'S RIDER DCI REVENUE CAPS.?

A. Section III.E.4 of the Stipulation addresses Rider DCI, and requests its continuation through May 31, 2025 with the following revenue caps:

2018 - $32M

2019 – $42.1M ($46.8M if SAIFI and CAIDI targets are met)

2020 - $56.1M ($60.8M if SAIFI and CAIDI targets are met)

2021 – 2024 – Increased of $18.7M per year

2025 (Jan. 1 – May 31) – Between 62.4M and $66.3M, depending upon reliability performance in prior years.

Q. HOW DOES THE STIPULATION ADDRESS RELIABILITY PERFORMANCE IN 2016 AND 2017?

A. The Stipulation states that neither CAIDI nor SAIFI performance in 2016 and/or 2017 shall be used to determine any penalty for non-compliance.

Q. WHAT ARE THE RELIABILITY TARGETS PROPOSED IN THE STIPULATION?

A. The reliability targets proposed in the Stipulation are shown in Table 1. Only the first three columns appear in the Stipulation (Year, CAIDI, SAIFI). I have added a SAIDI column (mathematically equal to CAIDI x SAIFI). I have also added three columns that normalize reliability index targets based on 2018 values.

Table 1. Reliability Targets in Stipulation

YEAR	CAIDI (min)	SAIFI (/yr)	SAIDI (min/yr)	CAIDI (%)	SAIFI (%)	SAIDI (%)
2018	134.34	1.12	150.46	100%	100%	100%
2019	134.34	1.00	134.34	100%	89%	89%
2020	134.34	0.91	122.25	100%	81%	81%
2021	135.52	0.83	112.48	101%	74%	75%
2022	137.00	0.75	102.75	102%	67%	68%
2023	137.00	0.75	102.75	102%	67%	68%
2024	137.00	0.75	102.75	102%	67%	68%
2025	137.00	0.75	102.75	102%	67%	68%

Q. THE STIPULATION TARGETS SHOW CAIDI EITHER STAYING THE SAME OR INCREASING. DOES THIS MEAN THAT RELIABILITY WILL BE GETTING WORSE?

A. No. CAIDI is a measure of how long an average interruption lasts. CAIDI can be lowered by reducing the length of interruptions, but can also be lowered by increasing the proportion of shorter-than-average interruptions. Consequently, an increase in CAIDI does not necessarily mean that reliability is getting worse; if SAIFI and SAIDI are both going down, but SAIFI is going down faster than SAIDI, CAIDI will go up even though reliability is getting better.

Q. THE STIPULATION TARGETS SHOW SAIFI EITHER STAYING THE SAME OR DECREASING. DOES THIS MEAN THAT RELIABILITY WILL BE GETTING BETTER?

A. Yes. SAIFI is a measure of how many sustained interruptions an average customer will experience over the course of a year. For a fixed number of customers, the only way to improve SAIFI is to reduce the number of sustained interruptions experienced by customers, which corresponds to better reliability.

Q. ALTHOUGH THE STIPULATION DOES NOT INCLUDE SAIDI TARGETS, YOUR COMPUTED SAIDI VALUE IN TABLE 1 SHOWS SAIDI EITHER STAYING THE SAME OR DECREASING. DOES THIS MEAN THAT RELIABILITY WILL BE GETTING BETTER?

A. Yes. SAIDI is a measure of how many interruption minutes an average customer will experience over the course of a year. For a fixed number of customers, SAIDI can be improved by reducing the number of interruptions or by reducing the duration of these interruptions. Since both of these reflect reliability improvements, a reduction in SAIDI indicates an improvement in reliability.

Q. WHY HAVE YOU INCLUDED SAIDI IN TABLE 1 WHEN THE STIPULATION DOES NOT INCLUDE SAIDI TARGETS?

A. The customer reliability experience is a function of both the frequency of interruptions and the duration of interruptions. Although frequency and duration are reflected in SAIFI and CAIDI, this combination can be confusing since CAIDI can go both up and down as reliability improves. SAIDI captures both frequency and duration effects in a single metric, thereby avoiding this potential confusion. In my reliability book I state, "Experience has shown that reliability spending decisions based on SAIDI alone do a good job of simultaneously improving SAIFI and the undesirable aspects of $MAIFI_E$."[1]

[1] R. Brown, *Electric Power Distribution Reliability*, 2nd Edition, CRC Press, 2009, p. 58. $MAIFI_E$ is a reliability index indicating the average number of momentary interruption events experienced by customers in a year.

Q. DO THE RELIABILITY TARGETS IN THE STIPULATION REFLECT A SIGNIFIGANT IMPROVEMENT IN RELIABILITY?

A. Yes. From 2018 through 2022, the targets in the Stipulation reflect a 33% reduction in SAIFI and a 32% reduction in SAIDI. This means that customers will experience about a one-third reduction in interruptions and about a one-third reduction in interruption minutes. From 2023 through 2025, reliability targets remain at 2022 values, indicating that reliability is expected to stay about the same over that time period.

IV. OVERVIEW OF CAPITAL PROGRAMS

Q. PLEASE DESCRIBE DUKE ENERGY OHIO'S CURRENT RELIABILITY PROGRAMS.

A. Some but not all of the current Duke capital reliability programs are listed in Table 2. Many of these programs primarily address aging infrastructure, some address issues other than reliability index improvement, and only a few will result in a noticeable SAIDI improvement (I use SAIDI since it captures both frequency and duration aspects of reliability improvement). I refer to these programs as they are familiar to the Commission, having been discussed in a previous proceeding. It is my understanding that there are others as well.

Table 2. Current Duke Capital Reliability Programs

Program	Addresses Aging Infrastructure?	Primary Benefit	Noticeable SAIDI Benefit
URD Cable Injection / Replacement	Yes	Reliability	
Outside-ROW Hazard Tree Removal		Reliability	Yes
Conversion of old 4kV Feeders	Yes	Capacity	
Manhole Lid Retrofit	Yes	Safety	
DTUG-Online DGA, Sump Pump, Oil Monitoring		Risk	
Manhole/Vault Capital Rebuild	Yes	Safety	
Network Secondary Main Replacement	Yes	Risk	
Vault Network Protector / Transformer Changeout	Yes	Risk	
Worst Congested Underground Structures		Risk	
Recloser Replacements	Yes	Reliability	
Circuit Sectionalization		Reliability	Yes
Transformer Retrofit	Yes	Reliability	Yes
Upgrade URD Submersible Transformers	Yes	Safety	
Distribution Substation Protection (Physical/Cyber)		Reliability	
Upgrade Live Front Transformers	Yes	Reliability	
Update Distribution Transformer Stations (Unique Customer Locations)	Yes	Reliability	
PILC Replacement (Feeder Exits)	Yes	Reliability	
Distribution Operation Center and Mobile Logistics / Modernization		Reliability	
Ownership of Underground Residential Services		Reliability	

Q. DO YOU HAVE AN OPINION REGARDING THE REASONABLENESS AND PRUDENCY OF DUKE ENERGY OHIO'S CURRENT RELIABILITY PROGRAMS?

A. Yes. I have examined each of these programs and all seem to be both reasonable and prudent expenditures. This is true even though most are not focused on maximizing reliability index improvement. Consider aging infrastructure. As distribution equipment ages, failure rates tend to increase. This causes reactive maintenance costs to increase, but also results in customer reliability getting worse. In this sense, aging infrastructure projects are keeping reliability indices from getting worse, but may not result in them getting better.

There are other reliability improvement programs not listed in Table 2 that can improve reliability indices. This includes what I consider "low hanging fruit" programs such as lateral fusing program. I have discussed these types of programs with Duke Energy Ohio reliability engineers and they have already been completed. In this sense, the Duke Energy Ohio has a "mature" system from a reliability perspective.

Since Duke Energy Ohio has already "picked all of the low hanging reliability fruit," opportunities for additional significant reliability index improvement are in the area of distribution automation. Duke Energy Ohio is currently addressing this area through its circuit sectionalizing program and plans to further address this area in a new program it calls the self-optimizing grid (SOG).

Q. PLEASE DESCRIBE THE PROPOSED SELF-OPTIMIZING GRID PROGRAM?

A. SOG refers to the use of interconnected distribution circuits and automated equipment that allow for smaller amounts of customers to be affected by faults on the system and shorter duration of outages when those faults occur. It bears a relationship to and complements Duke Energy Ohio's earlier investment in "self-healing teams." However, SOG is more integrated and will result in an almost real-time response. Instead of having circuit pairs that can back each other up, SOG allows for increased options when automatically isolating faults and restoring customer through alternate feeders.

V. SAIFI TARGETS

Q. WHAT ARE THE PRIMARY FACTORS RELATED TO SAIFI TARGETS?

A. Duke Energy Ohio has mature reliability improvement programs and therefore has two primary factors that can impact SAIFI. The first is aging infrastructure, which increases equipment failure rates and therefore results in a tendency for SAIFI to increase. The second is increased protection selectivity (e.g., an increase in line recloser deployment), which reduces the number of customers affected by a fault and therefore lowers SAIFI.

Aging infrastructure and protection selectivity address the inherent reliability of the distribution system, which relates to equipment failure rates and the system response to equipment failures. Duke Energy Ohio has two additional SAIFI factors that should be considered separately from inherent reliability. They are (1) planned interruptions needed for reliability programs; and (2) the increased use of “hot tag” safety procedures for linemen performing work on the distribution system.

Q. IS THE TREATMENT OF PLANNED INTERRUPTIONS AN IMPORTANT CONSIDERATION WHEN SETTING SAIFI TARGETS?

A. Yes. Many utilities do not include planned interruptions when calculating reliability indices, but Duke Energy Ohio does. This means that an increase in the amount of reliability program work will result in an increase in the number of customer interruptions and therefore an increase in SAIFI. Programs that will improve reliability will, when they are being implemented, actually make SAIFI worse.

Q. HOW SHOULD PLANNED INTERRUPTIONS BE TREATED WHEN SETTING SAIFI TARGETS?

A. When setting SAIFI targets, I recommend excluding the effect of planned interruptions. This allows inherent reliability to be better understood, and also accounts for the fact that customers perceive planned interruptions in a very different way when compared to unplanned interruptions. Utilities contact customers before a planned interruption happens, allowing the customer to make accommodations, providing a positive touch point with the customer, and communicating to the customer that monthly bills are going towards more than just energy. In this way, planned interruptions can actually increase customer satisfaction with their utility.

Duke Energy Ohio calculates the amount of SAIFI due to planned interruptions. It is therefore simple to subtract out this amount when calculating inherent reliability.

Q. IS THE TREATMENT OF HOT LINE TAG REQUIREMENTS AN IMPORTANT CONSIDERATION WHEN SETTING SAIFI TARGETS?

A. Yes. Duke Energy Ohio has recently changed its standards of when a “hot line tag” is required when work is being performed on the distribution system. A hot line tag is when work is being performed near an energized wire (i.e., “hot”) and the nearest upstream recloser or feeder breaker protection is temporarily modified to improve worker safety. This is done by temporarily disabling reclosing features and setting the device to trip and lock out without any intentional delay. This results in the fastest possible fault clearing and prevents the possibility of reclosing into a fault, both corresponding to increased worker safety. The protection modifications are restored to their normal settings after the crew has finished its work.

In the past, hot line tags were not required for all work being performed near an energized distribution wire. The new standard is that hot line tags are required for all work being performed near an energized distribution wire. The more frequent use of hot line tags results in an increase in SAIFI. Part of this is because faults will generally result in more customers being interrupted. The other part is that self-clearing faults now result in sustained interruptions rather than being cleared by reclosing (typically, more than 70% of overhead distribution faults can be cleared through reclosing).

Q. HOW SHOULD THE CHANGES IN HOT LINE TAG REQUIREMENTS BE TREATED WHEN SETTING SAIFI TARGETS?

A. Once fully implemented, the hot line tag program will result in a one-time increase in SAIFI. When setting reliability targets, this impact should be subtracted when calculating inherent SAIFI. Duke Energy Ohio calculates the amount of SAIFI due to planned interruptions. It is therefore simple to subtract out this amount when calculating inherent reliability.

Q. WHAT HAS THE HISTORICAL BASELINE SAIFI BEEN FOR DUKE ENERGY OHIO?

A. Historical Baseline SAIFI is equal to reported SAIFI minus the impact of planned outages and minus the impact of hot tag outages. Historical Baseline SAIFI calculations are shown in Table 3.

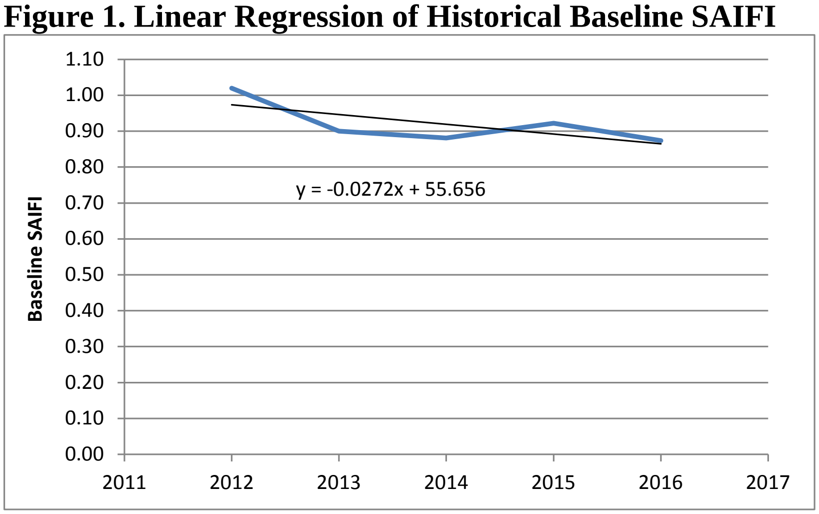
Table 3. Baseline SAIFI Calculation

Year	Historical SAIFI	SAIFI due to planned outages	SAIFI due to hot tag outages	Historical Baseline SAIFI
2011	1.38	0.05	0.00	1.33
2012	1.08	0.06	0.00	1.02
2013	0.98	0.08	0.00	0.90
2014	0.99	0.09	0.02	0.88
2015	1.04	0.07	0.05	0.92
2016	1.05	0.13	0.05	0.87
2017	1.16	0.15	0.09	0.92

Q. WHAT HAS BEEN THE TREND IN HISTORICAL BASELINE SAIFI?

A. Figure 1 shows a linear regression based of five years of baseline SAIFI (2012 to 2016).[2] This shows that inherent SAIFI is decreasing. It is therefore reasonable to base future SAIFI targets on a baseline SAIFI that continues to decrease.

Figure 1. Linear Regression of Historical Baseline SAIFI



[2] 2011 is excluded since it is an outlier that would tend to make SAIFI targets higher. 2017 excluded for the same reason, although it is not as extreme as 2011.

Q. BASED ON HISTORICAL BASELINE SAIFI VALUES, WHAT ARE PROJECTED SAIFI VALUES?

A. The linear regression equation in Figure 1 has been used to calculate an "Expected Baseline SAIFI" for years 2012 through 2022, assuming baseline SAIFI improves in 2017 through 2022 at the same rate it did from 2012 through 2016. The impact of planned outages and hot line tag outages are then added back to calculate an "Expected SAIFI," which is comparable to SAIFI that is reported to the Commission. Duke Energy Ohio has also calculated expected SAIFI improvements from its SOG program in years 2019 through 2022. These amounts are subtracted when calculating Expected SAIFI. Values for Expected Baseline SAIFI and Expected SAIFI are shown in Table 4.

Table 4. Expected Future SAIFI Values

Year	Historical SAIFI	SAIFI due to planned outages	SAIFI due to hot line tag outages	SOG	Historical Baseline SAIFI	Expected Baseline SAIFI	Expected SAIFI
2011	1.38	0.05	0.00		1.33	0.957	1.007
2012	1.08	0.06	0.00		1.02	0.930	0.990
2013	0.98	0.08	0.00		0.90	0.902	0.982
2014	0.99	0.09	0.02		0.88	0.875	0.985
2015	1.04	0.07	0.05		0.92	0.848	0.966
2016	1.05	0.13	0.05		0.87	0.821	0.998
2017	1.16	0.15	0.09		0.92	0.794	1.038
2018		0.18	0.10	-0.01		0.766	1.036
2019		0.19	0.11	-0.11		0.739	0.927
2020		0.19	0.11	-0.17		0.712	0.843
2021		0.19	0.11	-0.21		0.685	0.770
2022		0.19	0.11	-0.27		0.658	0.691

Q. BASED ON YOUR EXPECTED SAIFI CALCULATIONS, ARE THE SAIFI TARGETS IN THE STIPULATION REASONABLE AND ATTAINABLE?

A. Yes. A comparison of the SAIFI targets in the Stipulation compared to Expected SAIFI is shown in Table 5. In each year from 2018 through 2022, expected SAIFI is slightly lower than the SAIFI target, indicating a fair chance for Duke Energy Ohio to meet its SAIFI targets if the DCI reliability programs result in expected benefits.[3]

Table 5. SAIFI Targets vs. Expected SAIFI

YEAR	SAIFI Target	SAIFI Expected
2018	1.12	1.04
2019	1.00	0.93
2020	0.91	0.84
2021	0.83	0.77
2022	0.75	0.69

VI. CAIDI TARGETS

Q. WHAT ARE THE PRIMARY FACTORS RELATED TO CAIDI TARGETS?

A. As discussed previously, a higher or lower CAIDI does not necessarily correspond to higher or lower customer reliability. However, CAIDI is a required reliability metric in the Code. The Commission Staff, to my understanding, desires CAIDI reductions as a result of faster service restoration. To do this, it is necessary to calculate a baseline CAIDI that attempts to compensate for all of the CAIDI effects not related to the inherent reliability of the system. This includes work methods, dead/decaying ash trees, automatic sectionalizing devices, and planned interruptions.

[3] Reliability indices vary naturally from year-to-year. Therefore, setting SAIFI targets equal to expected SAIFI will result in Duke Energy Ohio not meeting the target in about half of all years due to random variation. Therefore it is appropriate to set targets slightly above expected values.

Q. IS THE TREATMENT OF WORK METHODS AN IMPORTANT CONSIDERATION WHEN SETTING CAIDI TARGETS?

A. Yes. Duke Energy Ohio has made changes in work methods that focus on improvements in workforce safety that affect CAIDI. This includes (1) a documented pre-job review to identify potential hazards and methods to mitigate the hazards; and (2) increased barrier requirements (insulation and isolation) between employees and energized equipment. For a given job, these changes in work methods add about 15 minutes of additional time for outages affected by these work method changes.

These revised work methods were fully implemented in 2016. Given that some outages are affected by the work method changes and some are not, the Company estimated a CAIDI increase of 10 minutes in 2016, and expects this to remain the case in future years. Duke Energy Ohio also estimates that this program was 20% implemented in 2015 and therefore had a CAIDI impact of 2 minutes.

Q. IS THE TREATMENT OF DEAD/DECAYING ASH TREES AN IMPORTANT CONSIDERATION WHEN SETTING CAIDI TARGETS?

A. Yes. Since the time to repair damage after ash tree damage is higher than for an average failure, CAIDI will tend to increase as ash tree failures increase. Duke Energy Ohio has a specific outage code for ash trees and can therefore calculate its impact on CAIDI. This impact was 3.4 minutes in 2016. This number is likely to rise, but I assume a 3.4 minute impact in 2017 and beyond to be conservative.

Q. IS THE TREATMENT OF AUTOMATIC SECTIONALIZING DEVICES AN IMPORTANT CONSIDERATION WHEN SETTING CAIDI TARGETS?

A. Yes. Duke Energy Ohio has experienced an increase in CAIDI due to the increased deployment of automatic sectionalizing devices (primarily line reclosers). When a line recloser interrupts a downstream fault instead of the main feeder breaker, fewer customers are interrupted which is a SAIFI benefit. However, there is less opportunity to perform step restoration since less of the feeder is impacted, resulting in an increase to CAIDI.

Duke Energy Ohio plans to continue the deployment of automatic sectionalizing devices through 2022. Duke Energy Ohio has calculated the expected impact of the deployment of automatic sectionalizing devices through this time.

Q. IS THE TREATMENT OF PLANNED OUTAGES AN IMPORTANT CONSIDERATION WHEN SETTING CAIDI TARGETS?

A. Yes. Duke Energy Ohio is experiencing a CAIDI reduction due to the increased number of planned outages, and has calculated this impact through 2016. I therefore add back these values when calculating baseline CAIDI.

Q. WHAT HAS THE HISTORICAL BASELINE CAIDI BEEN?

A. Historical Baseline CAIDI is equal to reported CAIDI minus the impact of modified work methods, minus the impact of increasing ash tree outages, minus the impact of increased automatic sectionalizing switches, and plus the impact of increased planned outages. Historical Baseline CAIDI calculations are shown in Table 6.

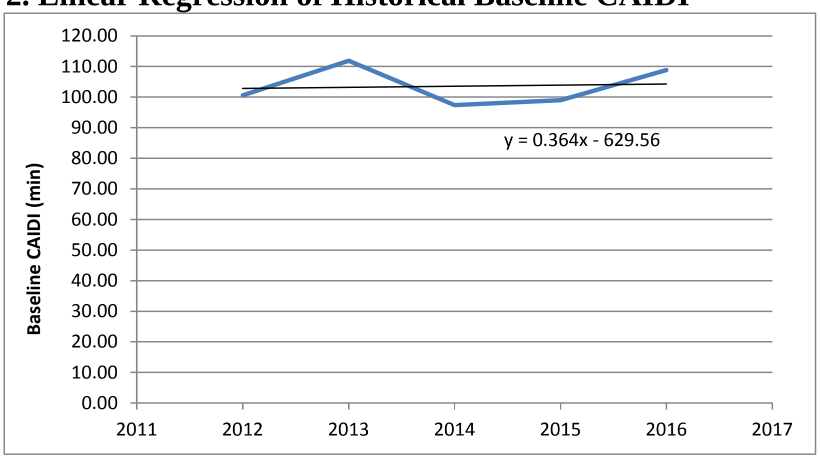
Table 6. Baseline CAIDI Calculation

Year	Historical CAIDI	CAIDI due to work methods	CAIDI due to ash tree outages	CAIDI due to automatic sectionalizing	CAIDI due to planned outages	Historical Baseline CAIDI
2011	107.00	0.0	0.0	0.0	0.0	107.0
2012	103.26	0.0	0.0	4.0	-1.3	100.6
2013	117.80	0.0	1.4	8.0	-3.5	111.9
2014	108.28	0.0	2.6	12.0	-3.7	97.4
2015	117.32	2.0	3.4	14.0	-1.1	99.0
2016	136.42	10.0	3.4	16.0	-1.8	108.8
2017	132.00	10.0	3.4	18.0	-2.3	102.9

Q. WHAT HAS BEEN THE TREND IN HISTORICAL BASELINE CAIDI?

A. Figure 2 shows a linear regression based of five years of baseline CAIDI (2012 to 2016, corresponding to the years used in calculating the SAIFI trend). This shows that inherent CAIDI is slightly increasing. Although the trend is small, this Baseline CAIDI trend can be considered undesirable since I attempted to make it reflect the speed of operational response.

Figure 2. Linear Regression of Historical Baseline CAIDI



Q. ARE THERE OTHER FACTORS TO CONSIDER WHEN PROJECTING CAIDI VALUES?

A. Yes, there are two additional considerations. The first consideration is the impact of SOG, which will increase CAIDI for reasons similar to the automatic sectionalizing program. Duke Energy Ohio has calculated this impact for 2019 through 2022, which I simply add back when calculating projected CAIDI.

The second consideration is my personal opinion that Duke Energy Ohio should reduce its baseline operational response time, which has been slightly increasing over recent years. I therefore make a reduction of two minutes per year from 2018 through 2022 to account for response time improvement.[4]

Q. BASED ON HISTORICAL BASELINE SAIFI VALUES, WHAT ARE PROJECTED CAIDI VALUES?

A. The linear regression equation in Figure 2 has been used to calculate an "Expected Baseline CAIDI" for years 2012 through 2022, assuming CAIDI increases in 2017 through 2022 at the same rate it did from 2012 through 2016. Expected CAIDI is then calculated by starting with Expected Baseline CAIDI, adding the impact of modified work methods, adding the impact of increasing ash tree outages, adding the impact of automatic sectionalizing, and then subtracting the impact of planned outages. An adjustment for the SOG program is also made starting in 2019. Last, additional cumulative CAIDI reductions are subtracted starting in 2018 (called "Target Baseline Reduction"), representing response time

[4] Duke does not address response time improvement in its RIDER DCI programs. Regardless, response time is an appropriate consideration when setting reliability targets according to the Code.

improvements not historically seen. All of these adjustments result in Expected CAIDI values for each year as shown in Table 7.

Table 7. Expected Future CAIDI Values

Year	Historical CAIDI	CAIDI due to work methods	CAIDI due to ash tree outages	CAIDI due to automatic sectionalizing	SOG	CAIDI due to planned outages	Historical Baseline CAIDI	Expected Baseline CAIDI	Target Baseline Reduction	Expected CAIDI
2011	107.00	0.0	0.0	0.0		0.0	107.0	102.4		102.4
2012	103.26	0.0	0.0	4.0		-1.3	100.6	102.8		106.8
2013	117.80	0.0	1.4	8.0		-3.5	111.9	103.2		112.6
2014	108.28	0.0	2.6	12.0		-3.7	97.4	103.5		118.1
2015	117.32	2.0	3.4	14.0		-1.1	99.0	103.9		123.3
2016	136.42	10.0	3.4	16.0		-1.8	108.8	104.3		133.7
2017	132.00	10.0	3.4	18.0		-2.3	102.9	104.6		136.0
2018		10.0	3.4	20.0		-2.3		105.0	2	136.4
2019		10.0	3.4	20.0	2.0	-2.3		105.4	4	136.8
2020		10.0	3.4	20.0	4.0	-2.3		105.7	6	137.1
2021		10.0	3.4	20.0	6.0	-2.3		106.1	8	137.5
2022		10.0	3.4	20.0	8.0	-2.3		106.4	10	137.8

Q. BASED ON YOUR EXPECTED SAIFI CALCULATIONS, ARE THE CAIDI TARGETS IN THE STIPULATION REASONABLE AND ATTAINABLE?

A. Yes, but it is close. A comparison of the CAIDI targets in the Stipulation to Expected CAIDI is shown in Table 8. In each year from 2018 through 2022, expected CAIDI is slightly <u>higher</u> than the CAIDI target. Therefore a perfectly typical year will result in the CAIDI target not being met.[5]

Table 8. CAIDI Targets vs. Expected CAIDI

YEAR	CAIDI Target	CAIDI Expected
2018	134.34	136.39
2019	134.34	136.76
2020	134.34	137.12
2021	135.52	137.48
2022	137.00	137.85

Based on my analysis, achieving CAIDI targets in 2018 through 2022 will be challenging for Duke Energy Ohio, and will generally require either an increase in

[5] Reliability indices vary naturally from year-to-year. Therefore, setting CAIDI targets equal to expected CAIDI will result in Duke Energy Ohio not meeting the target in about half of all years due to random variation. Therefore it would typically be is appropriate to set targets slightly above expected values, whereas they are set slightly below in this case.

the proportion of shorter-than-average interruptions and/or greater improvements in operational response time assumed in this analysis.

Q. CAN CAIDI BE REDUCED AT THE EXPENSE OF SAIFI?

A. Yes. An incremental shorter-than-average interruption will both increase SAIFI and decrease CAIDI. Therefore, many incremental shorter-than-average interruptions can materially increase SAIFI and decrease CAIDI.

Consider a situation where Duke Energy Ohio in Year 1 meets its SAIFI target but misses its CAIDI target. Now consider towards the end of Year 2 where Duke Energy Ohio is also meeting its SAIFI targets but is just missing its CAIDI target. The allowance of incremental shorter-than-average interruptions could potentially lower CAIDI such that the target is met. Even if this results in SAIFI targets being missed, neither SAIFI nor CAIDI were missed two years in a row and potential penalties would therefore be avoided.

VII. <u>CONCLUSIONS</u>

Q. PLEASE SUMMARIZE YOUR CONCLUSIONS WITH REGARDS TO THE SAIFI TARGETS PROPOSED IN THE STIPULATION.

A. The SAIFI targets proposed in the stipulation are reasonable and achievable and represent a significant improvement in reliability for Duke Energy Ohio customers from 2018 through 2025.

Q. PLEASE SUMMARIZE YOUR CONCLUSIONS WITH REGARDS TO THE CAIDI TARGETS PROPOSED IN THE STIPULATION.

A. The CAIDI targets proposed in the stipulation are reasonable, but will be difficult for Duke Energy Ohio to consistently achieve unless it finds a way to either an increase the proportion of shorter-than-average interruptions and/or achieve substantial improvements in post-interruption response time.

Duke Energy Ohio will only be subject to CAIDI-based penalties if it misses its CAIDI target for two consecutive years. If Duke Energy Ohio has about a 50/50 chance to meet its annual CAIDI target, it has about a 75% chance of meeting it in consecutive years.

It must be emphasized that a failure to meet CAIDI targets does not necessarily relate to the customer reliability experience since reliability improvements (and degradations) can occur with both increasing and decreasing CAIDI.

Q. DOES THIS CONCLUDE YOUR PRE-FILED DIRECT TESTIMONY?

A. Yes.

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Summary: Testimony Direct Testimony of Richard Brown in Support of Stipulation on Behalf of Duke Energy Ohio, Inc. electronically filed by Mrs. Adele M. Frisch on behalf of Duke Energy Ohio, Inc. and D'Ascenzo, Rocco O and Kingery, Jeanne W and Watts, Elizabeth H