COMMONWEALTH OF KENTUCKY
BEFORE THE PUBLIC SERVICE COMMISSION

In the Matter of:

JOINT SPECIAL CONTRACT FILING OF BIG RIVERS ELECTRIC CORPORATION AND KENERGY CORPORATION	))))	**TFS No. 2023-00____**

DIRECT TESTIMONY OF JOHN WOLFRAM

I. INTRODUCTION

Q. State your name, occupation and business address.

A. My name is John Wolfram. I am the Principal of Catalyst Consulting LLC. My business address is 3308 Haddon Road, Louisville, Kentucky 40241.

Q. On whose behalf are you testifying?

A. I am testifying on behalf of Big Rivers Electric Corporation ("*Big Rivers*").

Q. Briefly describe your education and work experience.

A. I received a Bachelor of Science degree in Electrical Engineering from the University of Notre Dame in 1990 and a Master of Science degree in Electrical Engineering from Drexel University in 1997. I founded Catalyst Consulting, LLC in June of 2012. From March 2010 through May 2012, I was a Senior Consultant with The Prime Group, LLC. I have developed cost of service studies and designed rates for numerous electrical and gas utilities, including electric distribution cooperatives, generation and transmission cooperatives, municipal utilities and investor-owned utilities. I have performed economic analyses, rate mechanism reviews, ISO/RTO membership evaluations, and wholesale formula rate reviews. I have also been employed by the parent companies for Louisville Gas and Electric Company and Kentucky Utilities Company, by the PJM interconnection, and by the Cincinnati Gas & Electric Company. A more detailed description of my qualifications is included in Exhibit Wolfram-1.

Q. Have you ever testified before the Kentucky Public Service Commission (the "*Commission*")?

A. Yes. I have testified in numerous regulatory proceedings before the Commission. A listing of my testimony in other proceedings is included in Exhibit Wolfram-1.

II. PURPOSE OF TESTIMONY

Q. What is the purpose of your testimony?

A. The purpose of my testimony is to sponsor the marginal cost analysis that Big Rivers submits with this application pursuant to the Commission's findings in its investigation into Economic Development Rates ("*EDRs*"). *See In the Matter of: An Investigation Into the Implementation of Economic Development Rates by Electric and Gas Utilities,* Administrative Case No. 327, Order dated September 24, 1990 ("*Admin 327 Order*").

Q. Are you sponsoring any exhibits?

A. Yes. I have prepared the following exhibits to support my testimony:

Exhibit Wolfram-1 – Qualifications of John Wolfram

Exhibit Wolfram-2 – Marginal Cost Analysis

Exhibit Wolfram-3 – Rate Comparison

III. MARGINAL COST ANALYSIS

Q. Please describe the requirement to submit a marginal cost analysis in conjunction with this filing.

A. In Admin 327 Order, the Commission noted the following in Finding #6:

> Upon submission of each EDR contract, a utility should demonstrate that the discounted rate exceeds the marginal cost associated with serving the customer. Marginal cost includes both the marginal cost of capacity as well as the marginal cost of energy. In order to demonstrate marginal cost recovery, a utility should submit, with each EDR contract, a current marginal cost-of-service study. A current study is one conducted no more than one year prior to the date of the contract.

Q. Did you perform a marginal cost analysis for Big Rivers?

A. Yes. I performed a marginal cost analysis for Big Rivers. The study is provided in Exhibit Wolfram-2.

Q. How did you perform the marginal cost analysis for Big Rivers?

A. I performed the analysis consistent with accepted industry guidelines included in the NARUC Electric Utility Cost Allocation Manual dated January 1992. I describe particular aspects of the approach in Exhibit Wolfram-2. I also relied upon information from a recent Big Rivers study related to the proposed conversion of the Green units to natural gas. *See In the Matter of: Electronic Application Of Big Rivers Electric Corporation For A Certificate Of Public Convenience And Necessity Authorizing The Conversion Of The Green Station Units To Natural Gas Fired Units And An Order Approving The Establishment Of A Regulatory Asset*, Case No. 2021-00079, filed February 28, 2021 ("*Green Conversion docket*").

Q. Do the results of the analysis demonstrate that in this case, the discounted rate in the proposed special contract exceeds the marginal cost associated with serving the customer, pursuant to the requirement of the Admin 327 Order?

A. Yes. The discounted rate in the proposed special contract exceeds the marginal cost associated with serving the customer. *See* Exhibit Wolfram-3.

IV. <u>CONCLUSION</u>

Q. Please summarize your conclusion and recommendation.

A. The marginal cost analysis provided is consistent with industry standards and provides a reasonable determination of Big Rivers' marginal costs of providing service. The analysis shows that the discounted rate in the proposed special contract exceeds the marginal cost associated with serving the customer. For this reason, the Commission should find that the discounted rate meets the requirements of Finding #6 of the Admin 327 Order.

Q. Does this conclude your testimony?

A. Yes.

BIG RIVERS ELECTRIC CORPORATION

JOINT SPECIAL CONTRACTS OF
BIG RIVERS ELECTRIC CORPORATION
AND KENERGY CORP.

TFS No. 2023-00___

VERIFICATION

I, John Wolfram, verify, state, and affirm that I prepared or supervised the preparation of the Direct Testimony filed with this Verification, and that this Direct Testimony is true and accurate to the best of my knowledge, information, and belief formed after a reasonable inquiry.

John Wolfram

COMMONWEALTH OF KENTUCKY)
COUNTY OF JEFFERSON COUNTY)

SUBSCRIBED AND SWORN TO before me by John Wolfram on this the 5 day of January, 2023.

GEOFFREY LEASE
Notary Public - State at Large
Kentucky
My Commission Expires June 09, 2023
Notary ID 623546

Notary Public, Kentucky State at Large

Kentucky ID Number 623546

My Commission Expires 06-09-2023

JOHN WOLFRAM

Summary of Qualifications

Provides consulting services to investor-owned utilities, rural electric cooperatives, and municipal utilities regarding utility rate and regulatory filings, cost of service studies, wholesale and retail rate designs, tariffs and special contracts, formula rates, and other analyses.

Employment

CATALYST CONSULTING LLC — June 2012 – Present
Principal

Provide consulting services in the areas of tariff development, formula rates, regulatory analysis, economic development, revenue requirements, cost of service, rate design, special rates, audits, rate filings, and other utility regulatory areas.

THE PRIME GROUP, LLC — March 2010 – May 2012
Senior Consultant

LG&E and KU, Louisville, KY — 1997 - 2010
(Louisville Gas & Electric Company and Kentucky Utilities Company)
Director, Customer Service & Marketing (2006 - 2010)
Manager, Regulatory Affairs (2001 - 2006)
Lead Planning Engineer, Generation Planning (1998 - 2001)
Power Trader, LG&E Energy Marketing (1997 - 1998)

PJM INTERCONNECTION, LLC, Norristown, PA — 1990 - 1993; 1994 - 1997
Project Lead – PJM OASIS Project
Chair, Data Management Working Group

CINCINNATI GAS & ELECTRIC COMPANY, Cincinnati, OH — 1993 - 1994
Electrical Engineer - Energy Management System

Education

Bachelor of Science Degree in Electrical Engineering, University of Notre Dame, 1990
Master of Science Degree in Electrical Engineering, Drexel University, 1997
Leadership Louisville, 2006

Associations

Senior Member, Institute of Electrical and Electronics Engineers ("IEEE") & Power Engineering Society

Articles

"FERC Formula Rate Resurgence" *Public Utilities Fortnightly*, Vol. 158, No. 9, July 2020, 34-37.

"Economic Development Rates: Public Service or Piracy?" *IAEE Energy Forum*, International Association for Energy Economics, 2016 Q1 (January 2016), 17-20.

Presentations

“New Developments in Kentucky Rate Filings” presented to Kentucky Electric Cooperatives Accountants' Association Summer Meeting, Jun. 2022.

“Avoiding Shock: Communicating Rate Changes” presented to APPA Business & Financial Conference, Sep. 2020.

“Revisiting Rate Design Strategies” presented to APPA Public Power Forward Summit, Nov. 2019.

“Utility Rates at the Crossroads” presented to APPA Business & Financial Conference, Sep. 2019.

“New Developments in Kentucky Rate Filings” presented to Kentucky Electric Cooperatives Accountants' Association Summer Meeting, Jun. 2019.

“Electric Rates: New Approaches to Ratemaking” presented to CFC Statewide Workshop for Directors, Jan. 2019.

“The Great Rate Debate: Residential Demand Rates” presented to CFC Forum, Jun. 2018.

“Benefits of Cost of Service Studies” presented to Tri-State Electric Cooperatives Accountants’ Association Spring Meeting, Apr. 2017.

“Proper Design of Utility Rate Incentives” presented to APPA/Area Development’s Public Power Consultants Forum, Mar. 2017.

“Utility Hot Topics and Economic Development” presented to APPA/Area Development’s Public Power Consultants Forum, Mar. 2017.

“Emerging Rate Designs” presented to CFC Independent Borrowers Executive Summit, Nov. 2016.

“Optimizing Economic Development” presented to Grand River Dam Authority Municipal Customer Annual Meeting, Sept. 2016.

“Tomorrow’s Electric Rate Designs, Today” presented to CFC Forum, Jun. 2016.

“Reviewing Rate Class Composition to Support Sound Rate Design” presented to EEI Rate and Regulatory Analysts Group Meeting, May 2016.

“Taking Public Power Economic Development to the Next Level” presented to APPA/Area Development’s Public Power Consultants Forum, Mar. 2016.

“Ratemaking for Environmental Compliance Plans” presented to NARUC Staff Subcommittee on Accounting and Finance Fall Conference, Sep. 2015.

“Top Utility Strategies for Successful Attraction, Retention & Expansion” presented to APPA/Area Development’s Public Power Consultants Forum, Mar. 2015.

“Economic Development and Load Retention Rates” presented to NARUC Staff Subcommittee on Accounting and Finance Fall Conference, Sep. 2013.

“Rates for Distributed Generation” presented to 2010 Electric Cooperative Rate Conference, Oct. 2010.

“What Utilities Can Do to Advance Energy Efficiency in Kentucky” panel session of Second Annual Kentucky Energy Efficiency Conference, Oct. 2007.

Expert Witness Testimony & Proceedings

FERC

Submitted direct testimony for Black Hills Colorado Electric, LLC in FERC Docket No. ER22-2185 regarding a proposed Transmission Formula Rate.

Submitted testimony for Evergy Kansas Central, Inc. and Evergy Generating, Inc. in FERC Docket Nos. ER22-1974-000, ER22-1975-000 and ER22-1976-000 regarding revised capital structures under transmission and generation formula rates.

Submitted affidavit for Constellation Mystic Power, LLC in FERC Docket No. ER18-1639-000 in response to arguments raised in formal challenges to an informational filing required for a cost-of-service rate for the operation of power plants in ISO New England.

Submitted direct testimony for El Paso Electric Company in FERC Docket No. ER22-282 regarding a proposed Transmission Formula Rate.

Submitted direct testimony for TransCanyon Western Development, LLC in FERC Docket No. ER21-1065 regarding a proposed Transmission Formula Rate.

Submitted direct testimony for Cleco Power LLC in FERC Docket No. ER21-370 regarding a proposed rate schedule for Blackstart Service under Schedule 33 of the MISO Open Access Transmission, Energy and Operating Reserve Markets Tariff.

Submitted direct testimony for Constellation Mystic Power, LLC in FERC Docket No. ER18-1639-005 supporting a compliance filing for a cost-of-service rate for compensation for the continued operation of power plants in ISO New England.

Submitted direct testimony for DATC Path 15, LLC in FERC Docket No. ER20-1006 regarding a proposed wholesale transmission rate.

Submitted direct testimony for Tucson Electric Power Company in FERC Docket No. ER19-2019 regarding a proposed Transmission Formula Rate.

Submitted direct testimony for Cheyenne Light, Fuel & Power Company in FERC Docket No. ER19-697 regarding a proposed Transmission Formula Rate.

Supported Kansas City Power & Light in FERC Docket No. ER19-1861-000 regarding revisions to fixed depreciation rates in the KCP&L SPP Transmission Formula Rate.

Supported Westar Energy and Kansas Gas & Electric Company in FERC Docket No. ER19-269-000 regarding revisions to fixed depreciation rates in the Westar SPP Transmission Formula Rate.

Submitted direct testimony for Midwest Power Transmission Arkansas, LLC in FERC Docket No. ER15-2236 regarding a proposed Transmission Formula Rate.

Submitted direct testimony for Kanstar Transmission, LLC in FERC Docket No. ER15-2237 regarding a proposed Transmission Formula Rate.

Supported Westar Energy and Kansas Gas & Electric Company in FERC Docket Nos. FA15-9-000 and FA15-15-000 regarding an Audit of Compliance with Rates, Terms and Conditions of Westar's Open Access Transmission Tariff and Formula Rates, Accounting Requirements of the Uniform System of Accounts, and Reporting Requirements of the FERC Form No. 1.

Submitted direct testimony for Westar Energy in FERC Docket Nos. ER14-804 and ER14-805 regarding proposed revisions to a Generation Formula Rate.

Supported Intermountain Rural Electric Association and Tri-State G&T in FERC Docket No. ER12-1589 regarding revisions to Public Service of Colorado's Transmission Formula Rate.

Supported Intermountain Rural Electric Association in FERC Docket No. ER11-2853 regarding revisions to Public Service of Colorado's Production Formula Rate.

Supported Kansas Gas & Electric Company in FERC Docket No. FA14-3-000 regarding an Audit of Compliance with Nuclear Plant Decommissioning Trust Fund Regulations and Accounting Practices.

Supported LG&E Energy LLC in FERC Docket No. PA05-9-000 regarding an Audit of Code of Conduct, Standards of Conduct, Market-Based Rate Tariff, and MISO's Open Access Transmission Tariff at LG&E Energy LLC.

Submitted remarks and served on expert panel in FERC Docket No. RM01-10-000 on May 21, 2002 in Standards of Conduct for Transmission Providers staff conference, regarding proposed rulemaking on the functional separation of wholesale transmission and bundled sales functions for electric utilities.

Kansas

Submitted report for Westar Energy, Inc. in Docket No. 21-WCNE-103-GIE regarding plans and options for funding the decommissioning trust fund, depreciation expenses, and overall cost recovery in the event of premature closing of the Wolf Creek nuclear plant.

Submitted direct and rebuttal testimony for Westar Energy, Inc. in Docket No. 18-WSEE-328-RTS regarding overall rate design, prior rate case settlement commitments, lighting tariffs, an Electric Transit rate schedule, Electric Vehicle charging tariffs, and tariff general terms and conditions.

Submitted direct and rebuttal testimony for Westar Energy, Inc. in Docket No. 18-KG&E-303-CON regarding the Evaluation, Measurement and Verification ("EM&V") of an energy efficiency demand response program offered pursuant to a large industrial customer special contract.

Submitted report for Westar Energy, Inc. in Docket No. 18-WCNE-107-GIE regarding plans and options for funding the decommissioning trust fund, depreciation expenses, and overall cost recovery in the event of premature closing of the Wolf Creek nuclear plant.

Submitted direct and rebuttal testimony for Westar Energy, Inc. in Docket No. 15-WSEE-115-RTS regarding rate designs for large customer classes, establishment of a balancing account related to new rate options, establishment of a tracking mechanism for costs related to compliance with mandated cyber and physical security standards, other rate design issues, and revenue allocation.

Kentucky

Submitted direct and rebuttal testimony and responses to data requests on behalf of Jackson Purchase Energy Corporation in Case No. 2021-00358 regarding revenue requirements, adjustments, cost of service and rate design in a base rate case.

Submitted direct and rebuttal testimony and responses to data requests on behalf of Big Rivers Electric Corporation in Case No. 2021-00289 regarding a Large Industrial Customer Standby Service Tariff.

Submitted direct testimony on behalf of Big Rivers Electric Corporation and Jackson Purchase Energy Corporation in Case No. 2021-00282 regarding a marginal cost of service study in support of an economic development rate for a special contract.

Submitted direct testimony, responses to data requests, and rebuttal testimony on behalf of sixteen distribution cooperative owner-members of East Kentucky Power Cooperative in Case Nos. 2021-00104 through 2021-00119 regarding rate design for the pass-through of a proposed wholesale rate revision.

Submitted direct testimony and responses to data requests on behalf of Kenergy Corp. in Case No. 2021-00066 regarding revenue requirements, pro forma adjustments, cost of service and rate design in a streamlined rate case.

Submitted direct testimony on behalf of Big Rivers Electric Corporation in Case No. 2021-00061 regarding two cost of service studies in a review of the Member Rate Stability Mechanism Charge for calendar year 2020.

Submitted direct testimony and responses to data requests on behalf of Licking Valley R.E.C.C. in Case No. 2020-00338 regarding revenue requirements, pro forma adjustments, cost of service and rate design in a streamlined rate case.

Submitted direct testimony and responses to data requests on behalf of Cumberland Valley Electric in Case No. 2020-00264 regarding revenue requirements, pro forma adjustments, cost of service and rate design in a streamlined rate case.

Submitted direct testimony and responses to data requests on behalf of Taylor County R.E.C.C. in Case No. 2020-00278 regarding the cost support and tariff changes for the implementation of a Prepay Metering Program.

Submitted direct testimony and responses to data requests on behalf of Meade County R.E.C.C. in Case No. 2020-00131 regarding revenue requirements, pro forma adjustments, cost of service and rate design in a streamlined rate case.

Submitted direct testimony and responses to data requests on behalf of Clark Energy Cooperative in Case No. 2020-00104 regarding revenue requirements, pro forma adjustments, cost of service and rate design in a streamlined rate case.

Submitted direct testimony and responses to data requests on behalf of Big Rivers Electric Corporation in Case No. 2019-00435 regarding an Environmental Compliance Plan and Environmental Surcharge rate mechanism.

Submitted direct testimony and responses to data requests on behalf of Jackson Energy Cooperative in Case No. 2019-00066 regarding revenue requirements, cost of service and rate design in a streamlined rate case.

Submitted direct testimony and responses to data requests on behalf of Jackson Purchase Energy Corporation in Case No. 2019-00053 regarding revenue requirements, pro forma adjustments, cost of service and rate design in a streamlined rate case.

Submitted direct testimony and data request responses on behalf of Big Rivers Electric Corporation in Case No. 2018-00146 regarding ratemaking issues associated with the anticipated termination of contracts regarding the operation of an electric generating plant owned by the City of Henderson, Kentucky.

Submitted direct testimony on behalf of fifteen distribution cooperative owner-members of East Kentucky Power Cooperative in Case No. 2018-00050 regarding the economic evaluation of and potential cost shift resulting from a proposed member purchased power agreement.

Submitted direct testimony on behalf of Big Sandy R.E.C.C. in Case No. 2017-00374 regarding revenue requirements, pro forma adjustments, cost of service and rate design in a base rate case.

Submitted direct testimony on behalf of Progress Metal Reclamation Company in Kentucky Power Company Case No. 2017-00179 regarding the potential implementation of a Load Retention Rate or revisions to an Economic Development Rate.

Submitted direct testimony on behalf of Kenergy Corp. and Big Rivers Electric Corporation in Case No. 2016-00117 regarding a marginal cost of service study in support of an economic development rate for a special contracts customer.

Submitted rebuttal testimony on behalf of Big Rivers Electric Corporation in Case No. 2014-00134 regarding ratemaking treatment of revenues associated with proposed wholesale market-based-rate purchased power agreements with entities in Nebraska.

Submitted direct and rebuttal testimony on behalf of Big Rivers Electric Corporation in Case No. 2013-00199 regarding revenue requirements, pro forma adjustments, cost of service and rate design in a base rate case.

Submitted direct and rebuttal testimony on behalf of Big Rivers Electric Corporation in Case No. 2012-00535 regarding revenue requirements, pro forma adjustments, cost of service and rate design in a base rate case.

Submitted direct and rebuttal testimony on behalf of Big Rivers Electric Corporation in Case No. 2012-00063 regarding an Environmental Compliance Plan and Environmental Surcharge rate mechanism.

Submitted direct, rebuttal, and rehearing direct testimony on behalf of Big Rivers Electric Corporation in Case No. 2011-00036 regarding revenue requirements and pro forma adjustments in a base rate case.

Submitted direct testimony for Louisville Gas & Electric Company in Case No. 2009-00549 and for Kentucky Utilities Company in Case No. 2009-00548 for adjustment of electric and gas base rates, in support of a new service offering for Low Emission Vehicles, revised special charges, and company offerings aimed at assisting customers.

Submitted discovery responses for Kentucky Utilities and/or Louisville Gas & Electric Company in various customer inquiry matters, including Case Nos. 2009-00421, 2009-00312, and 2009-00364.

Submitted discovery responses for Louisville Gas & Electric Company and Kentucky Utilities Company in Case No. 2008-00148 regarding the 2008 Joint Integrated Resource Plan.

Submitted discovery responses for Louisville Gas & Electric Company and Kentucky Utilities Company in Administrative Case No. 2007-00477 regarding an investigation of the energy and regulatory issues in Kentucky's 2007 Energy Act.

Submitted direct testimony for Louisville Gas & Electric Company and Kentucky Utilities Company in Case No. 2007-00319 for the review, modification, and continuation of Energy Efficiency Programs and DSM Cost Recovery Mechanisms.

Submitted direct testimony for Louisville Gas & Electric Company and Kentucky Utilities Company in Case No. 2007-00067 for approval of a proposed Green Energy program and associated tariff riders.

Submitted direct testimony for Louisville Gas & Electric Company and Kentucky Utilities Company in Case No. 2005-00467 and 2005-00472 regarding a Certificate of Public Convenience and Necessity for the construction of transmission facilities.

Submitted discovery responses for Kentucky Utilities in Case No. 2005-00405 regarding the transfer of a utility hydroelectric power plant to a private developer.

Submitted discovery responses for Louisville Gas & Electric Company and Kentucky Utilities Company in Case No. 2005-00162 for the 2005 Joint Integrated Resource Plan.

Presented company position for Louisville Gas & Electric Company and Kentucky Utilities Company at public meetings held in Case Nos. 2005-00142 and 2005-00154 regarding routes for proposed transmission lines.

Supported Louisville Gas & Electric Company and Kentucky Utilities Company in a Focused Management Audit of Fuel Procurement practices by Liberty Consulting in 2004.

Supported Louisville Gas & Electric Company and Kentucky Utilities Company in an Investigation into their Membership in the Midwest Independent Transmission System Operator, Inc. ("MISO") in Case No. 2003-00266.

Supported Louisville Gas & Electric Company and Kentucky Utilities Company in a Focused Management Audit of its Earning Sharing Mechanism by Barrington-Wellesley Group in 2002-2003.

Submitted direct testimony for Louisville Gas & Electric Company and Kentucky Utilities Company in Case No. 2002-00381 regarding a Certificate of Public Convenience and Necessity for the acquisition of four combustion turbines.

Submitted direct testimony for Louisville Gas & Electric Company and Kentucky Utilities Company in Case No. 2002-00029 regarding a Certificate of Public Convenience and Necessity for the acquisition of two combustion turbines.

Missouri

Submitted direct, rebuttal and surrebuttal testimony for Evergy Metro, Inc. in Case No. ER-2022-0130 regarding a jurisdictional cost allocation analysis in a retail rate case.

Virginia

Submitted direct testimony for Kentucky Utilities Company d/b/a Old Dominion Power in Case No. PUE-2002-00570 regarding a Certificate of Public Convenience and Necessity for the acquisition of four combustion turbines.

Big Rivers Electric Corporation

2022 Marginal Cost Analysis

October 2022

Prepared By

CATALYST
CONSULTING LLC

TFS No. 2023-00____
Exhibit Wolfram 2

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I. Executive Summary

This report describes the methods for estimating marginal production and transmission costs for Big Rivers Electric Corporation ("Big Rivers"). For production, the fixed marginal cost and the variable marginal cost are evaluated independently. Marginal distribution costs are not calculated because Big Rivers is a Generation and Transmission cooperative ("G&T") with no distribution assets.

The analysis is largely based on a recent study related to the proposed conversion of the Green units to natural gas. See *In the Matter of: Electronic Application Of Big Rivers Electric Corporation For A Certificate Of Public Convenience And Necessity Authorizing The Conversion Of The Green Station Units To Natural Gas Fired Units And An Order Approving The Establishment Of A Regulatory Asset,* Case No. 2021-00079, filed February 28, 2021 ("Green Conversion docket").

The analysis in the Green Conversion docket demonstrates that Big Rivers' marginal production demand cost is $3.80 per kW per month and the marginal production energy cost is [redacted] per kWh. Because of the existing capabilities of the electric transmission grid, as designed prior to the termination of the smelter contracts, retirement of other Big Rivers facilities and proposed conversion of the Green units, the marginal transmission cost is zero.

II. Introduction

Marginal cost is defined as the change in total cost with respect to a small change in demand. In this report "output" will be used in place of "demand" to avoid confusion with the standard way that the term "demand" is used in the industry to represent the maximum amount of power utilized during any interval over a specified period of time. Therefore, in this study, output refers to the total megawatts of capacity or megawatt-hours of energy, so that marginal cost is the change in total system cost relative to a small change in total system capacity or energy.

III. Marginal Cost Theory

Marginal cost is defined as an infinitesimal change in total cost with respect to an infinitesimal change in output. Mathematically, marginal cost can be represented as the partial derivative of total cost to output, and can be stated as follows:

$$MC = \frac{\partial C}{\partial q}$$

where

MC	=	Marginal Cost
$\partial \mathrm{C}$	=	Infinitesimal change in Total Cost
$\partial \mathrm{q}$	=	Infinitesimal change in Output

In the context of discrete cost and output, marginal cost can be *estimated* as follows:

$$MC = \frac{\Delta C}{\Delta q}$$

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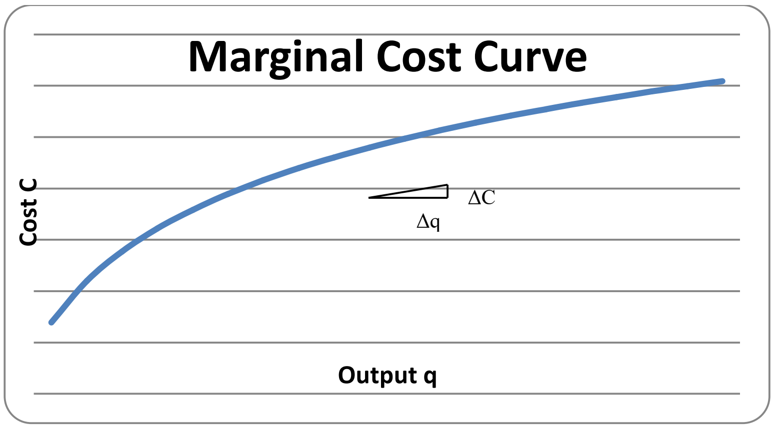
where

MC	=	Marginal Cost
ΔC	=	Change in Total Cost
Δq	=	Change in Output

Graphically, the marginal cost is the slope of the line resulting from the graph of the total cost C and the total output q, as shown in Figure 1.

Figure 1. Cost vs. Output Curve



In the figure, "output" refers to total megawatts of capacity or megawatt-hours of energy required, so that marginal cost is the change in total system cost relative to a small change in total system output.

IV. Application of Marginal Cost Theory to Big Rivers

The application of Marginal Cost theory here is influenced by Big Rivers' present resource acquisition plans.

Big Rivers explained its current net capacity position and future net capacity position in a recent filing with the Commission. In Case No. 2021-00079, Big Rivers requested a certificate of public convenience and necessity ("CPCN") to convert Big Rivers' two existing coal-fired generating units at its Robert D. Green generating station ("Green Station") to run on natural gas.[1]

Big Rivers owns and operates the Green Station, the Robert A. Reid Plant ("Reid Station"), and the D.B. Wilson Plant ("Wilson Station"). Big Rivers retired the Reid 1 coal-fired generating unit and the three coal-fired generating units at its Kenneth C. Coleman Plant ("Coleman Station") in September 2020. With the retirement of Reid 1 and Coleman Station, Big Rivers' total power capacity is 1,114 MW. The additional 260 MW of power capacity from the three solar Power

[1] *See In The Matter Of: Electronic Application Of Big Rivers Electric Corporation For A Certificate Of Public Convenience And Necessity Authorizing The Conversion Of The Green Station Units To Natural Gas-Fired Units And An Order Approving The Establishment Of A Regulatory Asset*, Case No. 2021-00079, February 28, 2021.

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Purchase Agreements ("Solar PPAs") that the Commission recently approved will bring Big Rivers' total generation resources to 1,374 MW once the solar facilities are operational by 2024.[2]

Big Rivers' Member peak demand requirement is approximately 627 MW. The Commission recently approved Big Rivers' and Meade County RECC's joint request in Case No. 2019-00365 for approval of contracts to provide electric service to a new steel mill in Bradenburg, Meade County, Kentucky, to be owned and operated by Nucor Corporation ("Nucor"). Big Rivers' Member peak demand requirements are projected to increase from [redacted] in 2020 to [redacted] in 2022 with the addition of the Nucor load and then grow slowly to about [redacted] (including transmission losses) by the summer of 2039.[3] These amounts do not include any Planning Reserve Margins ("PRMs"), which are established at 9 percent for planning purposes.

However, Big Rivers must cease coal-fired generation at Green Station by June 1, 2022, in order to meet the October 31, 2023, deadline for the closure of the Green Station ash pond. Big Rivers idling Green Station's coal fired units [redacted] even after the Solar PPAs are added and after the termination of the Owensboro Municipal Utilities ("OMU") and Kentucky Municipal Energy Agency ("KyMEA") agreements. Post Green Station conversion, there is a small short-term capacity deficit even with the new solar contracts.

The conversion of the Green units to natural gas will provide Big Rivers over 90% of the capacity it needs through owned generation and long-term PPAs to serve its native load and to satisfy its obligations under its power sales contracts with OMU and KyMEA. Big Rivers will hedge the remaining small capacity deficit with market capacity purchases.[4]

With the conversion of the Green Station units to natural gas, Big Rivers anticipates no base load or peaking capacity additions to meet its native load requirements over the next 10 years.

The key point of this review is that Big Rivers' plan to convert the Green Station units to natural gas is the only resource acquisition anticipated to meet incremental load requirements over the next decade.

V. Marginal Production Demand Cost

The marginal demand costs for production are the changes in capacity costs associated with serving changes in demand on the electric system.

Recall that marginal cost is broadly defined as the change in total cost with respect to a small change in output--so that marginal cost is the change in total system capacity cost relative to a small change in total system demand.

Marginal production demand cost and its calculation is best looked at from the perspective of the electrical system utility planner. The planner begins by developing a schedule of resource

[2] See *In the Matter of: Electronic Application of Big Rivers Electric Corporation for Approval of Solar Power Contracts, P.S.C. Case No. 2020-00183*, Order (Sept. 28, 2020). Big Rivers also maintains seven small solar arrays for educational purposes, which generate a combined 165,000 kWh each year.
[3] Big Rivers 2020 IRP at page 49-50 and Table 3.4 (September 21, 2020).
[4] Case No. 2021-00079, Application Exhibit A, Direct Testimony of Michael T. Pullen, Page 9.

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acquisitions which allows the utility to meet its forecasted demand obligations. The planner then must address how any incremental demand will be met. Perhaps most often, anticipated additional demand is met by taking the existing plan for generation expansion and accelerating it.[5]

Ordinarily, to evaluate the change in capacity costs, a base case is defined that specifies the capacity (and associated capacity cost) required to meet Big Rivers' base demand forecast for the planning period. Other scenarios are then developed in which the total system demand is increased by set increments, and the capacity acquisitions required to meet those incremental demands are determined. The net present value of the capacity costs in the base case is then compared to the net present value of the capacity costs for the incremental cases to determine the change in capacity cost associated with the change in total system demand. This is known as the Generation Resource Plan Expansion Method. [6]

In this case, Big Rivers' current resource plans consist only of the conversion of Green to natural gas. Thus, the marginal production demand cost is the capacity cost of the Green conversion as specified in the Green Conversion docket, or $3.80 per kW per month.

VI. Marginal Production Energy Cost

Marginal energy cost refers to the change in costs of operating and maintaining the utility generating system in response to a change in customer usage. Marginal energy costs consist of incremental fuel or purchased power costs and variable operation and maintenance expenses incurred to meet the change in customer usage.[7]

In this instance, the marginal production energy cost is derived from the projection of total system costs for Big Rivers included in the Green Conversion docket. The same seven year period used to determine the marginal production capacity cost with non-firm gas is used to determine the average annual energy cost. The annual energy cost increases from [redacted] The average of the energy costs over this period is [redacted]. Note the energy costs under the firm gas scenario is considerably lower, ranging from [redacted], with an average [redacted]

Based on the more conservative value consistent with the marginal production demand costs, the marginal production energy cost per kWh of additional energy [redacted]

VII. Marginal Transmission Cost

Recall that marginal costs are defined as the change in total cost with respect to a small change in output. For discrete costs and output, the formula is:

$$MC = \frac{\Delta C}{\Delta q}$$

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[5] Charles J. Cicchetti, et al, *The Marginal Cost and Pricing of Electricity: An Applied Approach* (Cambridge, MA: Ballinger Publishing Co., 1977), 8.
[6] NARUC Electric Utility Cost Allocation Manual (Washington, DC: NARUC, January 1992), 117.
[7] *Id* at 110.

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where

MC = Marginal Transmission Cost
ΔC = Change in Total Cost of Transmission Plant
Δq = Change in system demand

Here again the current state of Big Rivers capacity and load must be considered. The Big Rivers system is currently designed to accommodate a peak load higher than that which Big Rivers anticipates through the long term planning horizon. The system was designed to accommodate supply from the Coleman Station and Reid Station that have since retired. The system was also designed to handle supply from Green Station operating on coal; with its conversion to gas-fired units, Green Station is expected to experience a capacity reduction from 454 MW to 414 MW. [8]

For this reason, any small incremental load addition will not automatically create a need for incremental plant investment.

It is possible that the particular siting of an incremental load could create transmission reliability or stability issues for Big Rivers for which investment is required. This may be characterized as a "local" issue which Big Rivers would work with the customer to resolve. Local issues of this nature are not pertinent to the calculation of an overall, system-wide marginal transmission cost.

For these reasons, Big Rivers' marginal transmission costs are effectively zero.

VIII. Summary

The marginal costs for Big Rivers for Production Demand, Production Energy, and Transmission for 2016 are summarized below.

#	Item	Amount
1	Marginal Production Demand Cost ($/kW-month)	3.80
2	Marginal Production Energy Cost ($/kWh)	0.04108
3	Marginal Transmission Cost ($/kW-month)	0.00

[8] Green Conversion docket, Application Page 6.

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Exhibit Wolfram 2

IX. Resources

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3) Metin Celebi and Philip Q Hanser, *Marginal Cost Analysis in Evolving Power Markets,* Energy 2010 Issue 02 (Cambridge, MA: The Brattle Group, 2010).

4) Charles J. Cicchetti, et al, *The Marginal Cost and Pricing of Electricity: An Applied Approach* (Cambridge, MA: Ballinger Publishing Co., 1977).

5) Kenneth Gordon and Wayne P. Olsen, *Retail Cost Recovery and Rate Design in a Restructured Environment* (Washington DC: Edison Electric Institute, 2004).

6) Alfred E. Kahn, *The Economics of Regulation: Principles and Institutions* (Cambridge, MA: MIT Press, 1988), pp. 67-86.

7) Jonathan A. Lesser and Leonardo R. Giacchino, *Fundamentals of Energy Regulation, 2nd Edition* (Arlington, VA: Public Utilities Reports, Inc., 2013), p. 418.

8) National Association of Regulatory Utility Commissioners, *Electric Utility Cost Allocation Manual* (Washington DC: NARUC, 1992) pp. 108-119.

9) Hethie Parmesano and William Bridgman, *The Role and Nature of Marginal and Avoided Costs in Ratemaking: A Survey* (National Economic Research Associates, Inc., 1992), pp 3-6.

10) Charles E. Phillips, *The Regulation of Public Utilities: Theory and Practice, 2nd Edition* (Arlington, VA: Public Utilities Reports, Inc., 1988), pp. 418-425.

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Rate Comparison

	Usage			Marginal Cost				Discount	Comparison	
				3.80	[redacted]					
#	Period	Demand (MW)	Energy (MWH)	Demand ($)	Energy ($)	Total ($)	Total Rate ($/kWh)	Discounted Rate ($/kWh)	Disc less Marg Rate ($/kWh)	Disc > Marg?
1	2023	[redacted]								Yes
2	2024									Yes
3	2025									Yes
4	2026									Yes
5	2027									Yes
6	2028									Yes
7	2029									Yes
8	2030									Yes
9	2031									Yes
10	2032									Yes