

GRANT AGREEMENT

RIVERSIDE PUBLIC UTILITIES ENERGY INNOVATIONS GRANT PROGRAM

(Optimal Placement of Smart Meters to Improve Efficiency and Reliability of Power Distribution Systems)

THIS AGREEMENT is made and entered into this ____ day of _____, 2019, by and between the CITY OF RIVERSIDE, a California charter city and municipal corporation ("City"), through its Department of Public Utilities ("RPU"), and THE REGENTS OF THE UNIVERSITY OF CALIFORNIA, ON BEHALF OF ITS RIVERSIDE CAMPUS, a California non-profit corporation ("Recipient"), with reference to the following:

RECITALS

WHEREAS, California Public Utilities Code ("Code") Section 385 provides that a local publicly-owned utility shall establish a non-bypassable, usage-based charge on local distribution service to fund investments by the utility and other parties in (1) cost-effective, demand-side, management services to promote energy-efficiency and energy conservation; (2) new investment in renewable energy resources and technologies consistent with existing statutes and regulations which promote those resources and technologies; (3) research, development, and demonstration programs for public interest to advance science or technology which is not adequately provided by competitive and regulated markets; and (4) services provided for low-income electricity customers, including but not limited to, targeted energy efficiency and rate discounts; and

WHEREAS, RPU has funds available pursuant to the requirements of Code Section 385 for the purpose of providing financial funding to its public and private post-secondary educational institution electric customers, whose primary activities are within the city limits of Riverside, for the purpose of promoting the development and demonstration of energy efficiency, energy conservation, and investment in the advancement of renewable resource technology hereinafter referred to as the Energy Innovations Grant Program (the "Program"); and

WHEREAS, Recipient has submitted its Application and Proposal to RPU requesting funding from RPU's 2018-2019 Program, as set forth in Code Section 385 (the "Proposal"); and

WHEREAS, following screening by the RPU Program Committee and recommendation by the Board of Public Utilities and the City Council of the City of Riverside ("City Council"), the "Optimal Placement of Smart Meters to Improve Efficiency and Reliability of Power Distribution Systems" project ("Grant Project") was selected for funding.

NOW, THEREFORE, in consideration of the mutual covenants herein set forth and the mutual benefits to be derived therefrom, the City and Recipient mutually agree as follows:

1. Grant Award. City hereby allocates to Recipient the amount of \$100,000 (the "Grant") for development and implementation of Recipient's Grant Project, for the purpose and subject to the terms hereinafter set forth. The Grant funds ("Grant Funds") will be paid from available RPU Program funds for the fiscal year 2018-2019.

2. Scope of Services. The Grant Funds shall be used in furtherance of the purposes set forth in Code Section 385 to develop and implement the Grant Project as more fully set forth in Recipient's Proposal attached hereto as Exhibit "A" and incorporated herein by this reference.

3. Independent Contractor.

a. Recipient is a California corporation and an electric customer whose primary activities are within the city limits of Riverside. All acts of Recipient and all others acting on behalf of Recipient relating to the performance of this Agreement shall be performed as independent contractors and not as agents, officers, or employees of City. Recipient, by virtue of this Agreement, has no authority to bind or incur any obligation on behalf of City. Recipient has no authority or responsibility to exercise any rights or power vested in City. No agent, officer, or employee of City is to be considered an employee of Recipient. It is understood by both Recipient and City that this Agreement shall not under any circumstances be construed or considered to create an employer-employee relationship or a joint venture.

b. Recipient is, and at all times during the term of this Agreement shall represent and conduct itself as, an independent contractor and not as an employee of City.

c. Recipient shall design, develop, and implement the Grant Project in its entirety. Recipient shall be responsible to City only for the requirements and results specified in the Proposal and, except as expressly provided in this Agreement, shall not be subjected to City's control with respect to determination of the Grant Project, selection of materials or the methods for

completion. However, Recipient agrees to be responsible to City for all of the foregoing with respect to the Proposal and description of the Grant Project under this Agreement.

d. If necessary, Recipient has the responsibility for employing other persons or firms at its sole cost to assist Recipient in fulfilling the terms and obligations under this Agreement.

e. If, in the performance of this Agreement, any third persons are employed by Recipient, such persons shall be entirely and exclusively under the direction, supervision, and control of Recipient. All terms of employment including hours, wages, working conditions, discipline, hiring, and discharging or any other term of employment or requirements of law shall be determined by Recipient.

f. It is understood and agreed that as an independent contractor and not an employee of City, neither Recipient nor Recipient's assigned personnel shall have any entitlement as a City employee, right to act on behalf of the City in any capacity whatsoever as an agent, or ability to bind the City to any obligation whatsoever.

g. It is further understood and agreed that Recipient must issue W-2 or other tax forms as required by law for income and employment tax purposes for all of Recipient's assigned personnel under the terms of this Agreement.

h. As an independent contractor, Recipient hereby indemnifies and holds City harmless from any and all claims that may be made against City based upon any contention by any third party that an employer-employee relationship exists by reason of this Agreement.

4. Effective Date and Funding of Grant.

a. This Agreement shall commence upon the date of its execution ("Effective Date") and shall terminate twelve (12) months from the date of Grant Project Initiation, as defined in Section 4.b ("Termination Date"), unless extended pursuant to Section 4.c or Section 6.

b. City shall provide Recipient the Grant Funds in three installments in accordance to the Milestone Schedule below. Recipient must achieve each Milestone Deliverable on or prior to the corresponding Milestone Date to be eligible for funding:

Milestones	Quarter 1			Quarter 2			Quarter 3			Quarter 4			Grant Funds
	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	
Objective 1 – Identify key use cases of smart meter data for RPU; and analyze and summarize business values and technical requirements of smart meter data-driven applications													\$33,333
Objective 2 – Identify and determine optimal placement of smart meter data-driven application													\$33,333
Objective 3 – Recommend location of smart meters that can maintain reasonably optimal characteristics for most of the applications													\$33,334

c. If Recipient fails to achieve any one Milestone by the applicable Milestone Date therefor, Recipient shall immediately notify City of such failure and may request a Cure Period of up to thirty (30) days to achieve the missed Milestone. The requested Cure Period must be approved by City, and such approval shall not be unreasonably withheld, delayed or conditioned. For the avoidance of doubts, each Milestone Date in the Milestone Schedule may be extended by a maximum of thirty (30) days, and without prejudice to City's rights to terminate this Agreement under Section 20, all Milestone Dates subsequent to the missed Milestone Date as well as the Termination Date of this Agreement shall be extended accordingly on a day-to-day basis, *provided* that in no event shall the Termination Date of this Agreement be later than August 31, 2020.

- d. The Grant Funds check will be issued to Recipient as named in Exhibit "A."
- e. City reserves the right, in its discretion, to award a portion of the requested Grant Funds.

5. Performance.

a. Recipient shall perform in accordance to the Milestone Schedule in Section 4.b. Failure to promptly commence work and/or diligently pursue such work to completion may be grounds for termination of this Agreement.

b. Recipient shall be responsible to begin, proceed with, and complete the Grant Project according to the Milestone Schedule in Section 4.b and quarterly tasks completion deadline as set forth in the Project Timeline included in the Proposal.

c. For the Term of this Agreement, Recipient shall make its facility available for City's inspection of the Grant Project any time upon City's request.

d. If Recipient fails to meet a Milestone listed in the Milestone Schedule in Section 4.b by the end of the requested Cure Period, City may, at its sole discretion, terminate this Agreement pursuant to Section 19.a. In the event of such termination, Recipient agrees to return all previously released Grant Funds back to City within five (5) days of receipt of City's written termination notice.

e. Releasing of Grant Funds for the following Milestones will depend on Recipient meeting certain performance criteria detailed in Performance Standards attached hereto as Exhibit "D" and incorporated herein by this reference:

- i) Objective 1
- ii) Objective 2
- iii) Objective 3
- iv) Final Report

6. Extension. This Agreement may be extended from time to time, with mutual consent from both Parties, by quarterly increments following the completion of Quarterly Report II, *provided*, such extension shall be agreed upon, along with new Milestones for the duration of the extension, sixty (60) days prior to the original Termination Date.

7. Project Budget.

a. Recipient hereby certifies and agrees that the Grant Funds it receives shall be used entirely as set forth in the Project Budget attached hereto as Exhibit "B" and incorporated herein by this reference ("Budget").

b. The Grant Funds represents the City's total contribution to the Grant Project.

c. Recipient agrees that any amounts required to complete the Grant Project over and above the Grant Funds will be paid by Recipient.

d. Recipient agrees funds over and above the Grant are available so as not to delay completion of the Grant Project due to insufficient Project funding.

e. Recipient agrees to keep within the Budget, and any variations from the Budget will be reported to RPU.

f. Recipient agrees to pay for all costs necessary to operate and maintain the Grant Project for the term of this Agreement.

g. Recipient agrees to pay for all costs necessary to operate and maintain the Grant Project for the term of this Agreement.

8. Use of Grant.

a. The Grant Funds shall be used exclusively for costs of the Grant Project as set forth in the Proposal and the Budget.

b. Grant Funds shall not be used for any other purpose, including within limitation:

(i) As security or to guarantee payments for any non-Program obligations, nor as loans for non-Program activities; or

(ii) To pay for entertainment, meals, or gifts.

9. Intellectual Property Provisions. Recipient and RPU agree that all patents, software and copyrightable material shall be subject to the Intellectual Property Provisions attached hereto as Exhibit "C" and incorporated herein by this reference.

10. No Assignment or Transfer of Grant Funds. The Grant Funds are personal to Recipient, based upon the unique qualification of Recipient set forth in the Proposal and are for the purpose of accomplishing the goals set forth in the Proposal. Recipient shall not assign any right or obligation under this Agreement, and any such purported Assignment shall be void *ab initio*.

11. Transfer of Project Equipment.

a. For any Grant Proposal that provides for the development, purchase, or installation of equipment paid for in whole or in part by Grant Funds:

(i) Recipient shall install and operate the equipment only at Recipient's business location within City's utility service territory; and

(ii) Recipient shall not remove or transfer any equipment developed, purchased, or installed, in whole or in part, with Grant Funds within five (5) years of the Effective Date, without the express written consent of City. City reserves the right to withhold such consent.

b. Recipient agrees that if it removes or transfers such equipment without City's consent as required herein, Recipient shall reimburse City the costs of equipment purchased, developed, or installed by Grant funding, proportionately as follows:

(i) Transfer or removal within first year from Effective Date—100%

(ii) Transfer or removal within second year from Effective Date—80%

(iii) Transfer or removal within third year from Effective Date—60%

(iv) Transfer or removal within fourth year from Effective Date—40%

(v) Transfer or removal within fifth year from Effective Date—20%

12. Final Report. Recipient shall prepare and submit to City a final report on or prior to the Termination Date. The final report shall include: title page, introduction and background, project objectives, project performance, project expenses (including receipts) and project time line, conclusions, and recommendations.

13. Interim Grant Project Changes. Recipient shall promptly notify City in writing of any and all proposed Grant Project changes. Grant Project changes must be pre-approved by RPU and must be consistent with the purpose and scope of the Grant Project. A detailed description of Grant Project changes and impacts to the project schedule and/or Budget must be provided to RPU and approved prior to any changes to all or part of the Grant Project.

14. Program Monitoring.

a. Recipient shall maintain financial, programmatic, statistical, and other supporting records of the Grant Project feasibility study, design, development, installation, implementation and purchase of equipment. In addition, Recipient shall prepare and maintain the following records and reports to assist City in maintaining its record keeping requirements:

- (i) Documentation of Grant Project expenses;
- (ii) Quarterly progress reports on Grant Project deadlines as defined in Proposal; and
- (iii) Any other related records and reports as City shall require from time to time.

b. Failure to keep and provide such records and reports may result in demand for return of Grant Funds to City.

15. Audits.

a. The Recipient's records in connection with the Grant Project shall be open to inspection and audit by an authorized City representative.

b. Said records shall be retained for no less than three (3) years after completion of the Grant Project.

c. Records which relate to (i) complaints, claims, administrative proceedings, or litigation arising out of the performance of this Agreement; or (ii) costs and expenses of this Agreement to which City or any other governmental agency takes exception, shall be retained beyond the three (3) years until resolution or disposition of such appeals, litigation claims, or exceptions.

16. Taxes and License. Recipient understands and agrees that City has no obligation to pay or withhold state or federal taxes or to provide workers' compensation or unemployment insurance. Recipient, as an independent contractor, shall be responsible for any and all taxes that apply to it as an employer.

17. Publicity. The City acknowledges that the name "University of California" is the property of the State of California and that City's use of the name "University of California" must also comply with section 92000 of the California Education Code. Recipient agrees to cooperate with the City in publicizing, advertising, or otherwise promoting the Program or Grant Project in accordance with the California Education Code section 92000.

18. General Compliance with Laws. Recipient shall keep fully informed of federal, state, and local laws and regulations which in any manner affect the performance of services by Recipient pursuant to this Agreement and shall at all times observe and comply with all such laws and regulations.

19. Non-Discrimination. Except as provided in Section 12940 of the California Government Code, during Recipient's performance of this Agreement, Recipient shall not discriminate on the grounds of race, religious creed, color, national origin, ancestry, age, physical disability, mental disability, medical condition including the medical condition of Acquired Immune Deficiency Syndrome (AIDS) or any condition related thereto, marital status, sex or sexual orientation, genetic information, gender, gender identity, or gender expression, in the selection and retention of employees and subcontractors and the procurement of materials and equipment. Contractor shall also comply with the requirements of the Americans with Disabilities Act in the performance of the Agreement.

20. Termination.

a. In the event of a substantial failure of performance by Recipient, City may terminate this Agreement upon a ten (10) day written notice to Recipient. The ten-day notice period shall be used by both parties in an attempt to negotiate resolution of disputes and remedy any breach.

b. In the event of a material breach of this Agreement by Recipient, City may terminate this Agreement and Recipient agrees to refund the Grant Funds to City within five (5) days of receipt of the City's written notice of such termination. Recipient agrees that any of the following, individually or collectively, shall be conclusively deemed a material breach or breaches of the Agreement:

(i) Recipient's fraudulent misrepresentation as to Recipient's use of the Grant Funds or as to any material matter in the Grant application and Proposal;

(ii) Delay in beginning, development, or completion of the Grant Project without written approval of extensions by RPU's General Manager; or

(iii) Substantial changes in the Grant Project or use of Grant Funds.

21. Contract Administration. A designee of City will be appointed in writing by City's Public Utilities General Manager to administer this Agreement on behalf of City and shall be referred to herein as Contract Administrator.

22. Certifications. Recipient certifies to City that Recipient will select equipment or products on the basis of Recipient's own investigation including without limitation as to the effectiveness, merchantability, and fitness of the equipment or products for the Grant Project and that Recipient has not relied on any statement by City or an agent of City in making such selection.

23. Amendments. This Agreement may be modified or amended only by a written agreement executed by the City and Recipient.

24. Venue. Any action at law or in equity brought by either of the parties hereto for the purpose of enforcing a right or rights provided for by this Agreement shall be tried in a court of competent jurisdiction in the County of Riverside, State of California, and the parties hereby waive all provisions of law providing for a change of venue in such proceedings to any other county.

25. Notices. Service of any notices, bills, invoices, or other documents required or permitted under this Agreement shall be sufficient if sent by one party to the other by United States mail, first class postage prepaid and addressed as follows:

City of Riverside

City of Riverside
Department of Public Utilities
3750 University Avenue
Riverside, CA 92501
Attention: RPU General Manager

Recipient

University of California, Riverside
Office of Research and Economic Development
200 University Office Building
Riverside, CA 92521-0217
Attn: Robert Chan,
Principal Contract & Grant Officer

Either party may change such address by giving notice to the other party in writing herein.

26. Assignment. It is mutually understood and agreed that this Agreement shall not be assigned to any third party by either City or Recipient.

27. Severability. Each provision, term, condition, covenant, and/or restriction, in whole and in part, in this Agreement shall be considered severable. In the event any provision, term, condition, covenant, and/or restriction in this Agreement is declared, in whole and/or in part, invalid, unconstitutional, or void for any reason, such provision or part thereof shall be severed from this Agreement and shall not affect any other provision, term, condition, covenant, and/or restriction of this Agreement, and the remainder of the Agreement shall continue in full force and effect.

28. Authority. The individuals executing this Agreement and the instruments referenced herein on behalf of Recipient each certifies that they have the legal power, right, and actual authority to bind Recipient to the terms and conditions hereof and thereof.

29. Entire Agreement. This Agreement constitutes the final, complete, and exclusive statement of the terms of the agreement between the parties pertaining to the subject matter of this

Agreement and supersedes all prior and contemporaneous understandings or agreements of the parties. Neither party has been induced to enter into this Agreement by, and neither party is relying on, any representation or warranty outside those expressly set forth in this Agreement.

30. Exhibits. The following exhibits attached hereto are incorporated herein to this Agreement by this reference:

Exhibit "A" – Recipient's Proposal

Exhibit "B" – Project Budget

Exhibit "C" – Intellectual Property Provisions

Exhibit "D" – Performance Standards

[SIGNATURES ON FOLLOWING PAGE.]

IN WITNESS WHEREOF City and Recipient have caused this Agreement to be duly executed on the day and year first above written.

CITY OF RIVERSIDE, a California
charter city and municipal corporation,
through its Department of Public Utilities

THE REGENTS OF THE UNIVERSITY
OF CALIFORNIA, ON BEHALF OF ITS
RIVERSIDE CAMPUS, a California non-
profit corporation

By: _____
City Manager

Attest: _____
City Clerk

Approved as to Form:

By: Susan Wilson
Assistant City Attorney

By: Robert Chan
Its: 6/20/2019
Robert Chan
Pr. Contract 3 Grant officer
By: N/A
Its: _____

CERTIFIED AS TO FUNDS AVAILABILITY:

BY: Marie Piri
ASSISTANT CHIEF FINANCIAL OFFICER

EXHIBIT "A"
RECIPIENT'S PROPOSAL

Cover Sheet for Limited Submission Internal Review

Sponsoring Agency: Riverside Public Utilities
Division/Directorate: _____
Program Name: Energy Innovation Grant
UCR Deadline: 2019/01/04
Agency Deadline: _____

Proposal Title: Optimal Placement of Smart Meters to Improve Efficiency and Reliability of Power Distribution Systems
Project Period: 2019/08/01 to 2020/07/31
Amount Requested (total project): \$100000
Matching Funds Requested: \$
(indicate source of any commitments) _____

Investigators (list Principal Investigator first)

Name/Title	Department	Email
Nanpeng Yu/Assistant Professor	Electrical and Computer Engineering	nyu@ece.ucr.edu
Sadrul Ula/Managing Director and Research Faculty	CE-CERT	sula@cert.ucr.edu
Weixin Yao/Associate Professor	Statistics	weixin.yao@ucr.edu

Checklist:

- ☒ **This Completed Cover Sheet**
- ☒ **Narrative: 3 pages max. in 12-point font. Please summarize project Specific Aims/Intellectual Merit/Goals and agency priorities, e.g. outreach, evaluation, organizational structure.**
- ☒ **Attach: One-page summary budget**
- ☒ **Attach: CV/biosketch for each investigator listed above (2 page max. each)**
- ☒ **Attach: Any agency reviews of prior submissions**
- ☒ **Attach: PI/Co-PI funding histories with agency**
- ☒ **Please send your completed application as one document in PDF format.**

Submit to: limitedsubmissions@ucr.edu

**Research and Economic Development
200 University Office Building
Phone: (951) 827-5535**

Optimal Placement of Smart Meters to Improve Efficiency and Reliability of Power Distribution Systems

1. Executive Summary

The advanced metering infrastructure (AMI) collects and transmits smart meter data, on hourly intervals for residential customers and 5 to 15-minute intervals for commercial and industrial customers. This can result in at least a 3,000 fold increase in the amount of data utilities would have processed in the past. The primary and secondary value imbedded in the smart meter data sets is immense [1]. However, due to limited operating budgets and long remaining life of legacy electric meters, a utility may decide to perform only a partial deployment of smart meters. In this case, it is crucial for the utility to strategically determine the locations of smart meters that can maximize their return on investment.

This project develops a smart meter placement strategy, which will allow Riverside Public Utilities (RPU) to determine the optimal locations for their electric smart meters. Specifically, the strategy will consider multiple crucial AMI applications such as 1) behind-the-meter solar photovoltaic (PV) estimation and forecasting [2]; 2) distribution network topology identification [3-5]; 3) distribution system equipment predictive maintenance [6]; 4) distribution network state estimation and forecasting [7]; 5) anomaly detection/electricity theft detection [8]; 6) customer voltage quality evaluation; 7) conservation voltage reduction [9]; 8) fault detection and location; 9) load diversification estimation; and 10) demand response estimation [10].

The optimal smart meter placement strategy for each individual application will first be developed following well developed methodologies outlined in [2-10]. Then an overall smart meter placement strategy, which considers both the technical and economic aspects of the applications will be developed using a statistically based approach that attempts to optimize the objective functions of the multiple applications across a single placement strategy. The overall scope of the project and major groups of smart meter applications are depicted in Figure 1. This real-world case study project will leverage RPU's distribution system information to determine the optimal placement of approximately 14,000 residential smart meters across the city.

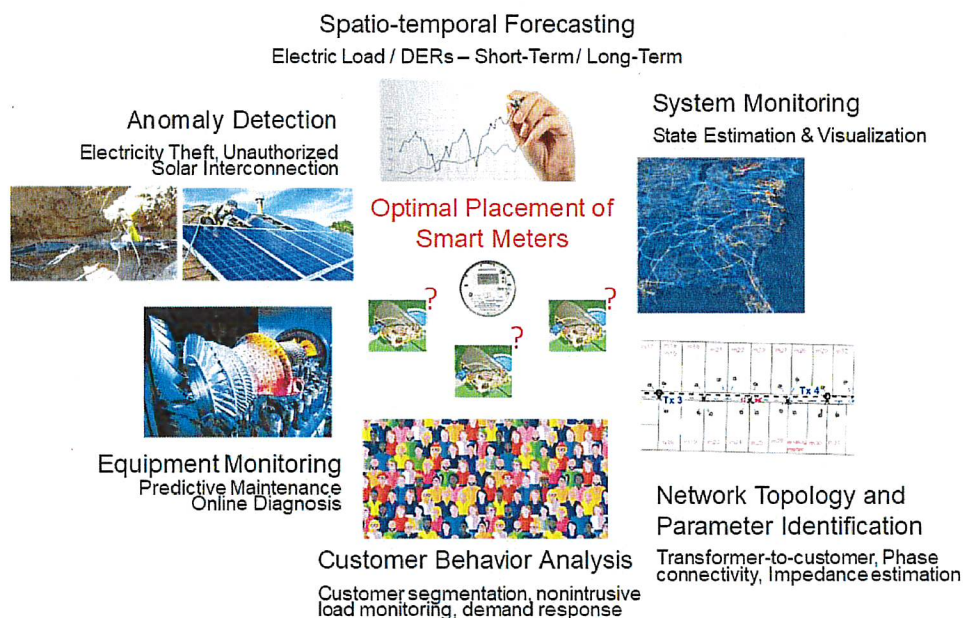


Figure 1: Overall scope and major groups of smart meter applications.

2. Project Description and Innovation

The proposed research addresses the challenge of determining the optimal location of smart meters in power distribution systems. In this project, we will first identify the key data-driven applications which can be accomplished with the help of smart meter data. The business values and technical requirements of each data-driven application will be analyzed and summarized. The optimal placement of smart meters for each application will then be determined and identified. Finally, the location of smart meters which can maintain reasonably optimal characteristics for most of the applications will be recommended. The important big data applications based on smart meters are described below.

Spatial-temporal Load and Renewable Energy Estimation/Forecasting: The net loads recorded by smart meters can be used to estimate solar PV generation and perform spatio-temporal electric load forecast. Preventive Equipment Maintenance: The voltage magnitude and real power measurements from smart meter can serve as features to estimate the probability for failure to equipment such as transformers. System Monitoring: The voltage and load measurements from smart meters can be used to estimate and/or forecast the states of the power distribution system. Customer Behavior Analysis: Smart meter measurements can be leveraged to evaluate the load impact from demand response and conservation voltage reduction programs and to segment the customers. Anomaly Detection: Smart meter data can be used to detect anomalies such as electricity theft, isolate faults, and detect illegal solar PV interconnections.

3. Benefits to RPU and Its customers

The proposed project will provide significant practical benefits and value to RPU and its customers in multiple ways. First, developing an optimal strategy for the placement of smart meters allows for the collection of data to be more effectively used in many data-driven analytics, which can significantly improve the efficiency, reliability and operations of the power distribution system. Second, the mining and analysis of optimally gathered smart meter data can be more quickly and effectively used to develop programs that improve customer satisfaction and reduce electricity bills for RPU's customers. Third, the practical nature of this project will provide valuable training and learning opportunities for both RPU staff involved in the AMI roll-out and undergraduate and graduate students at UCR. This collaboration will also contribute to preparing potential workforce candidates for future employment in the field of Power Engineering at RPU. (In the past two years, three undergraduate students from Dr. Yu's power system analysis class have either interned or obtained full-time employment at RPU.)

4. Research Team and Facility

The project has a very high chance of success due to the project team's track records of relevant research works and publications in big data applications in power distribution systems with smart meter data. *Team Members and Qualifications:* The project team includes two investigators, Dr. Nanpeng Yu, Dr. Sadrul Ula, Dr. Weixin Yao, one graduate student researcher, one postdoctoral research, and one undergraduate researcher. Dr. Yu will serve as the principal investigator.

Dr. Yu is a tenure track Assistant Professor in the College of Engineering at UCR. He has over 13 years of professional experience in big data analytics with smart meter data and power distribution system analysis, and has led multiple research and development projects in both electric utility industry and academia. Dr. Yu served as project manager at Southern California Edison for an aggregated demand response project to integrate over 1 GW of demand response resources into the CAISO market. The industrial projects Dr. Yu led have resulted in millions of dollars of savings for electricity ratepayers. Dr. Yu has over 50 high quality scientific papers in prominent international journals and conferences. He won several best paper awards. Dr. Yu is

the recipient of the Regents Faculty Fellowship and Regents Faculty Development award from University of California. He is the co-chair of IEEE big data analytics in distribution system working group. Dr. Yu offers four undergraduate and graduate level courses in power engineering at UCR. Dr. Weixin Yao is an associate professor in the Department of Statistics from UCR. Dr. Yao specializes in high-dimensional data analysis and predictive analytics in energy systems. Dr. Sadrul Ula is the managing director and research faculty at Center for Environmental Research & Technology.

Facilities, Infrastructure and Resources Available to the Team: Each investigator has a 650 square feet research laboratory equipped with state-of-the-art computing hardware and software. The students in this research project will be assigned a workstation space in the lab, with desktop computer and access to the UCR Grid Portal with 65 computation nodes. In addition, the research group has access to the Oracle Big Data appliance, which has 216 cores, 48 TB of high capacity SAS disks, with 768 GB of DDR4 memory. It combines the newest technologies from the Hadoop ecosystem and powerful Oracle SQL.

Funding Amount: \$100,000 to support all distribution system data gathering and analysis activities, development of project deliverables, and undergraduate/graduate student support.

5. Reference

- [1] Nanpeng Yu, Sunil Shah, Raymond Johnson, Robert Sherick, Mingguo Hong and Kenneth Loparo, "Big Data Analytics in Power Distribution Systems", IEEE PES Conference on Intelligent Smart Grid Technology, Washington DC, Feb. 2015.
- [2] Wenyu Wang, Nanpeng Yu, and Raymond Johnson "A Model for Commercial Adoption of Photovoltaic Systems in California," Journal of Renewable and Sustainable Energy, Vol. 9, Issue. 2, pp. 1-15, 2017.
- [3] Wenyu Wang, Nanpeng Yu, Brandon Foggo, and Joshua Davis, "Phase Identification in Electric Power Distribution Systems by Clustering of Smart Meter Data," 15th IEEE International Conference on Machine Learning and Applications (ICMLA), pp. 1-7, Anaheim, CA, 2016.
- [4] Wenyu Wang and Nanpeng Yu, "AMI Data Driven Phase Identification in Smart Grid," the Second International Conference on Green Communications, Computing and Technologies, Rome, Italy, Sep. 2017.
- [5] Brandon Foggo, Nanpeng Yu, and Wenyu Wang, " A Comprehensive Evaluation of Supervised Machine Learning for the Phase Identification Problem," in the 20th International Conference on Machine Learning and Applications, pp.1-9, Copenhagen, Denmark, 2018.
- [6] Farzana Kabir, Brandon Foggo, and Nanpeng Yu, " Data Driven Predictive Maintenance of Distribution Transformers," in the 8th China International Conference on Electricity Distribution, pp. 1-5 2018.
- [7] Yuanqi Gao and Nanpeng Yu, "State Estimation for Unbalanced Electric Power Distribution Systems Using AMI Data," The Eighth Conference on Innovative Smart Grid Technologies (ISGT 2017), pp. 1-5, Arlington, VA.
- [8] Yuanqi Gao, Brandon Foggo, and Nanpeng Yu "A Physically Inspired Data-Driven Model for Electricity Theft Detection with Smart Meter Data," submitted to IEEE Transactions on Industrial Informatics, 2018.
- [9] Jinhui Yang, Nanpeng Yu, Weixin Yao, Alec Wong, Larry Juang, and Raymond Johnson, "Evaluate the effectiveness of Conservation Voltage Reduction with Robust Regression," in 2018 Probabilistic Methods Applied to Power Systems, pp.1-6, 2018.
- [10] Xiaoyang Zhou, Nanpeng Yu, Weixin Yao and Raymond Johnson, "Forecast Load Impact from Demand Response Resources," IEEE Proceedings, Power and Energy Society General Meeting, pp. 1-5, Boston, USA, 2016.

Summary Budget

Graduate Student Support: \$35,000

Postdoctoral Researcher Support: \$30,000

Undergraduate Student Support: \$5,000

Faculty Summer Support: \$30,000

Total Requested Funding: \$100,000

PI/Co-PI Funding History with Agency

Dr. Ula, Co-PI

RPU Project Title: Monitoring and Control of PVs, Battery Storage Systems, and EV Chargers at a 12 kV Industrial Feeder and Substation Level

Project Period: 03/01/2015 to 02/29/2016

PI Dr. Yu and Co-PI Dr. Yao did not receive prior funding from RPU.

Nanpeng Yu | Assistant Professor

Department of Electrical and Computer Engineering, University of California, Riverside

Phone: (951) 827-3688 | E-mail: nyu@ece.ucr.edu

Education and Training

Institution	Degree	Year	Field of Study
Tsinghua University, Beijing, China	B.E.	2006	Electrical Engineering
Iowa State University, Ames, IA	M.S.	2007	Electrical Engineering
Iowa State University, Ames, IA	Ph.D.	2010	Electrical Engineering
Iowa State University, Ames, IA	M.S.	2012	Economics

SUMMARY:

Dr. Yu is a tenure track assistant professor in the Electrical and Computer Engineering department at University of California, Riverside. He has over 13 years of professional experience in power system research, development and project management in academia and electric utility industry. Before Dr. Yu joined UCR, he held various positions at Southern California Edison including senior power system planner for renewable integration and project manager of demand response integration. He is an expert in big data analytics in power systems. He has led many research and development projects in both electric utility industry and academia. Dr. Yu served as project manager for an aggregated demand response project to integrate over 1 GW of demand response resources into CAISO market. The industrial projects Dr. Yu led have resulted in millions of dollars of savings for electricity ratepayers. Dr. Yu has over 50 high quality scientific papers in prominent international journals and conferences. He won several best paper awards including the Second International Conference on Green Communications, Computing and Technologies and IEEE Power & Energy Society General Meeting 2013, 2015. Dr. Yu is the recipient of the Regents Faculty Fellowship and Regents Faculty Development award from University of California. He is the co-chair of IEEE big data analytics in distribution system working group.

RESEARCH AND PROFESSIONAL EXPERIENCE:

University of California, Riverside

Assistant Professor | September 2014 – present

Assistant Professor, Department of Electrical and Computer Engineering

Southern California Edison

Demand Response Integration Project Manager | January 2011 – August 2014

Demand Response Integration Project Manager, Power Supply

PUBLICATIONS:

1. Nanpeng Yu, Sunil Shah, Raymond Johnson, Robert Sherick, Mingguo Hong and Kenneth Loparo, "Big data analytics in power distribution systems", *IEEE PES Conference on Intelligent Smart Grid Technology*, Washington DC, Feb. 2015.

2. Farzana Kabir, Brandon Foggo, and Nanpeng Yu, "Data driven predictive maintenance of distribution transformers," in the *8th China International Conference on Electricity Distribution*, pp. 1-5 2018.
3. Brandon Foggo, Nanpeng Yu, and Wenyu Wang, "A comprehensive evaluation of supervised machine learning for the phase identification problem," in the *20th International Conference on Machine Learning and Applications*, pp.1-9, Copenhagen, Denmark, 2018.
4. Jinhui Yang, Nanpeng Yu, Weixin Yao, Alec Wong, Larry Juang, and Raymond Johnson, "Evaluate the effectiveness of conservation voltage reduction with robust regression," in *2018 Probabilistic Methods Applied to Power Systems*, pp.1-6, 2018.
5. Wenyu Wang and Nanpeng Yu, "AMI data driven phase identification in smart grid," the *Second International Conference on Green Communications, Computing and Technologies*, Rome, Italy, Sep. 2017. Received Best Paper Award.
6. Jie Shi and Nanpeng Yu, "Spatio-temporal modeling of electric loads," *49th North American Power Symposium*, pp.1-6, Morgantown, WV, 2017.
7. Yuanqi Gao and Nanpeng Yu, "State estimation for unbalanced electric power distribution systems using AMI data," the *Eighth Conference on Innovative Smart Grid Technologies (ISGT 2017)*, pp. 1-5, Arlington, VA.
8. Wenyu Wang, Nanpeng Yu, Brandon Foggo, and Joshua Davis, "Phase identification in electric power distribution systems by clustering of smart meter data," *15th IEEE International Conference on Machine Learning and Applications (ICMLA)*, pp. 1-7, Anaheim, CA, 2016.
9. Xiaoyang Zhou, Nanpeng Yu, Weixin Yao and Raymond Johnson, "Forecast load impact from demand response resources," *IEEE Proceedings, Power and Energy Society General Meeting*, pp. 1-5, Boston, USA, 2016.
10. Farzana Kabir, Nanpeng Yu, Weixin Yao, Longtao Wu, and Jonathan Jiang, "Impact of aerosol on reservoir inflows: A case study for Big Creek hydroelectric system in California," in press, *Hydrological Processes*, 2018.

SYNERGISTIC ACTIVITIES:

- *Session Chairs* at 2014, 2015, 2017, 2018 IEEE Power and Energy Society General Meeting and 2016, 2018 IEEE PES T&D Conference and Exposition.
- Co-chair for IEEE Power and Energy Society Big Data Applications in Power Distribution Networks Task Force.
- Develop and deliver short courses on big data analytics in power distribution systems to over 100 industry professionals.
- Develop *EE Online Master program and classes with a focus on power system* at University of California, Riverside, 2015-present.
- *Best Paper Finalists and Award*: IASP 2007 (best paper award), PES General Meeting 2014 (two best paper finalists), PES General Meeting 2016 (best paper finalist), GREEN 2018 (best paper award).
- *Technical Program Committee Member / Associate Editor / Referee*
 IEEE Transactions on Smart Grid / Associate Editor
 International Transactions on Electrical Energy Systems / Associate Editor
 2017 Innovative Smart Grid Technologies / TPC Member
 2017 Intelligent System Applications to Power Systems / TPC Member
 2017 The Second International Conference on Green Communications, Computing and Technologies / TPC Member

Sadrul Ula
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EDUCATION

<u>Institute</u>	<u>Major/Area</u>	<u>Degree</u>	<u>Year</u>
University of Rajshahi	Electrical Engineering	B.S.	1968
University of Leeds	Electrical Engineering	Ph.D.	1977
Massachusetts Institute of Technology	Electrical Engineering	Post-Doctoral	1977-78

PROFESSIONAL EXPERIENCE

Sadrul Ula is the Co-Director of the Winston Chung Global Energy Center at the College of Engineering, University of California – Riverside. He is a Research Faculty at the College of Engineering - Center for Environmental Research and Technology (CE-CERT), UCR's largest multi-disciplinary research center. Prior to joining UCR, he was Professor of Electrical and Computer Engineering at the University of Wyoming for 28 years. During 2004-2005, he served as the Energy Advisor to the Governor of Wyoming – the largest energy producing and exporting state in the country.

Dr. Ula's area of expertise is electric power generation, transmission, distribution and utilization, including renewable energy integration in the grid. He was the founding director of Electric Motor Training and Testing Center at the University of Wyoming. He developed innovative methods and algorithms for demand side management using electric motors – the largest energy user as a group in the US. Over the last 4 years, he designed and implemented a number of microgrid systems including 2.2 MWh of battery energy system, 500 kW solar PV, multiple electric vehicle charging systems including supervisory control and data acquisition system.

ACADEMIC/PROFESSIONAL APPOINTMENTS

Co- Director, Winston Chung Global Energy Center (WCGEC), UC Riverside	June 2011-To date
Research Faculty, College of Engineering, University of California-Riverside	May 2010-To date
Energy Advisor to the Governor of Wyoming - Wyoming,	May 2004- Aug 2005
Professor of Electrical & Computer Engineering, University of Wyoming	Sept 1982-May 2010
Research Staff Engineer, MIT, Cambridge, Massachusetts	Nov 1978- Sept 1982

PUBLICATIONS MOST CLOSELY RELATED TO PROPOSAL

Tianshu Wei, Taeyoung Kim, Sangyoung Park, Qi Zhu, Sheldon X.-D. Tan, Naehyuck Chang, Sadrul Ula, Mehdi Maasoumy, "Battery Management and Application for Energy-Efficient Buildings". DAC, 2014 Proceedings of the The 51st Annual Design Automation Conference, Association of Computing Machinery (ACM), San Francisco, California, June, 2014.

Kala Meah, A.H.M. Sadrul Ula, "A New Simplified Adaptive Control Scheme for Multi-Terminal HVDC Transmission Systems," International Journal of Electrical Power and Energy Systems, Vol. 32, No. 4, May 2010, pp 243-253

Kala Meah, A.H.M. Sadrul Ula, "A Self-Coordinating Adaptive Control Scheme for HVDC Transmission Systems" Electric Power Systems Research, Vol. 79, No. 11, November, 2009, pp 1593-1603.

Kaili Xu, Kala Meah, and A.H.M. Sadrul Ula, "A Novel Method for Reducing Harmonics in Series-connected Rectifiers," Electric Power Systems Research, Vol. 78, No. 7, July 2008, pp 1256-1264.

Kala Meah, A.H.M. Sadrul Ula, "Simple Fuzzy Self-Tuning PI Controller for Multi-terminal HVDC Transmission Systems," Electric Power Components and Systems, Vol. 36, No. 3, March 2008, pp 224-238

Kala Meah, Steven Fletcher, and Sadrul Ula, "Solar Photovoltaic Water Pumping for Remote Locations," Journal of Renewable and Sustainable Energy Reviews, vol. 12, no. 2, February, 2008.

Kala Meah, Sadrul Ula, Steven Barrett, "Solar Photovoltaic Water Pumping – Opportunities and Challenges," Journal of Renewable and Sustainable Energy Reviews, Vol. 12, no. 4, 2008, pp 1162-1175.

Kala Meah, Sadrul Ula, and Steven Barrett, "Integrating Wind and Solar Electric Energy into Power System Teaching," 2007 ASEE Conference & Exposition, June 24-27, 2007, Honolulu, Hawaii, USA.

Other Significant Publications

Kala Meah, A.H.M. Sadrul Ula, "Simulation Study of the CIGRE HVDC Benchmark Model with the WSCC Nine-bus Power System Network," IEEE Power and Energy Society Power System Conference and Exposition, March 15-18, 2009, Seattle, WA, USA

Pierre, John W., Tuffner, Francis K., Anderson, Jeffrey R., Whitman, David L., Ula, A. H. M. Sadrul; Kubichek, Robert F. Wright, Cameron H. G., Barrett, Steven F., Cupal, Jerry J, Hamann, Jerry C., "A One Credit Hands-On Introductory Course in Electrical and Computer Engineering Using a Variety of Topic Modules," IEEE Transactions on Education, Vol. 52, No. 2, May 2009.

Biographical Sketch: Weixin Yao

(a) Professional Preparation

- University of Science and Technology of China, Statistics, B.S. July 2002
- The Pennsylvania State University, Statistics, Ph.D. August 2007
Advisors: Dr. Bruce G. Lindsay and Dr. Runze Li

(b) Appointments

- Associate Professor, Department of Statistics, University of California, Riverside, 07/2014-present
- Associate Professor, Department of Statistics, Kansas State University, 07/2013-06/2014
- Assistant Professor, Department of Statistics, Kansas State University, 08/2007-06/2013

(c) Publications

Five Most Relevant Products:

1. **Yao**, Nandy, D., Lindsay, B., and Chiaromonte, F. (2018). Covariate Information Matrix for Sufficient Dimension Reduction. *Journal of the American Statistical Association*. In press.
2. **Yao**, W. and Li, L. (2014). A new regression model: Modal linear regression. *Scandinavian Journal of Statistics*, 41, 656-671.
3. Huang, M. and **Yao**, W.* (2012). Mixture of regression models with varying mixing proportions: A semiparametric approach. *Journal of the American Statistical Association*, 107, 711-724. (*Corresponding author)
4. **Yao**, W. and Li, R. (2012). New local estimation procedure for nonparametric regression function of longitudinal data. *Journal of the Royal Statistical Society, Ser B*, 75, 123-138.
5. **Yao**, W. and Lindsay, B. G. (2009). Bayesian mixture labelling by highest posterior density. *Journal of the American Statistical Association*, 104, 758-767.

Five Additional Products:

1. Chen, Y* and **Yao**, W. (2017). Unified Inference for Sparse and Dense Longitudinal Data in Time-Varying Coefficient Models. *Scandinavian Journal of Statistics*, 44, 268-284. (*Former Yao student)
2. Chen, Y*, Wang, Q., and **Yao**, W. (2015). Adaptive Estimation for Varying Coefficient Models. *Journal of Multivariate Analysis*, 137, 17-31. (*Former Yao student)
3. Cao, J. and **Yao**, W.* (2012). Semiparametric mixture of binomial regression with a degenerate component. *Statistica Sinica*, 22, 27-46. (*Corresponding author)
4. **Yao**, W., Lindsay, B. G., and Li, R. (2012). Local modal regression. *Journal of Nonparametric Statistics*, 24, 647-663. (*The winner of The Journal of Nonparametric Statistics Best Paper Award in 2015.*)
5. Wang, Q. and **Yao**, W.* (2012). An adaptive estimation of MAVE. *Journal of Multivariate Data Analysis*, 104, 88-100. (*Corresponding author)

(d) Synergistic Activities (up to 5)

- I currently serve as an Associate Editor of *Biometrics*, *Journal of Computational and Graphical Statistics*, *Journal of Multivariate Analysis*, and *The American Statistician* and was the program co-chair and the Editor of the Conference on Statistics in Agriculture in 2010.
- I have been a very active supervisor of Ph.D. students. I had seven students graduated. Currently I am supervising four Ph.D. students. I do this supervision with no bias towards gender or race or nationality. *Six of the above mentioned students are women, an underrepresented group in STEM.*
- I was President of Kansas-Western Missouri Chapter of ASA from 2013 to 2014 and a co-organizer of Symposium on “Innovations in Design, Analysis, and Dissemination: Frontiers in Biostatistical Methods”, Kansas city, MO, April 2012.
- I have provided services to many scientific and engineering communities. In 2005, I served as the judge for 2015 Riverside Unified School District’s Science and Engineering Fair.
- I have developed several advanced Ph.D. courses focusing on some new advanced statistical methods such as methods for longitudinal repeated measures data, generalized linear models and generalized mixed models, nonparametric and semiparametric methods, robust regressions, and mixture models.

EXHIBIT "B"
PROJECT BUDGET

Direct Expense Categories:

PI Salary

Support for Postdoc and Graduate Students

Employee Benefits

Publication Costs

Supplies

Travel

Total Direct Expense: \$70,336

Total Indirect Costs: \$29,665

Total Project Costs: \$100,000

EXHIBIT "C"

INTELLECTUAL PROPERTY PROVISIONS

1. Recipient Rights, Responsibilities and Indemnity

a. Patent rights for inventions conceived and first actually reduced to practice in performance of this Grant, whether actually patented or unpatented, will be the property of the Recipient whose employees or researchers are inventors of such inventions pursuant to U.S. patent law. The Recipient shall grant a non-exclusive, non-commercial license to any patented invention to the sponsor, the City of Riverside. Recipients must obtain Agreements to effectuate the government use license with all persons or entities, except for the U.S. Department of Energy (DOE), obtaining ownership interest in such patent rights. Upon the perfecting of a patent application for subject inventions, Recipient will fill out and sign a Uniform Commercial Code (UCC.1) Financing Statement that documents the City of Riverside's use license.

The Recipient will disclose to the City of Riverside on a confidential basis all inventions, software and copyrightable material that was first conceived or first actually reduced to practice in performance of this Grant.

Recipient and all persons and/or entities obtaining an ownership interest in invention(s) shall include within the specification of any United States patent application, and any patent issuing thereon covering a Subject Invention, the following statement:

"This invention was made with support from the City of Riverside. The City of Riverside has certain rights to this invention."

b. All software and copyrightable material first produced under this Grant shall be the property of the Recipient. The Recipient shall grant a non-exclusive, non-commercial license to any such software or copyrightable material to the sponsor, the City of Riverside.

c. Recipient shall provide the City of Riverside with a copy of all technical, generated and deliverable data produced under this Agreement. Recipient does not have to copy and submit data the City has identified as being unusable for City purposes. For instance, some data may not warrant routine copying and shipping because the raw data is too disaggregated or voluminous for practical application. Recipient shall retain such data at the Recipient's facility for inspection, review and possible copying by the City.

d. To the extent permitted by law, Recipient will defend and indemnify the City of Riverside from and against any claim, lawsuit or other proceeding, loss, cost, liability or expense (including court costs and reasonable fees of attorneys and other professionals) to the extent arising out of any third party claim solely arising out of the negligent act(s) or omission(s) by the Recipient, its employees or agents, in connection with intellectual property claims against either deliverables or the Recipient's performance under this Agreement.

e. In no event will the City of Riverside be liable for any special, incidental or consequential damages based on breach of warranty, breach of contract, negligence, strict tort or any other legal theory for the disclosure of Recipient's confidential information, even if the City of Riverside has been advised of the possibility of such damage. Damages that the City of Riverside will not be responsible for include, but are not limited to, loss of profit; loss of savings or revenue; loss of goodwill; loss of use of the produce or any associated equipment; cost of capital; cost of any substitute equipment, facilities or services; downtime; the claims of third parties, including customers; and damage to property.

2. City of Riverside Rights and Responsibilities

a. For all inventions that were first conceived and first actually reduced to practice in the performance of this Grant, the City of Riverside retains a no-cost, non-exclusive, non-transferable, irrevocable, perpetual, royalty-free, paid-up worldwide, non-exclusive license to use or have practiced such rights for or on behalf of the City of Riverside for governmental purposes to the degree that it is consistent with federal law. The City retains the right to file a Uniform Commercial Code (UCC.1) Financing Statement on all subject inventions that are patented in order to document the City of Riverside's right to use such items for governmental purposes. Previously documented (whether patented or unpatented under the patent laws of the United States of America or any foreign country) inventions are exempt from this provision.

b. For software first developed in performance of this Grant, the Recipient shall grant the City of Riverside a royalty-free, no-cost, non-exclusive, irrevocable, non-transferable, worldwide, perpetual license to produce and use for governmental purposes.

c. For copyrightable material first produced in performance of this Grant, the Recipient shall grant the City of Riverside a royalty-free, no-cost, non-exclusive, irrevocable, non-transferable, worldwide, perpetual license to produce, translate, publish, use and dispose of, and to authorize others to produce, translate, publish, use and dispose of all copyrightable material.

d. The City of Riverside shall not purposefully enter into competition with Recipient's Licensee or take affirmative actions intended to effectively destroy the commercial market where a Licensee has introduced a Licensed Product.

e. Data provided to the City of Riverside by Recipient, which data the City has not already agreed to keep confidential and which Recipient seeks to have designated as confidential or is the subject of a pending application for confidential designation, shall not be disclosed by the City, except as provided in Title 20 CCR, Sections 2506 and 2507 (or as they may be amended), unless disclosure is ordered by a court of competent jurisdiction.

f. It is the City of Riverside's intent to use and release project results, such as deliverables and data, in a manner calculated to further the intent of California Public Utilities Code, Section 385, while protecting proprietary or patentable interests of the parties. Therefore, the City agrees not to disclose confidential data or the contents of reports containing data considered by

Recipient as confidential, without first providing a copy of the disclosure document for review and comment by Recipient. Recipient shall have no less than ten (10) working days for review and comment and, if appropriate, to make an application for confidential designation on some or all of the data. The City of Riverside shall consider the comments of Recipient and use professional judgment in revising the report, information or data accordingly.

EXHIBIT "D"
PERFORMANCE STANDARDS

Grant Report Completion. Submit Final Report recommending location of smart meters that can maintain reasonably optimal characteristics for most applications.

Quarterly Report I.

Due by the last day of the fourth month of the contract. Identify key use cases of smart meter data for RPU and analyze and summarize business values and technical requirements of smart meter data-driven applications.

Quarterly Report II.

Due by the last day of the eighth month of the contract. Identify and determine optimal placement of smart meter data-driven application.