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Challenges and opportunities: Microgrid modular design for Tribal Healthcare facilities

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***Abstract*—There exist significant challenges and opportunities for improvement the power system of healthcare facilities for American Indian and Alaska natives. Creativities, new technologies, and joint efforts among different stakeholders are needed to address tribal concerns about their environment, their wild life and their traditions while improving the electrical power system. This paper establishes plans and methodology to include the research process in the power system design utilizing Kayenta health center, which is located in the Navajo nation, as a subject study. A microgrid modular design architecture is defined. Modeling and simulation tools combined with experimental results are proposed for future implementation of the actual microgrid. The microgrid architecture can be used for improvement the power system of existing and new healthcare facilities for American Indian and Alaska natives.**

Keywords—Microgrid; tribal healthcare facilities; renewable energy; power systems improvement; Indian Health Services

I. Introduction

Congress recognized the importance of tribal decision-making in tribal affairs and the primacy of the nation-to-nation relationship between the Unites States and Tribes through the passage of the Indian Self-Determination and Education Assistance Act (ISDEAA, Public Law 93-638, 1975). In subsequent amendments to the ISDEAA, among other things congress authorized federally recognized Tribes the option of entering into self-governance compacts to gain more autonomy in the management and delivery of their health care programs [3].

Throughout the process of construction of new healthcare facilities and updating existing ones, the Tribes are facing significant challenges regarding the design process as well as the reliability and efficiency of the electrical power service:

1. The healthcare facilities are usually located in remote locations. In some cases, there is no electrical power service or the service is not reliable enough for a healthcare facility.

2. Most Tribes does not have the expertise in latest technologies of power systems and they rely on the support of the Indian Health Services (IHS) and private designers. In some cases, the electrical system is over design, low efficient or has power quality issues.

3. Tribes prefer to be as much independent as possible from the US government and they have specific preferences about the way they foresee the power system for the healthcare facilities. The electrical power system needs to be designed such way that it fits in Tribes concerns about their environment, their wild life or their traditions.

4. The budget available for the design and construction and upgrades of power system for healthcare facilities varies significantly among different tribes.

5. One of the top priorities of the IHS is to renew and strengthen partnerships with Tribes and Urban Indian Health Programs. Most of the time, Tribes expect IHS to perform costly changes during the design process for the power system of healthcare facilities.

The question is how is it possible to overcome all these issues all together? Is there a way to optimize the power system of a typical healthcare facility located in the Indian lands by developing a Microgrid modular design?

IHS current A/E Design Guide (2013) provides general guidance and rules for the development of design documents, specifications, and other contract documents, architectural and engineering design features, submittals, and supplemental information. However, it does not contain specific information or guidance related to the power system reliability, efficiency and security or survivability analysis. The quality of the power system design rely mostly on the competence of the A/E design firm (which varies significantly from project to project) and the design revision process from IHS and the Tribal team. There is no research component in the A/E Design Guide [4].

IHS recognizes the need of going beyond the traditional way of providing Electrical Engineering support to the Tribes. This paper explores the feasibilities of deploying Microgrid (either grid tie or islanded) to improve the reliability and quality of the power supply of healthcare facilities for American Indian and Alaska natives. Since the electrical power system needs to be designed such way that it fits in Tribes concerns about their environment, their wild life or their traditions, it is necessary to combine the available latest technologies and processes, the Clean Energy resources and the new ideas into the research process in order to come up with improved and acceptable solutions. Through extensive

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literature search it is realized that the microgrid is a good option to achieve desired goals [6], [7], [8], [13], [14].

II. Facility Selection Process

A. *General information*

Indian health care services are provided in over 640 IHS and tribal health care facilities, located mostly in rural and isolated areas. The IHS also operates nearly 2,300 staff quarters units to support health care services in remote locations. The health care facilities are distributed among twelve (12) different tribal areas: Alaska, Albuquerque, Bemidji, Billings, California, Great Plains, Nashville, Navajo, Oklahoma City, Phoenix, Portland, and Tucson [3]. Fig. 1 illustrates a typical architecture of a Microgrid for tribal healthcare facilities with renewable energy sources. Since they are location dependent, it is necessary to gather data from IHS to select a typical Indian tribal healthcare facility for a target location that can potentially benefit a significant population by improving the power system. The study of the power system of the subject facility will result in improved renewable energy based power systems for upcoming new projects in the region. By means of the study, analysis and experimental results of the power system for a healthcare facility, it is expected to discover additional challenges and opportunities for the implementation of a Microgrid modular design.

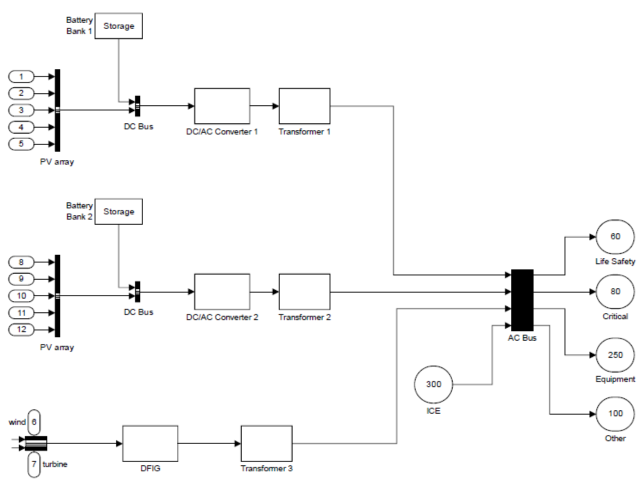

Fig. 1. Typical Architecture for the design of a Microgrid for tribal HC facilities

B. *Selecting a healthcare facility*

In order to determine the best fit for a typical tribal healthcare facility, there are certain important factors that determine the power system load, applicability of renewable energy sources, complexity of the system, and usefulness of the study. The factors considered were location, healthcare services offered, power quality, whether the facility is combined with staff quarters, size of the facility, size of the electrical power system of the facility and whether the facility is new or old. Each factor received a rank (points) in terms of the way it accommodates to the solution of the target problems (previously identified by IHS for tribal HC facilities). Over fifty (50) facilities were evaluated. Table 1 show summary results for the higher rated facilities. From the two higher rated of this group, Kayenta HC (Navajo area) was selected for the proposed Microgrid study. Kayenta HC is a new healthcare facility located in the northeast side of Arizona, 77 miles from the four corners point.

Table 1: Higher Rated Facilities

Area	Facility	Location	HC services offered	Power Quality	Combined with staff quarters	Size GSM	Size of power system	New or Old	Total points
ALB	Zuni comprehensive HC	5	5	3	5	4	4	2	28
NAV	Four Corners Regional HC	5	4	3	5	4	5	2	28
	Kayenta HC	5	5	3	5	5	3	5	31
	Pinon HC	5	4	3	4	4	4	4	28
PHX	Hopi Health Care Center Service Unit	5	5	3	5	4	4	2	28
	San Carlos Service Unit	5	5	3	5	5	3	5	31
TUC	Sells Hospital	5	5	3	3	5	5	2	28
OTHER	Choctaw HC (Nashville)	4	5	3	5	5	1	5	28

C. *Renewable energy source data*

The National Renewable Energy Laboratory (NREL) database provides information about the amount of solar radiation received in the United States and its territories. Fig 2 illustrates the average daily solar radiation per year [1]. Notice that Arizona and New Mexico zone receives the highest average solar radiation throughout the year (6 to 7 kWh/m^2/day). The Navajo nation, the target zone for the proposed study, is located in a region that overlaps AZ and NM.

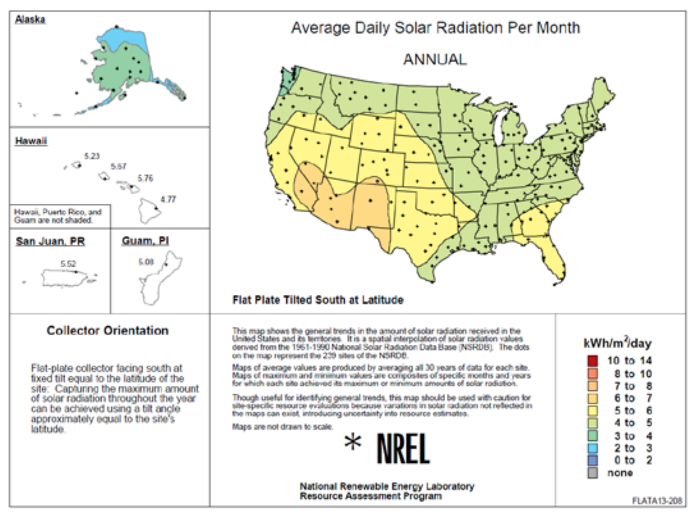

Fig. 2: Average daily solar radiation per year

NREL database contains 30 years (1961-1990) historical environmental data, which includes solar radiation, temperature and wind speed for different locations within the US and territories. In Arizona, the data includes four locations: Flagstaff, Phoenix, Prescott and Tucson. Flagstaff is located just 23 miles west of the Navajo nation region. Based on historical data, the average wind speed per year is 6.1mph and the average temperature per year is 7.7ºC in Flagstaff. There is additional historical environmental information available in the National Oceanic and Atmospheric Administration database, which includes many different point locations within the US. The renewable energy source historical data will be used as an engineering design tool to predict the availability, behavior and operation of the power system for the Microgrid.

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On April 15, 2016, the US Department of Energy (DOE) announced nearly $4 million for projects to increase access to solar data. According to DOE, four partners will help launch the new Orange Button℠ initiative, which will increase solar market transparency and fair pricing by establishing data standards for the industry [11].

D. Renewable Energy Technologies

Multiple laws and executive orders define requirements for the use of renewable energy in federal facilities, for example: the Energy Policy Act of 2005 (EPACT 2005) and Executive Order (EO)13693. Literature widely explains the advantages and challenges with renewable energy technologies [5], [7], [13], [14], [15]. IHS also encourages the use of renewable energy power sources for all new tribal healthcare facilities. It is typical to install Photovoltaic (PV) systems to supplement the normal power from the utility. However, other types of renewable energy sources are seldom considered to be combined together as Distributed Energy (DE) resources. As it is important to join efforts with the academia, IHS is working with University of Texas at Arlington (UTA) in the research process for Microgrid modular design to improve the power system of healthcare facilities for American Indian and Alaska natives. Fig. 3 shows a picture (partial view) of the PV system installed in Kayenta HC. It is expected that experimental data will be collected during this summer from the power system of Kayenta HC, including the utility, PV system and special loads applicable for healthcare facilities (i.e. medical equipment).

Fig. 3: Kayenta PV System

U.S. Energy Information Administration (EIA) publishes data among other things about net generation from different sources, including renewable [2]. According to EIA, solar and wind are the fastest growing among all renewable energy generation types in the US. Fig. 4 shows the increasing tendency on solar and wind renewable energy generation in the US. The wind generation increased 4.1% in Arizona and 3.7% in New Mexico from 2013 to 2014, while the solar PV generation increased 25.5% in Arizona and 32.7% in New Mexico for the same period. Arizona is the state with the second larger net generation of solar PV energy (2,538 GWh, in 2014), only overcome by California (8,336 GWh, in 2014) [2].

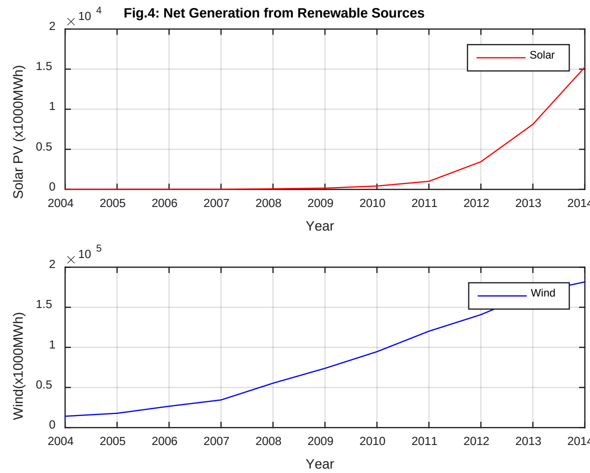

Fig. 4: Net Generation from Renewable Sources

Due to the increasing tendency in the use of renewable energy, many universities, private organization and government entities are conducting research studies regarding renewable energy and distributed generation resources. However, there are still many challenges regarding renewable energy, for example: the scalability and timing, commercialization, substitutability, material input requirements, intermittency, energy density, and energy return on investment.

There are many different factors when considering renewable energy generation technologies [5], [7]. For tribal healthcare facilities in the Navajo area (as proposed) Photovoltaic systems and Wind turbines show advantage due to the natural energy resources available, low level of fault current, foot print availability in tribal lands, mature technology, increasing trend and environmental friendly. However, these technologies need energy storage components and have to combine with other nonrenewable energy generation technologies in order to improve reliability of the system and increase the power system capacity.

E. Challenges and Opportunties

There are still gaps in terms of improvement the reliability and efficiency of the electrical power service in tribal healthcare facilities. It is important in the design process to perform beyond traditional ways of providing electrical engineering support to the Tribes, including addition of a wide base of knowledge, experience and tolls through the research process. Creativities, new technologies, and joint efforts among different stakeholders are needed to address Tribal concerns about their environment, their wild life and their traditions while improving the electrical power system.

As mentioned earlier, the health care facilities are located in twelve (12) different tribal areas. Due to the size, location and configuration of healthcare facilities, the climate, transportation and other factors, certain areas (e.g. Alaska) deserve separate future studies. The renewable energy resources, the power quality issues and hence the solutions for the power system improvement will vary significantly from different areas. For example, efficient Combined Heat and

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Power (CHP) solution alternatives would receive stronger consideration in some areas. Kayenta HC was selected as a representative healthcare facility within the Navajo area. Power systems for other areas will be considered in the future study.

Available data about natural resources demonstrates that the Navajo area (which overlaps AZ and NM) offers great opportunity to take advantage of solar PV and wind renewable energy as part of the components to be included in the Microgrid. The accessibility, accuracy and standardization of the solar data will increase as DOE is putting efforts and resources for it.

Navajo Generating Station is a 2250-megawatt coal-fired power plant located 65 miles West of Kayenta. The Navajo Generating Station is the United States of America's third largest emitter of carbon dioxide [9]. Thus, the environmental concern in the Navajo nation also drives the applicability of renewable energy components for the microgrid. In fact, the Navajo Tribal Utility Authority (NTUA) announced in 2009 the Salt River Project as its first utility customer for an 85-megawatt wind project at the Big Boquillas Ranch and they also offers solar PV services for residential customer in remote locations [10]. Nevertheless, one of the main challenges will be the reconciliation the return on investment with the additional cost of energy storage components.

Existing literature provide background, information and tools for the modeling and simulation of PV systems [19], [20], [21], [22], energy storage components [12] and wind turbine generation [23]. The modeling and simulation tools are very useful to gather additional information about the behavior of renewable energy systems in tribal healthcare facilities. Experimental results will be obtained from the full-scale PV system installed in Kayenta HC.

III. THE MICROGRID CONCEPT

A. *Existing power system in Kayenta HC*

Fig. 5 shows a simplified model of the existing electrical power system in Kayenta HC. NTUA provided two separate feeders, each one connected to a 2.5MVA, 25KV - 480/277V transformer. Each transformer feeds one side of double-ended switchgear (3000A, 480/277V). The system provides redundancy of main feeder and transformer. However, the power source comes from the same substation.

The PV system consists of Suniva optimus monocrystalline solar modules (model OPT # 265-60-4-100). There are 378 modules installed in two different roof areas of the facility. The inverter is Solectria Renewables, model PVI 100KW, 480V. The inverter output is connected to the double-ended switchgear, such that the system supplements the NTUA commercial power. In compliance with IEEE 1547 and NEC 690.61, the inverter system automatically de-energizes when there is an outage from the utility.

Five (5) diesel generators (1000KVA @ 0.8PF, 480/277V) provide emergency power for the entire facility in case of loss of power or power quality issues from the utility. The emergency power supply system (EPSS) also includes three main automatic transfer switches (ATS) to separate the loads into the different categories for healthcare facilities: critical, life safety and equipment branches.

The design is very stiff, traditional and not planned around the microgrid concept.

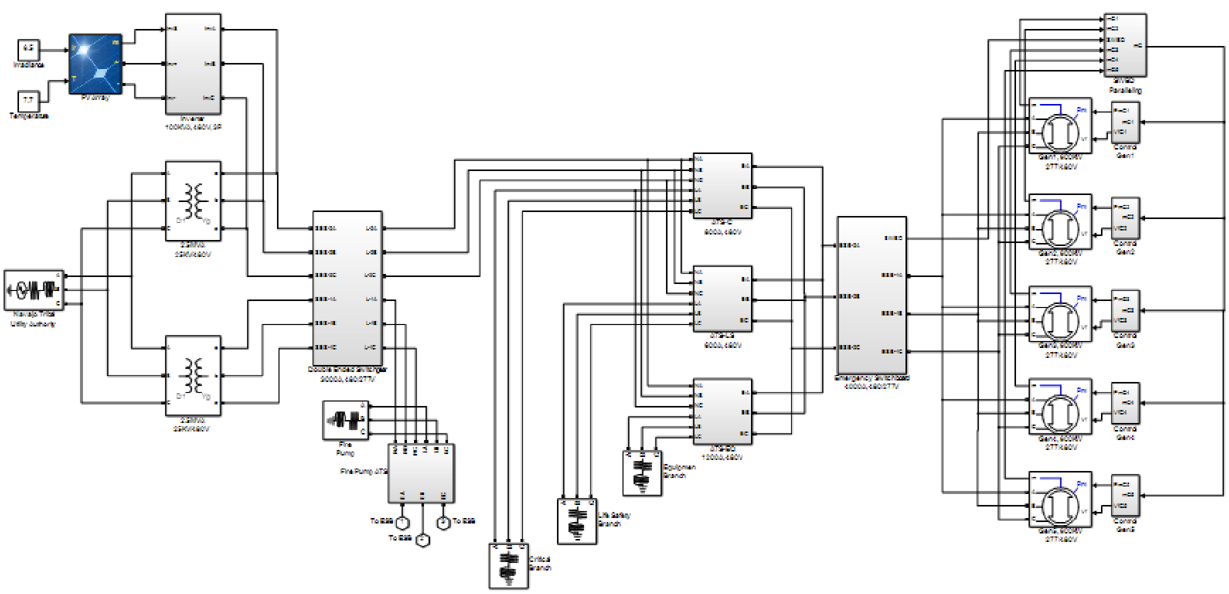

Fig 5: Existing configuration of electrical system in Kayeta

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B. Microgrid architecture

More flexible and reliable power system designs have potential around the microgrid concept. In order to balance the reliability and power system capacity against the capital investment and energy savings, energy storage components and other nonrenewable energy generation are considered. Generation technologies considered for this microgrid application in Kayenta HC are:

- Internal combustion engines (ICE, diesel 600 kW)
- Photovoltaic systems (typical 100kW modules)
- Intermediate wind turbines (100kW-250kW)
- Battery banks (typical 100kW, 100kWh)
- Flywheel energy storage (190kW nom., 225kW max).

A static switch is also necessary at the point of common coupling (PCC) between the utility and the microgrid. The static switch has the ability to interchange the mode of operation of the microgrid from grid connected to island or vice versa. Each component of the microgrid needs to be a peer-to-peer and plug-and-play to avoid disturbances among the controls and the power system protection [24].

It is important to notice that the reliability of the ICE depends on the maintenance of the units. Hence, the Navajo area (Kayenta facility personnel) requires of proper training, documentation and support in this subject. Microgrids composed of considerable ICE capacity should perform very well handling day-to-day fluctuations in loading and typical load steps [5].

The International Electromechanical Commission (IEC) standard 61400 and manufacturer data available for intermediate wind turbines shows nominal wind speed to be 13 m/s, the cut in speed < 3 m/s, and the cut out speed 25 m/s. However, the NREL database states that the highest annual average wind speed in the zone (near Kayenta) is less than 5 m/s. Under these conditions, existing intermediate wind generation turbines would perform at very low efficiency.

Energy storage systems provide a mean to smooth the shape of the characteristic response of intermittent power generation sources. There are several advantages of energy storage systems for transmission and distribution applications listed in [25]. Lithium-ion technology battery banks and flywheel technology are more suitable for this microgrid application. Taking field measurements of real time power system data is important for adequately sizing the energy storage systems and proper identification of strategic locations for the installation.

The propose microgrid architecture will include additional PV system modules, addition of battery banks and/or flywheel systems, and the static switch connected to intercept the main feeders at the primary side of transformer. Then, the simplified model shown in Fig. 5 modified accordingly and simulation results obtained.

C. Methodology and proposed studies

It is required to conduct additional studies for completeness of the microgrid research and figure out better alternatives for the feasibility of the actual implementation. Experimental results will demonstrate the behavior and efficiency of the PV system installed in Kayenta. Real time data obtained will be compared to results from equivalent PV system model built in Matlab/Simulink. Experimental results will also provide light about the power quality of the utility and the behavior of the different type of loads in the electrical system of Kayenta HC. This method will define gaps and constraints for consideration in the addition of PV modules, energy storage components and the static switch for islanded operation.

Modeling and simulation is a proven method for research and development of the microgrid concept within the power systems. However, due to certain limitations (simulation time, storage data capacity, inaccurate assumptions, complexity of real full-scale system, etc.) it is not practical to model the entire microgrid with all detailed components and possible incidents over time. Instead, some aspects of the microgrid and specific important incidents (faults, sudden load changes, power quality issues, insufficient capacity or loss of a component, etc.) which we can both understand and quantify are feasible for modeling. Another interesting topic is the interaction between subsystems added to the microgrid.

IV. Oportunities For Improvement

Two different categories classify the opportunities for improvement: general and technical.

A. General opportunities

- Provide better solutions for the quality of power system for healthcare facilities of the American Indian and Alaska natives.
- Increase access to solar data initiative by DOE will enhance accuracy to engineering calculations and models.
- Address environmental concern in the Navajo nation and the US government by providing power system designs with generous renewable energy components. Reduce carbon dioxide emissions from Navajo Generating Station. Consider different types of renewable energy sources combined as DE resources in the microgrid.
- Add research component in the A/E Design Guide and establish new standards for the design of power systems around the microgrid concept.

B. Technical opportunities

- Improving the PV system efficiency in Kayenta HC.
- Develop accurate models and perform simulation studies for microgrid system and components applicable for tribal healthcare facilities.
- Investigate the interaction among additional parallel inverters proposed for Kayenta HC.

The above list is not all-inclusive. As the research process continues, new opportunities for improvement will be

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discovered. There are many healthcare facilities with different constraints in the electrical power systems that deserve separate studies that will result in additional opportunities.

V. Conclusions

The purpose of this work is to establish plans and methodology to include the research process in the power system design utilizing Kayenta HC as a subject study. The first step is the facility selection process, as the constraints of the power system are dependent of the geographical location. Then, renewable energy source data is obtained and different technologies considered and analyzed as DE resources in the microgrid. Next, determine existing electrical power system in the facility and define microgrid architecture. Once the possible challenges and solutions are identified, experiments and field test will be performed.

Acknowledgment

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References

[1] National Renewable Energy Laboratory (NREL) database. [Online]. Available: http://rredc.nrel.gov/solar/

[2] US Energy Information Administration. [Online]. Available: http://www.eia.gov/renewable/

[3] US Department of Health and Human Services (DHHS), Indian Health Service (IHS). [Online]. Available: http//www.ihs.gov

[4] US DHHS, IHS, Office of Environmental Health & Engineering (OEHE), Division of Engineering Services (DES), "Architect/Engineer Design Guide", 2013.

[5] P. Barker, B. Johnson, A. Maitra, "Investigation of the technical and economic feasibility of micro-grid-based power systems", EPRI PEAC Corporation; final report, december 2001.

[6] Peng Li, Xiaochun Li, Jinxin Liu, Jing Chen, Jianjie Chen, "Analysis of acceptable capacity of microgrid connected to the main power grid", IEEE; 2011, pp. 1799-1802

[7] Ali Keyhani, Mohammad N. Marwali, Min Dai, "Integration of green and renewable energy in electric power systems", Wiley; 2010

[8] Majid Ahmadi, Jay M. Rosenberger, Wei-Jen Lee, Asama Kulvanitchaiyanunt, "Optimizing load control in a collaborative residential microgrid environment", IEEE Transactions on smart grid, 2015, vol. 6, issue 3.

[9] Wikipedia, the free encyclopedia. [Online]. Available: https://en.wikipedia.org/wiki/Navajo_Generating_Station

[10] Navajo Tribal Utility Authority. [Online]. Available: http://www.ntua.com/news.html

[11] Energy.gov, Office of Energy & Renewable Energy. [Online]. Available: http://energy.gov/eere/articles/energy-department-announces-4-million-projects-launching-orange-button-solar-energy.

[12] Mahesh S. Illindala, Hussam J. Khasawneh, Ajit A. Renjit, "Felxible distribution of energy and storage resources", IEEE Indutry applications magazine, sept/oct 2015, vol. 21, No 5.

[13] K. C. McIntyre, C. Clancey-Rivera, M. C. Tobin, M. D. Erickson, X. Zhang, "The feasibility of an environmentally friendly microgrid", IEEE NAPS, 2010.

[14] Y. Nian, S. Liu, D. Wu, J. Liu, "A method for optimal sizing of stand-alone hybrid PV/wind/battery system", IEEE Renewable power generation conference (RPG 2013), 2nd IET.

[15] Robert H. Lasseter, "Extended CERTS microgrid", IEEE Power and energy society general meeting-conversion and delivery of electrical energy in the 21st century, 2008.

[16] Peng Li, Xubin Wang, Wei-Jen Lee, Duo Xu, "Dynamic power conditioning method of microgrid via adaptive inverse control", IEEE Transactions on power delivery, 2015, vol. 30, issue 2.

[17] Giuseppe Parise, Luigi Parise, Luigi Martirano, Antonino Germole, "Service continuity safety by design, the relevance of electrical power-system architectures in hospitals", IEEE Indutry applications magazine, jan/feb 2016, vol. 22, No 1.

[18] Duotong Yang, Haniph A. Latchman, Dave Trigling, Anim Adrian Amarsingh, "Design and return on investment analysis of residential solar photovoltaic systems", IEEE potentials magazine, jul/aug 2015, vol. 34, No 4.

[19] Weidong Xiao, Fonkwe Fongang Edwin, Giovanni Spagnuolo, Juri Jatskevich, "Efficient approaches for modeling and simulating photovoltaic power systems", IEEE journal of photovoltaics, jan 2013, vol. 3, No. 1.

[20] Jan T. Bialasiewicz, "Renewable energy systems with photovoltaic power generators: operation and modeling", IEEE transactions on industrial electronics, jul 2008, vol. 55, No. 7.

[21] P.I. Muoka, M.E. Haque, A. Gargoom, M. Negnevitsky, "Modeling, simulation and hardware implementation of a PV power plant in a distributed energy generation system", IEEE PES, 2013.

[22] Amirnaser Yazdani, Anna Rita Di Fazio, Hamidreza Ghoddami, Mario Russo, Mehrdad Kazerani, Juri Jatskevich, Kai Strunz, Sonia Leva, Juan A. Martinez, "Modeling guidelines and benchmark for power system simulation studies of three-phase single-stage photovoltaic systems", IEEE transactions on power delivery, apr 2011, vol. 26, No. 2.

[23] S. Tamalouzt, N. Benyahia, T. Rekioua, R. Abdessemed, "A doubly fed induction generator wind turbine and fuel cell hybrid power sources system for micro-grid applications", IEEE 2015 3rd international conference on control, engineering & information technology (CEIT).

[24] Robert H. Lasseter, "CERTS microgrid", IEEE International conference on system of system engineering, 2007.

[25] Paulo F. Ribeiro, Brian K. Johnson, Mariesa L. Crow, Aysen Arsoy, Yuli Liu, "Energy storage systems for advance power applications", Proceedings of IEEE, vol. 89, No. 12, Dec 2001.

[26] Kathie Zipp, Solar power world, May 5, 2016. [Online]. Available: http://www.solarpowerworldonline.com/2015/08/what-is-the-best-type-of-battery-for-solar-storage.

S. V. Cotto and W. J. Lee, "Challenges and opportunities: Microgrid modular design for tribal healthcare facilities," *2016 North American Power Symposium (NAPS)*, Denver, CO, 2016, pp. 1-6. doi: 10.1109/NAPS.2016.7747839 keywords: {distributed power generation;health care;power system planning;Alaska natives;American Indian;Kayenta health center;Navajo nation;electrical power system;microgrid modular design;tribal healthcare facilities;Medical services;Microgrids;Power system reliability;Reliability;Renewable energy sources;Solar radiation;Indian Health Services;Microgrid;power systems improvement;renewable energy;tribal healthcare facilities}, URL: http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=7747839&isnumber=7747829