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Poster Contributions

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Technical Condition Management for a PV-based Distributed Energy System

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Abstract. Distributed energy systems are a key success factor for the future and self-determined living in undeveloped or emerging regions. Education, culture and economic growth are significantly influenced by energy processes. In order to be able to use a built-up infrastructure, maintenance and condition control of the systems along their entire life cycle are indispensable. However, this can only be achieved if an independent technical condition management system can be established. Event-based data and warnings can be transmitted or retrieved at any time. Due to this, decisions can be made on the basis of the information obtained, which then lead to the maintenance of the targeted functional scope of the power systems. In the following paper, a TCM for pv-based distributed energy systems is presented. It consists of a low performance single board computer which can be connected to a cloud system with mobile communication and transmits essential data.

Keywords: Technical Condition Management, MRO, pv-system

Introduction

Due to the continuing growth in global energy demand, the dilemma of extraction available energy sources and using them efficiently must also be solved especially in rural areas. Decentralized, distributed solutions based on renewable energy systems can provide a remedy and drive regional development. For several years, utility concepts for renewable energy systems have been designed for the sub-Saharan region of West Africa and pv (photovoltaics)-based energy supplies have been established, especially for powering elementary schools [1, 8].

A barrier to the readiness of a more widespread use of these technologies is often due to the fact that, due to a lack of means of communication, it was not possible to guarantee support for the plants by maintenance and repair (MRO) teams. This is where new technological enablers come in, offering the possibilities of health monitoring and alarm event management [3, 4, 5].

Data-driven information processing and decision support, especially through a transcript of historical data about the operating conditions on site, are an advantage for an efficient and long-lasting operation that should not be underestimated [6, 9]. Sophisticated applications have been set up as part of various project work on decentralized energy supply based on the use of regenerative energy systems. Since access to the systems is often difficult, maintenance and possible error analysis should be made possible remotely.

Architecture and Entities

Due to the described challenge, a holistic approach as well as a prototypical realization for a Technical Condition Management (TCM) is presented for pv-based distributed energy

systems. The core architecture consists of an inexpensive, commercially available single board computer (Raspberry PI 3 B) with various interoperable interfaces and additional PCBs for special sensors like as follows (hardware architecture see figure 1):

- temperature sensor DHT22
- current sensor ACS712-5
- voltmeter unit ADS1115 (M5Stack) as well as
- GSM GPRS module with antenna SIM800L GSM for mobile communication.

The system is used to health monitor and log the states of the energy system and to provide event-based decisions on its adapted continued operation. Regularities for the demand of provided energy resources are collected in order to enable an optimized utilization of existing capacities at any time. Furthermore, an escalating alarm management is presented to operators and MRO service providers on the basis of collected data. The data processing is enabled by the opensource software NodeRED and the communication via GSM/Internet protocol.

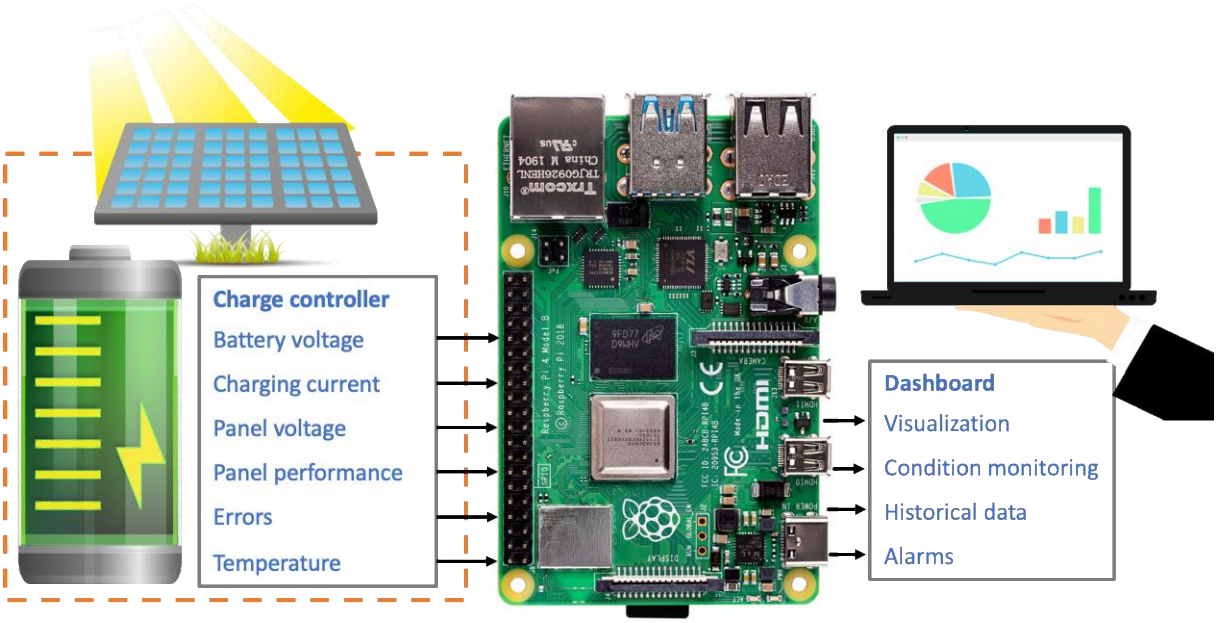

Figure 1. Architecture of the TCM system.

The innovation value of the TCM system lies in the distributed information provision across the application limits of the power systems. Here, the priority is to find a lightweight data structure that makes use of a narrow transmission bandwidth. A program for M2M communication and historical data acquisition was set up and implemented on NodeRED. By using common M2M protocols such as MQTT, the cloud infrastructure can be applied for external access to the distributed energy systems. Different architectural approaches for centralized and decentralized data storage as well as testing the use of an edge server for pre-processing the data have been examined.

Prototypical Realisation

An initial trial installation was carried out on the basis of the Roadshow logistics system in place at TH Wildau to raise the digital awareness of companies. Here, an overall package was designed and the basic feasibility is demonstrated. It is essential that the data of the system are transmitted mobile parallel to their use in the whole of Brandenburg region and reflect a constant overview of the state of the energy supply. For the frequently changing operators of the roadshow, the display elements were provided with a traffic light system.

This allows the operator to see quickly whether the actual values are within the required range (green) or whether a deviation is occurring.

As part of the development of the *Center for Renewable Energy Systems* (CenRES) at Kara University, a follow-up installation will be made on the Mobile Energy System of the BONITA House built in 2016. A prototype implementation of the graphical user interface of TCM especially for condition monitoring can be seen in figure 2. The data is transmitted collectively to the cloud server at TH Wildau in Germany. Event-driven applications are then mapped on the basis of self-analyzing process chains.

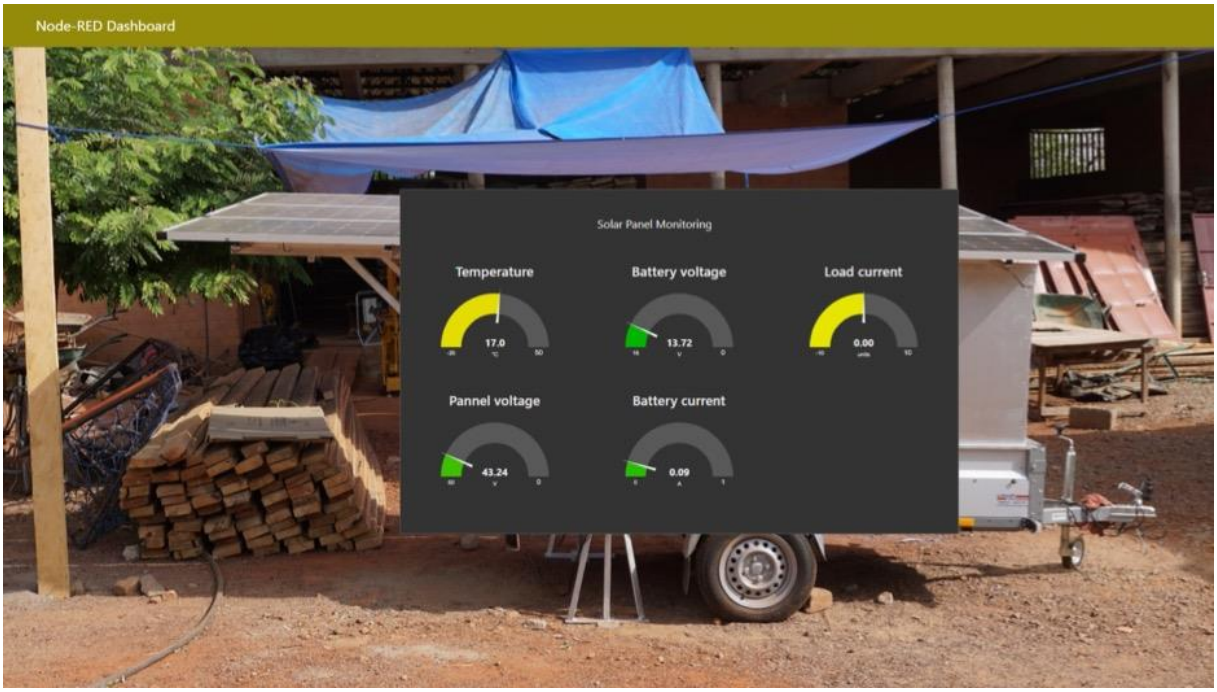

Figure 2. TCM-dashboard

Based on the cloud data storage, trend analyses can be prepared that provide an optimal insight into the energy system’s condition. In this way, deviations from target states can be identified at an early stage and alarms triggered. Before a failure of subsystems such as the batteries occurs, maintenance can be initiated or replacement prepared. It is also possible to implement a billing system based on the actual times consumers are switched on. This makes the economic viability of such solutions for use in the savannah possible.

Conclusions

Technical condition management enables a holistic view on the ability of the equipment to fulfil the customer needs. Finally, the following key enablers for future TCM systems can be derived from the approaches presented:

- The development of smart sensors, and other low-cost on-line monitoring systems that will permit the cost-effective continuous monitoring of key equipment items
- The increasing provision of built-in sensors as standard features in complex controlling items,
- The acceptance of Condition Monitoring within the "mainstream" of operations and maintenance, with service operators increasingly utilizing this technology as part of their day-to-day duties
- An increasing focus on the business implications and applications of Condition Monitoring technologies, leading to the utilization of TCM-technologies to improve equipment reliability and performance, rather than to merely predict component failure.

- A reduction in the cost-per-point of applying TCM technologies.

Ultimately, event-based alerting ensures high availability of the technique. Planned downtimes for maintenance tasks can be minimized and the safe use of the energy supply can be ensured.

Acknowledgement

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References

[1] Bullinger H, ed. Technology Management. Dordrecht, Heidelberg, London, New York: Springer; 2009.

[2] Uhlmann E, Laghmouchi A, Hohwieler E, Geisert C. Condition Monitoring in the Cloud. Procedia CIRP. 2015;38:53-57. https://doi.org/10.1016/j.procir.2015.08.075

[3] Reiff-Stephan J, Richter M, von Lipinski R. Intelligent sensor systems for self-optimising production chains. Proceedings of the 1th International Conference and Exhibition on Fu-ture RFID Technologies Eszterhazy Karoly University of Applied Sciences and Bay Zoltán Non-profit Ltd. for Applied Research Eger. 2014 November, pp. 115–125.

[4] Kumar NP, Jatoth RK. Development of cloud based light intensity monitoring system using raspberry Pi. 2015 International Conference on Industrial Instrumentation and Control (ICIC). 2015 International Conference on Industrial Instrumentation and Control (ICIC). 2015 05. https://doi.org/10.1109/iic.2015.7150959

[5] Heuberger A, Gamm E. Software Defined Radio-Systeme für die Telemetrie. Berlin Heidelberg: Springer; 2017.

[6] Dable E. Construction of PV Systems for Elementary Schools in the Savannah of Togo. 1st German-West African Conference on Sustainable, Renewable Energy Systems SusRes. 2020 July, pp. 111-115. https://doi.org/https://doi.org/10.15771/978-3-9819225-5-4

[7] Lee E. The Past, Present and Future of Cyber-Physical Systems: A Focus on Models. Sensors. 2015 02 26;15(3):4837-4869. https://doi.org/10.3390/s150304837

[8] Reiff-Stephan J. Solar power in product development. 1st German-West African Conference on Sustainable, Renewable Energy Systems SusRes; Kara, Togo. 2020 July, pp. 55-65. https://doi.org/https://doi.org/10.15771/978-3-9819225-5-4

[9] van de Sand R, Schulz S, Reiff-Stephan J. Smart Process Communication for Small and Medium-Sized Enterprises. In: Enterprise Interoperability VIII. Proceedings of the I-ESA Conferences. Springer International Publishing; 2019:pp. 411-420.