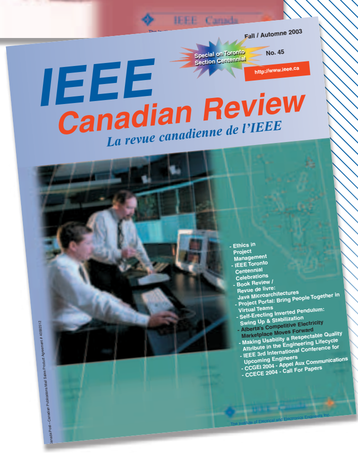
Renewable Energy - ways to make it work

In 2003 interest in developing renewable energy sources ran high. The International Energy Agency had predicted a 2.7% per annum increase in hydropower usage over the period of 1997-2020. Renewables were expected to be the fastest growing energy source with a predicted annual growth rate of 2.8% in the OECD countries. (International Energy Agency, World Energy Outlook 2000) In keeping with this heightened interest included are two related articles: applications for photovoltaic cells and the production of hydroelectric hydrogen.

WHEN DISASTER STRIKES, engineering skills are often needed to restore essential community infrastructure. Recognizing this need RedR Canada (Registered Engineers for Disaster Relief) was formed in 2001. Their mandate is to provide engineering expertise to front line humanitarian relief agencies.

"Projected world primary energy demand will increase by 57% between 1997 and 2020" (World Energy Outlook 2000)



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Powering the Future with Photovoltaics

by Anton Driesse
Queens University, Kingston, ON

Abstract

Photovoltaic cells convert energy from sunlight directly into electricity without moving parts or chemical reactions. The technology of photovoltaic cells and of the components that make up photovoltaic systems continues to evolve and mature, but it is already the technology of choice to provide electricity in many situations. This article provides an introduction to photovoltaics and an overview of the different system components and configurations with reference to applications in which they are used. The article also describes recent developments from the research side, and identifies some starting points for further reading on this subject.

Sommaire

Les cellules photovoltaïques transforment l'énergie solaire en électricité sans moyens mécaniques ou processus chimiques. Cette technologie évolue sans cesse, tout comme celles des autres composantes qui constituent les systèmes photovoltaïques, mais elle est déjà une option privilégiée pour assurer l'approvisionnement en électricité dans de nombreuses situations. Cet article se veut une introduction aux systèmes photovoltaïques : il a pour but d'expliquer leur fonctionnement et de donner un aperçu de leurs différentes composantes, configurations et applications. Des développements récents dans ce domaine de recherche sont également présentés, ainsi que quelques références pour approfondir le sujet.

1.0 Introduction

Photovoltaic cells perform an impressive feat: they transform radiant energy from the most abundant, least expensive and widely available source - the sun - into one of the most versatile energy forms known - electricity. The cells accomplish this without moving parts or chemical reactions; their operation causes no noise or environmental pollution. With such attributes, could they be the solution to the world's energy problems? Despite impressions given by the global petroleum trade and continental electrical grid operators, many energy needs can in fact be met using alternate technologies such as photovoltaics. What's more, the alternate technologies can be better overall solutions.

In the 50 years since researchers at the Bell Labs in New Jersey created the first practical cells, photovoltaic (PV) systems have become the technology of choice for an increasing range of applications - from outer space to pocket calculators, to weekend cottages. Technological advances, declining system costs and rising prices for conventional energy make PV systems ever more viable as a solution to an ever wider range of energy needs.

PV systems are also being used successfully as distributed electrical generation sources feeding into the electrical grid (as opposed to constituting an alternative, such as grid-independent power). Such grid-connected systems can be integrated into building designs to provide secondary benefits such as shading and can also offset other building material costs (Figure 1). Specialized products are already on the market to facilitate integration of PV into various types of roofs, such as shingles or tiles, feasible on a mass-market scale.

Identifying appropriate applications for PV systems is both a business opportunity and engineering challenge, as it requires an understanding of a variety of topics. The challenge is well worth accepting, since a successful PV installation is a win-win-win for suppliers, consumers and our natural environment alike.

Figure 1: A 20 kW grid-connected, building-integrated PV system at Queen's University provides summer shading and year-round electricity. (Photo: Anton Driesse)

2.0 The Solar Resource

Although sunshine is widely perceived to be variable and difficult to predict, the sun in fact provides the earth with a nearly constant influx of energy. In specific locations this influx is modulated by atmospheric or climatic conditions and of course, the rotation of the earth. At first this variability appears to make the sun a very unreliable source of energy, but is this really so?

The motion of the earth around the sun is very predictable. Sunrise and sunset times can be calculated with high precision and the exact path of the sun in the sky as seen from any position on earth can be determined for any relevant future date. Both daily and seasonal variations are well understood and reliable.

Atmospheric conditions are more difficult to predict, but in this case the accuracy of the predictions depends on how far into the future they are made, and what period of time the prediction represents. For example, it may be possible to achieve a very high accuracy for predictions that are merely one hour in the future; or for predictions several years into the future that represent monthly averages. In fact, long-term monitoring has shown that such averages show only small variation from year to year and can therefore be quite reliably predicted.

The key to using the sun's energy is to understand its variability, and to understand how this variability relates to the energy needs of the application. These may correlate positively, such as in the case of a pump to provide drinking water; or negatively, such as in the case of street lights. When the correlation is less than perfect a PV system requires either a supplementary source of generation (making it a hybrid system) or some form of energy storage. A mechanical tracking system can also be used to keep solar cells facing the sun throughout the day and year, thereby modifying the energy supply profile as well as increasing the capacity factor (Figure 2).

To view this article in its entirety please visit www.ieee.ca/canrev/cr48/cr48.pdf

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Integrated Stand-alone Renewable Energy System Based On Energy Storage In The Form Of Hydrogen

by Kodjo Agbossou, Mohan Kolhe, Jean Hamelin, Tapan K. Bose

Institut de recherche sur l'hydrogène,

Université du Québec à Trois-Rivières, QC

Abstract

Electrolytic hydrogen offers a promising alternative for long-term energy storage of renewable energies (RE). A stand-alone RE system based on hydrogen production has been developed at the Hydrogen Research Institute and successfully tested for automatic operation with designed control devices. The system is composed of a wind turbine, a photovoltaic array, an electrolyser, batteries for buffer energy storage, hydrogen and oxygen storage tanks, a fuel cell, AC and DC loads, power conditioning devices and different sensors. The long-term excess energy with respect to load demand has been sent to the electrolyser for hydrogen production and then the fuel cell has utilised this stored hydrogen to produce electricity when there were insufficient wind and solar energies with respect to load requirements. The RE system components have substantially different voltage-current characteristics and they are integrated on the DC bus through power conditioning devices for autonomous operation by using the developed control system. The experimental results clearly indicate that a stand-alone RE system based on hydrogen production is quite safe and reliable.

Sommaire

L'hydrogène électrolytique offre une alternative prometteuse pour le stockage à long terme des énergies renouvelables (ER). Un système à ER autonome basé sur la production d'hydrogène a été développé et testé avec succès, à l'Institut de Recherche sur l'Hydrogène. Le système est composé d'une éolienne, de panneaux solaires, de batteries comme mode de stockage énergétique tampon, de charges CC et CA, d'un électrolyseur, de réservoirs d'hydrogène et d'oxygène pour le stockage, d'une pile à combustible, d'un module de contrôle, d'appareils d'interface de puissance et de plusieurs capteurs. L'excès d'énergie à long terme, par rapport aux besoins de la charge, est dirigé vers l'électrolyseur pour la convertir sous forme d'hydrogène stocké sous pression. Cet hydrogène est ensuite utilisé pour alimenter la pile à combustible afin de produire de l'électricité lorsque les énergies éoliennes et solaires sont insuffisantes pour satisfaire les besoins de la charge. Les composantes du système à ER ont des caractéristiques tension-courant substantiellement différentes et elles sont intégrées au bus CC via des interfaces de puissance, pour une opération autonome en utilisant le système de contrôle développé. Les résultats expérimentaux indiquent clairement qu'un système à ER autonome basé sur la production d'hydrogène est sécuritaire et fiable.

1.0 Introduction

Energy storage can play an important role in the development and operation of an environment friendly renewable energy (RE) system. The integrated wind and solar energy system, based on long-term seasonal storage as electrolytic hydrogen (H_2), is considered a promising alternative to overcome the intermittence of the RE sources [1-2]. In comparison to commonly used battery storage, H_2 is well suited for seasonal storage applications, because of its inherent high mass energy density. A typical self-sufficient RE system must include both short-term and long-term energy storage. A battery bank is used for short-term energy storage due to its high charging-discharging efficiency, and also to take care of the effects caused by instantaneous load ripples / spikes, electrolyser transients, wind energy peaks. However, batteries alone are not appropriate for long-term storage because of their low energy density, self-discharge and leakage. The combination of a battery bank with long-term energy storage in the form of H_2 can significantly improve the performance of stand-alone RE systems. In such a RE system, electricity production in excess of demand is converted to H_2, using an electrolyser; electricity requirement in excess of production is met by converting H_2 to electricity through a fuel cell. The intent is to demonstrate that H_2 is a practical energy storage medium for RE and that it is safe and reliable.

The overall RE system performance is very sensitive to local weather conditions, and to achieve an adequate performance from such a system requires appropriate components and well-designed control system [3-5]. The control system for proper energy management in a stand-alone RE plant was a real challenge. We have designed and developed a control system with power conditioning devices to integrate the different components of the RE system and to manage the energy flow in the system to assure continuous supply of the load demand. The system parameters are monitored continuously for real time operation and control. The system operation has been tested for autonomous operation and technical feasibility of the stand-alone RE system based on hydrogen production. Our integrated RE system has been in operation for the last 2 years.

2.0 System Description

The stand-alone RE system based on hydrogen production has been tested successfully at the Hydrogen Research Institute (HRI). The system consists of a 10 kW wind turbine generator (WTG) and a 1 kW (peak) solar photo voltaic (PV) array as primary energy sources. The excess energy with respect to load demand has been stored as electrolytic hydrogen through a 5 kW electrolyser and utilized to produce electricity as per energy demand through a 5 kW fuel cell system. The RE system components have substantially different voltage-current characteristics and are integrated through the developed power conditioning devices on a 48V DC bus, which allows power to be managed between input power, energy storage and load. The DC-DC buck and boost converters are connected for power conditioning between the electrolyser and the DC bus, and between the fuel cell and the DC bus, respectively. The schematic of the RE system is shown in Figure 1 and the system components' specifications are given in Table 1.

Current from the DC bus bar keeps batteries (short-term energy storage) charged, feeds power to the load bank via an inverter and also supplies power to electrolyser via power-conditioning device. To simulate any type of electrical load profile, we have used DC and AC programmable loads. Our developed RE system has also a programmable power source at DC bus and can be used to test the system, when there is no power available from wind and solar energy system. The programmable power source can simulate any type of intermittent power output. The electrolyser and the fuel cell are major components of the RE system. We have also studied the polarization characteristics of them, which depend mainly on voltage, current and temperature. The different sensors are used to record real time voltages and currents of WTG, PV array, DC bus / battery, electrolyser, fuel cell, load, H_2 detectors, electrolytic H_2 flow rate from the electrolyser, H_2 consumption rate in the fuel cell, oxidant consumption rate in the fuel cell, H2 and oxidant pressure in the fuel cell, fuel cell stack temperature, electrolyzer cell temperature, DC-DC converter (boost and buck) duty ratio. There are also some sensors in the electrolyzer and the fuel cell system that provide the secondary information.

3.0 RE System Operation and Control

A control system is required for efficient energy management and autonomous operation of the RE plant. The control system is a challenge because the sensor data is required for continuous real time operation and the same control algorithm is needed to send signals to

To view this article in its entirety please visit www.ieee.ca/canrev/cr44/cr44.pdf

RedR - Registered Engineers for Disaster Relief

by Kirk Thompson
Executive Director of RedR Canada, Ottawa, ON

Established in London in 1979, RedR is now an international organization working to save lives and reduce suffering around the world from offices in the U.K., Australia, New Zealand, Canada and India. Members provide engineering expertise and technical, logistical and management support to front-line humanitarian relief agencies like the Red Cross, CARE, Oxfam and Save the Children.

Every year, millions of people at home and around the world suffer the devastating impact of natural and man-made disasters. Humanitarian agencies and governments respond with financial aid, and shipments of food, clothing and medical supplies.

At RedR, members complement the front-line relief groups by providing technical assistance vital to restoring the everyday lives of the affected communities by:

- Rebuilding roads and bridges,
- Re-establishing fresh water supplies,
- Managing waste,
- Restoring communications,
- Protecting the environment, and
- Managing financial, material and human resources

1.0 RedR Canada

In January 2001, the Association of Consulting Engineers of Canada (ACEC) signed a memorandum of understanding with RedR International, paving the way to the establishment of a RedR office in Canada. RedR Canada was incorporated as a federal charitable society in August 2001 when three other leading engineering organizations joined the ACEC as Founding Partners:

1. The Canadian Council of Professional Engineers (CCPE), representing the 160,000 professional engineers licensed to practice engineering in Canada;
2. The Engineering Institute of Canada (EIC), representing the engineering technical societies;
3. The Canadian Academy of Engineering (CAE), which honours individuals who have had eminent careers in engineering.

2.0 Update on Activities

RedR Canada has completed its first year of operations with very encouraging results. The Board of Directors finalised and adopted a governance model along professional lines, a start-up strategy was elaborated, membership recruiting and accreditation processes were set-up, 36 members were successfully registered, a member training plan was developed and initiated, and field placements were orchestrated.

On September 1, 2003, a grand ceremony was organised in Ottawa in honour of the humanitarian work performed by Her Royal Highness the Princess Royal (Princess Anne). Firstly, Princess Anne addressed the second annual general meeting of RedR Canada held at the Fairmont Château Laurier hotel noting that she agreed to come to the RedR annual meeting because she believes the organization has an enormous potential to make a difference. And she urged different aid delivery groups to work together to find ways of delivering assistance efficiently. Having money is not enough, she said; there must be co-ordination, understanding and efficient use of the expertise available. The party then travelled to Rideau Falls Park, where HRH laid a wreath of flowers on the monument to honour Canadian humanitarian aid workers following prayers led by representatives from seven of Ottawa's religious faiths. A group of about 150 was in attendance, including families of aid workers who lost their lives in the performance of their duties.

Later that night, at the Chateau Laurier, Princess Anne received the first RedR Canada Award for Meritorious Service in Humanitarian Aid, which was presented by the then Minister for International Cooperation, the Honourable Susan Whelan.

3.0 Membership

RedR Canada now has 36 members on the 2000 strong global Register and has created a new class of membership, reflecting the requirements of many of its clients: the Member-in-Training. Like the successful Engineer-in-Training program of the provincial engineering governing bodies, RedR's MIT program brings in younger and less experienced engineers to acquire experience, whereby they can become full members. With regards to membership, the goal is to recruit at least 14 more members by the end of the year.

4.0 Placements

Of the Canadian membership, four of them are presently on assignment overseas as a result of their own efforts. RedR Canada was instrumental in placing a New Zealand engineer with an American non-government organization (NGO) operating in Iraq. All Canadian members are well-qualified and the aim is to place as many of them as possible with RedR clients - the NGOs who operate on the front lines of disaster relief. But the office lacks the resources at present to do this in any meaningful way and we therefore hope to engage the efforts of volunteers to seek out placement opportunities.

5.0 Training

RedR's Canadian Training Program was initiated with a 2-week training program in Kingston that certified 8 Canadians as RedR Trainers and 21 Canadian participants which took an Essentials of Humanitarian Practice course. The idea of this first training period was to develop a pool of Canadian trainers able to present training packages in Canada and the rest of N. America as demands require, and to present the first RedR Canada training course. The course was led by a UK training team and produced a very successful event. All participants expressed that the course had been very good and all had fully participated.

In the near future, RedR Canada plans to establish and improve the training skills and confidence of the new trainers with several 2-day "So You Want To Be an Aid Worker" courses in the Ottawa, Kingston, Toronto and London (Canada) areas. Efforts are also under way for 3 day Conflict Resolution and Media relations skills course.

6.0 The Future

At its most recent general assembly in Auckland, NZ, RedR International decided to start addressing needs in disaster preparedness, in addition to its traditional markets in disaster relief, and to pursue partnerships in the commercial sector. This new development was supported by the Canada office and should be of considerable interest to engineering consulting firms with staff working on overseas development projects. RedR Canada will take a proactive position with regard to assisting disaster preparedness and is prepared to promote engineering services in this regard.

But to achieve this new objective, RedR Canada must first focus on two key goals - firstly, to spread awareness about RedR Canada, particularly within Canada's engineering community, and secondly, to create a stable financial basis from which to operate. RedR Canada is the only Canadian charitable organization that focuses on providing engineering expertise to disaster relief and preparedness operations, and every Canadian engineer should rightly be proud of the role that this organization is playing to help alleviate worldwide suffering. It is hoped that RedR Canada will become one of the charities of choice for the engineering community and that all engineers will consider making a modest contribution to support its activities.

To find out more about Red, visit our web sites: www.redr.ca and www.redr.org