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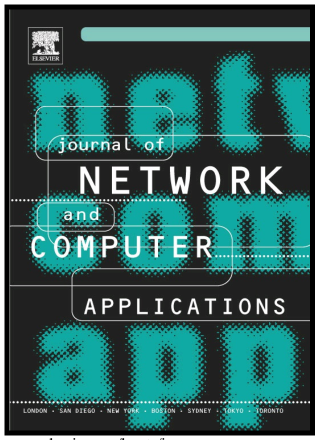

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A Survey of Smart Grid Architectures, Applications, Benefits and Standardization

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Abstract

The successful transformation of conventional power grids into Smart Grids (SG) will require robust and scalable communication network infrastructure. The SGs will facilitate bidirectional electricity flow, advanced load management, a self-healing protection mechanism and advanced monitoring capabilities to make the power system more energy efficient and reliable. In this paper SG communication network architectures, standardization efforts and details of potential SG applications are identified. The future deployment of real-time or near-real-time SG applications is dependent on the introduction of a SG compatible communication system that includes a communication protocol for cross-domain traffic flows within the SG. This paper identifies the challenges within the cross-functional domains of the power and communication systems that current research aims to overcome. The status of SG related machine to machine communication system design is described and recommendations are provided for diverse new and innovative traffic features.

***Index Terms*—Telecommunications, Smart Grid, Standards, Survey, Smart Grid Application.**

I. Introduction

In the era of advanced automation and broadband communications where every aspect of daily life can be positively affected by smart applications; our power grids continue to be operated using antiquated technologies and systems. Although the traditional power grid has been an effective solution for more than 50 years, the future is uncertain as the shift from coal and gas to solar and wind occurs. As more efficient and lower cost batteries come onto the market the opportunity for bidirectional electricity flows will grow and the open loop system, where power flows from the generation plant to the customer, will cease to be the norm. Also, a lack of situational awareness, poor visibility and control over the power grid is making it more vulnerable to disturbances such as blackouts and brownouts [1, 2]. However, there are other pressing issues such as the move to incorporate renewable energy and gradually reduce carbon emissions. In the United States of America power generation produces more than 40% of carbon emissions [3]. Similarly, Australia's total carbon emissions are projected to reach 685 Mt and 801 Mt of CO2 in 2020 and 2030 respectively, where power generation will be producing 30% of the carbon emissions in both cases [4]

Governments around the world are now putting substantial effort into greenhouse gas emission reduction in order to slow the adverse effects of climate change. In Australia, more than 3.5 million people are living in premises with rooftop solar panels. The introduction of Electric Vehicles (EV) has been another promising step towards lower carbon emissions, but it will take some time until EV sales eclipse sales of oil dependent vehicles. The Australian Clean Energy Council estimated that the power produced from Australian rooftop solar panels will soon produce up to 3 GW which is equivalent to the electrical energy needed to run Melbourne's train network [5]. According to the Australian Energy Market Commission EV sales will increase by 20 per cent by 2020 and by 45 per cent by 2030. The Commission also found that there will be an additional peak electricity demand of 1900MW [6].

Fig. 1 shows a traditional power grid where the power flow follows a hierarchical pattern and is functionally unidirectional. The power is generated from the power plant and supplied to the distribution domain via a high voltage electricity transmission network. In the distribution domain the power is transmitted to customers via substations and a low voltage distribution network. The advent of renewable energy and increasing use of various Distributed Energy Resources (DER) have made it necessary for the power grid to facilitate bidirectional power flows. To stabilize operational parameters and balance load profiles to enable bidirectional energy flow capability, the existing power grid should be efficiently operated using enhanced control and monitoring technologies. The shift towards bidirectional energy flows and improved control and monitoring of the power grid