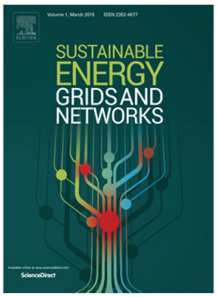
Accepted Manuscript



A Fuzzy Analytic Hierarchy Process algorithm to prioritize Smart Grid Technologies for the Saudi electricity infrastructure

Turki A. Alaqeel, Siddharth Suryanarayanan

PII: S2352-4677(17)30066-8
DOI: https://doi.org/10.1016/j.segan.2017.12.010
Reference: SEGAN 135

To appear in: *Sustainable Energy, Grids and Networks*

Received date : 3 March 2017
Revised date : 24 September 2017
Accepted date : 30 December 2017

Please cite this article as: T.A. Alaqeel, S. Suryanarayanan, A Fuzzy Analytic Hierarchy Process algorithm to prioritize Smart Grid Technologies for the Saudi electricity infrastructure, *Sustainable Energy, Grids and Networks* (2018), https://doi.org/10.1016/j.segan.2017.12.010

A Fuzzy Analytic Hierarchy Process Algorithm to Prioritize Smart Grid Technologies for the Saudi Electricity Infrastructure

Turki A. Alaqeel[a] *and* Siddharth Suryanarayanan[b]

[a] *Advanced Power Engineering Laboratory, Department of Electrical and Computer Engineering, Colorado State University, Fort Collins, CO 80523-1373, USA,* turki.alaqeel@colostate.edu
[b] *Advanced Power Engineering Laboratory, Department of Electrical and Computer Engineering, Colorado State University, Fort Collins, CO 80523-1373, USA,* sid@colostate.edu

Corresponding author: Turki A. Alaqeel, *Advanced Power Engineering Laboratory, Department of Electrical and Computer Engineering, Colorado State University, Fort Collins, CO 80523-1373, USA,* turki.alaqeel@colostate.edu

Highlights

- Saudi Transformation Program is adapted to develop a systematic framework for technology prioritization
- The framework proposes a transitional roadmap of grid modernization for policy makers
- A Fuzzy Analytic Hierarchy Process algorithm is used to prioritize Smart Grid technologies
- Triangular fuzzy numbers are used to model planning uncertainty
- Advanced metering infrastructure is the most important alternative for the modernization of the Saudi grid

Abstract

Uncertainty is an inherent feature in grid modernization planning decisions. The paper presents a decision analysis framework to integrate Smart Grid technologies and applications for the modernization of the Saudi electricity infrastructure. The analysis applies a fuzzy set theory accompanied by the Analytic Hierarchy Process. Imprecision in decision making—particularly those arising from human subjectivity in input—is explicitly modeled using fuzzy sets. This paper demonstrates the use of triangular fuzzy numbers to model uncertainty in planning decisions. The Saudi electricity infrastructure aims at meeting certain goals stated in the Saudi Vision 2030 and the National Transformation Program. We propose an algorithm for prioritizing candidate Smart Grid technologies for grid modernization. This is intended as a tool for charting a transitional modernization plan for policy makers and for meeting specific targets in a transformation program.

Keywords

Analytic Hierarchy Process
Fuzzy set theory
Electric Grid modernization
Multi-criteria decision making
Saudi National Transformation Program
Smart Grid

Nomenclature

AAM	Advanced Assets Management
ADO	Advanced Distribution Operations
AHP	Analytic Hierarchy Process
AMI	Advanced Metering Infrastructure
ATO	Advanced Transmission Operations
BSCFD	Billion Standard Cubic Feet per Day
CI	Consistency Index
DOE	Department of Energy
FACTS	Flexible AC Transmission Systems
FCL	Fault Current Limiter
HAN	Home Area Networks
HVDC	High Voltage Direct Current
IEEE	Institute of Electrical and Electronics Engineers
KPI	Key Performance Indicator
MAIFI	Momentary Average Interruptions Frequency Index of durations under 5 minutes
MCDM	Multi-Criteria Decision Making
MDMS	Meter Data Management System
NETL	National Energy Technology Laboratory
NIST	National Institute of Standards and Technologies
PES	Power and Energy Society
PEV	Plug-in Electric Vehicle
PHEV	Plug-in Hybrid Electric Vehicle
PMU	Phasor Measurement Unit
RI	Random Index
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SEC	Saudi Electricity Company
SGTs	Smart Grid Technologies
UPFC	Unified Power Flow Controller
WAM	Wide Area Monitoring

1. Introduction

The modernization of electricity grid infrastructure occurs in several stages of improvement and upgrades as evidenced in multiple electricity infrastructures across the world. In some grid systems, the focus has been on upgrading the infrastructure of assets and renewing the devices and machines, which are the backbone of the grid. In some other grid systems, the focus has been on improving the level and depth of inter-communication and control among grid sectors, namely generation, transmission, distribution, and consumers. In other electricity infrastructures, electricity markets were given much more attention by liberalizing the market and enabling two-way communication means between service