Applied Energy 172 (2016) 360–371

Contents lists available at ScienceDirect

Applied Energy

journal homepage: www.elsevier.com/locate/apenergy

Assessing energy business cases implemented in the North Sea Region and strategy recommendations

Bing Xu [a,*], Amar Nayak [b], David Gray [b], Jamal Ouenniche [c]

[a] School of Management and Languages, Heriot-Watt University, Edinburgh EH14 4AS, UK
[b] Aberdeen Business School, Robert Gordon University, Aberdeen AB10 7QE, UK
[c] Business School, The University of Edinburgh, Edinburgh EH8 9JS, UK

HIGHLIGHTS

- Propose an integrated MCDA-based framework to benchmark DSM energy business cases.
- Address interests from various stakeholders, different forms of data, both fuzzy and crisp relations.
- Contract optimisation and offering reserve capacity strategies works well.
- Lack of strong incentives for firms to implement energy solutions on a larger scale.
- Need to design attractive incentive programmes to attract more industry engagement.

ARTICLE INFO

Article history:
Received 8 November 2015
Received in revised form 11 March 2016
Accepted 28 March 2016
Available online 7 April 2016

Keywords:
Smart energy
Demand-side management
Energy flexibility
North Sea Region
Harbours

ABSTRACT

e-harbours is a unique European project that was set out to identify viable energy business cases on the exploitation of energy flexibility, which optimise their operations to match energy demand and supply while taking account of the additional volatility in supply caused by renewable energy sources, improve energy efficiency, and reduce dependence on fossil fuels. In this paper, we propose an integrated multi-criteria decision analysis based framework to assess the relative performance of 21 energy business cases, which implemented different demand-side management strategies. Our proposed methodology has the ability to address complex problems involving multiple conflicting interests from various stakeholders, different forms of data, and different fuzzy and crisp relations. We find that business cases based on contract optimisation and offering reserve capacity were ranked relatively high, while those based on trading on the wholesale market or hybrid approaches fared less well. Despite finding viable pilot business cases, *e-harbours* found that there was little enthusiasm among industrial partners to scale up the pilots. Consequently, EU governments should consider offering attractive incentive programmes for industry engagement in achieving their objectives in reducing greenhouse gas emissions, improving energy supply security, diversifying energy supplies, and improving Europe's industrial competitiveness.
© 2016 Elsevier Ltd. All rights reserved.

1. Introduction

1.1. Motivation

The promotion of renewable energies is a key pillar of the European Commission's broader energy and climate objectives of reducing greenhouse gas emissions, improving energy supply security, diversifying energy supplies, and improving Europe's industrial competitiveness. However, the intermittency of renewable energy has introduced additional volatility into the management of energy grids, leading to an increasing challenge around balancing energy supply and demand through traditional *supply-side management*. The deregulation of electricity markets along with the advances in information and communication technologies (ICTs) have encouraged various stakeholders (e.g., policy makers, energy companies and grid operators) to look increasingly at opportunities presented by *demand side management* (DSM). DSM is typically achieved through economic incentives along with energy storage technologies with the aim of flattening peaks and troughs in demand to help reduce load volatility and stress on the grid infrastructure, reduce the volume of the expensive standby capacity required, and create capacity to absorb excess renewable production to feed it back into the grid at times when

* Corresponding author.
E-mail address: b.xu@hw.ac.uk (B. Xu).

http://dx.doi.org/10.1016/j.apenergy.2016.03.110
0306-2619/© 2016 Elsevier Ltd. All rights reserved.

there is demand. In practise, DSM allows end-users to adjust electricity consumption in response to market signals and is often considered as an efficient way to reduce energy costs and greenhouse gas emissions, improve system reliability and operational security [1,2].

Despite many advantages of DSM, it has had limited widespread usage to date [3,4]. The main barriers include low awareness of DSM programmes in promoting energy, carbon, and cost reductions, the lack of compelling business cases to demonstrate how one can exploit flexibility within their systems to persuade both businesses and households to invest in the necessary infrastructure or alter established consumption practises [5,6].

1.2. Scope

Most empirical studies tend to measure the effectiveness of DSM programmes via simple cost-benefit analysis (CBA) or in terms of carbon reduction. For example, [7] assessed the potential for cost reductions by considering a future German power system with a variable renewable energy share of 70% of the total energy supplied scenario. [8] investigated the potential for DSM to match the energy demand for a domestic dishwasher with available renewable energy supply to reduce cost and greenhouse gas emissions from thermal generation. [9] developed a techno-economic methodology to evaluate three capacity-based DSM business cases for domestic and commercial end-users. [4] compared the performance of various DSM programmes (i.e., short term operating reserve, triad, fast reserve and smart meter roll-out) based their ability on carbon savings.

Governments and municipalities are keen for end-users to implement DSM. However, the capital costs associated with DSM technology and/or the organisational disruption required to alter established operational practises are significant barriers potentially for large industrial energy users. Energy companies also need to see some benefit in encouraging their customers to consume less energy. Consequently, it is likely that the most effective DSM interventions – in terms of energy management – will not be the most attractive ones for all stakeholders. It is arguably more important identify *deliverable* interventions that are acceptable to all stakeholders rather than those with the best CBA or which are best at mitigating carbon emissions. It is also important to compare very different types of isolation. Typically, the merits of technical interventions are considered by engineers, while the potential of market are considered by economists. Previous studies have rarely sought to compare technical and financial instruments using common criteria. A methodology is therefore required that can consider – systematically – the often divergent perspectives of all stakeholders who are potentially involved in delivering DSM interventions and a range of disparate interventions ranging from engineering to financial management.

1.3. Contributions

In this study, we use an integrated multi-criteria decision analysis (MCDA)-based framework to assess the relative performance of different DSM strategies. Our methodology explicitly takes different stakeholders' perspectives into account. Moreover, it allows us to evaluate the effectiveness of DSM strategies under multiple criteria and with data in different forms. For example, some criteria are measured on monetary scale (e.g., additional investment cost, additional running costs), while a discrete scale can be used for those factors that are difficult to quantify in monetary values (e.g., technical transferability, stakeholders' attitudes). In addition, we allow for fuzzy relations for some criteria instead of crisp relations, by considering the magnitudes of differences so that small differences in performance would not matter in discriminating between DSM programmes. Our proposed approach is a generic framework and as such could be applied to assess any DSM programmes.

The methodology was developed as part of *e-harbours*, a European Interreg 4b North Sea Region funded project. Our model was applied to 21 *e-harbours DSM business cases* piloted across five European countries. By focusing on a motives, attitudes and decision making of end-users, stakeholders and experts – rather than merely the pure technical or financial aspects of DSM – the paper makes a new contribution to the field. The paper also compares and accesses a range of different pilot interventions (e.g., engineering investments, operational changes, contract optimisation and market trading). We also discuss how flexibility might more effectively be exploited within operations ranging from large industrial businesses, to small businesses, to private users in real applications and we conclude by making some practical points on the need for government and policy makers to take the lead on the large scale implementation of DSM.

1.4. Outline

The paper is organised as follows. Section 2 discusses the key approaches for managing the electricity supply–demand balance, and provides information on the *e-harbours* partners and their business cases. Section 3 describes the proposed MCDA-based framework. In Section 4, we present and discuss our empirical results. Section 5 discusses policy recommendations. Section 6 concludes the paper.

2. Demand side management and energy business cases

2.1. Common approaches to maintaining the electricity network equilibrium

Running an electricity system reliably requires energy supply and demand to be balanced in real time. This balance is not necessarily easy to achieve, as both supply and demand levels can change rapidly and unexpectedly due to many reasons, such as generation outages, transmission and distribution line outages, and sudden load changes [1,5]. The traditional approach to maintain the network equilibrium is to vary electricity supply to match fluctuations in demand. However, with the increasing penetration of renewable energy sources (e.g., wind and PV) and the liberalisation of electricity markets, new uncertainties have been introduced into the energy system [10,11]. The geography of renewable energy production (e.g., wind, PV energy) provides one challenge for energy companies and grid managers. The grid is designed to transfer energy from a handful of central generation points outwards. Feeding renewables into the grid causes uncertainty of supply and – given that wind renewables in particular are often generated in remote, rural or island communities, renewable energy also places a strain on the transmission infrastructure in parts of the grid that are not designed for heavy input loads [12,13]. Thus, the intermittency of renewables creates problems for grid operators, in terms of the need to have expensive power generation capacity on standby. In some countries, this creates opportunities for third party power balancing companies, who make a large amount of money out of matching increasing unpredictable energy supply with demand (increasing costs for large energy consumers), while an excess of renewable off-peak times creates market anomalies, with negative energy markets (where suppliers have to pay consumers to use energy), which have been experienced in Belgium and Germany, set to become more widespread [14].

Download English Version:

https://daneshyari.com/en/article/6683289

Download Persian Version:

https://daneshyari.com/article/6683289

Daneshyari.com