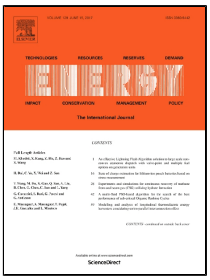
Accepted Manuscript



Smart Energy and Smart Energy Systems

Henrik Lund, Poul Alberg Østergaard, David Connolly, Brian Vad Mathiesen

PII:	S0360-5442(17)30881-2
DOI:	10.1016/j.energy.2017.05.123
Reference:	EGY 10931
To appear in:	*Energy*
Received Date:	19 February 2017
Revised Date:	30 April 2017
Accepted Date:	19 May 2017

Please cite this article as: Henrik Lund, Poul Alberg Østergaard, David Connolly, Brian Vad Mathiesen, Smart Energy and Smart Energy Systems, *Energy* (2017), doi: 10.1016/j.energy.2017.05.123

Smart Energy and Smart Energy Systems

Henrik Lund[1][A], Poul Alberg Østergaard[A], David Connolly[B] and Brian Vad Mathiesen[B]

[A]*Department of Planning, Aalborg University, Skibbrogade 5, 9000 Aalborg, Denmark*
[B]*Department of Planning, Aalborg University, A.C. Meyers Vænge 15, 2450 Copenhagen, Denmark*

HIGHLIGHTS:

- A review of the use of *Smart Energy Systems* in scientific papers
- The term *Smart Energy Systems* was first mentioned in 2009.
- In recent years, used mostly to express a holistic systems approach as opposed to a single sector approach
- The *Smart Energy Systems* concept represent a radical shift in approach and understanding
- The *Smart Energy Systems* approach has the potential to identify more efficient and affordable solutions.

Abstract

In recent years, the terms "Smart Energy" and "Smart Energy Systems" have been used to express an approach that reaches broader than the term "Smart grid". Where Smart Grids focus primarily on the electricity sector, Smart Energy Systems take an integrated holistic focus on the inclusion of more sectors (electricity, heating, cooling, industry, buildings and transportation) and allows for the identification of more achievable and affordable solutions to the transformation into future renewable and sustainable energy solutions. This paper first makes a review of the scientific literature within the field. Thereafter it discusses the term Smart Energy Systems with regard to the issues of definition, identification of solutions, modelling, and integration of storage. The conclusion is that the Smart Energy System concept represents a scientific shift in paradigms away from single-sector thinking to a coherent energy systems understanding on how to benefit from the integration of all sectors and infrastructures.

Key words: Renewable Energy Systems, Smart Grid, Energy system modelling, Electro fuels, Power-to-Gas, Power-to-heat

1. Introduction

In recent years, several new definitions and terms have been put forward to develop new approaches and understandings on how to design future sustainable energy systems such as e.g. *smart grid* [1], *Net Zero Energy Buildings (NZEB)* [2] and *power to gas* [3]. These terms are typically defined and applied within the limits of sub-sectors and sub-infrastructures and therefore often represent a single-sector approach, which cannot be fully understood or analysed if not properly placed in the context of the overall energy system.

The term *Smart Energy* or *Smart Energy Systems* was defined and used in order to provide the scientific basis for a paradigm shift away from single-sector thinking into a coherent and integrated understanding of

[1] Corresponding Author: Lund@plan.aau.dk and +45 9940 8309