TECHNOLOGY-ANALYSIS:

Energy Management of renewable energy sources

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1 INTRODUCTION

This document consists of a collection of abstracts of scientific papers dealing with several topics in energy management. Special focus is given on the integration of renewable energy generation systems, mainly photovoltaics, and battery storage. Also grid-connection, the effects of variable pricing and the management of neighbourhood energy exchange in micro grids have been elaborated.

2 PAPERS

2.1 Battery Storage versus Neighbourhood Energy Exchange to Maximize Local Photovoltaics Energy Consumption in Grid-Connected Residential Neighbourhoods

Author:

R. Velik

Publication:

IJARER International Journal of Advanced Renewable Energy Research, Volume 2, Number 6, 2013

Abstract:

Over the last decade, European renewable energy laws and funding policies have led to a strong growth of the installed photovoltaic (PV) capacity within Europe. The increasing amount of these decentralized, weather and time of year dependent energy production sources is starting to challenge our grid capacity, grid stability, and security of supply. As a reaction, feed-in tariffs for solar power have started to decrease and laws are being put into place to limit the allowed amount of grid feed-in of photovoltaics installations. Accordingly, a current trend in research goes towards developing technologies, concepts, and strategies to minimize grid-feeding and maximize the local consumption of locally produced PV energy. One key concept in this context is local energy storage. Another idea is the local exchange of energy within “neighbourhood compounds”. In this article, we analyze and compare the achievable local PV energy consumption of PV-equipped residential buildings embedded into a residential neighbourhood for two different optimization strategies: (1) maximization of PV consumption within individual buildings via the temporal storage of surplus energy in a battery, (2) maximization of local PV consumption within the neighbourhood by energy exchange between neighbours instead of or in addition to energy storage in batteries. Analyses base on real-word measurement data and include investigations for different storage sizes and for different seasons of the year (summer/winter).

2.2 The Influence of Battery Storage Size on Photovoltaics Energy Self-Consumption for Grid-Connected Residential Buildings

Author:

R. Velik

Publication:

IJARER International Journal of Advanced Renewable Energy Research, Volume 2, Number 6, 2013

Abstract:

A current trend in renewable energy research goes towards the development of storage technologies in order to bridge gaps in energy supply. In this context, one prominent, hotly debated application scenario is the employment of battery storage systems for photovoltaic-equipped buildings to maximize the self-consumption/supply of produced photovoltaics (PV) energy and minimize the purchase of grid energy as well as grid feed-in. Due to currently still high prices for battery storage systems, finding the optimal cost-benefit ratio between employed storage size and achievable energy self-consumption/supply is a crucial research topic. Accordingly, in this article, we investigate the effect of employed storage size on the achievable energy self-consumption/supply of photovoltaic-supplied households based on real-world household load data and solar irradiance data in combination with computational simulations. Differences in results are analyzed in dependence of the season of the year (summer/winter). Results show that the achievable PV energy self-consumption and supply increase with storage size until they reach a “plateau” at a storage size sref that equals the average amount of daily PV-consumption/production. While in summer, 98% of all load energy could be supplied via PV energy using a storage size of sref, in winter, this amount was only 66%. Concerning PV-self-consumption, in winter, with a storage size of sref, 88% of PV energy could be consumed “in-house” and 75% in summer.

2.3 Cognitive Architectures as Building Energy Management System for Future Renewable Energy Scenarios – A Work in Progress Report

Author:

R. Velik

Publication:

IJSEI International Journal on Science and Engineering Investigations, Volume 2, Number 17,pp. 68–72, 2013

Abstract:

As determined in the EU climate and energy package, until 2020, 20% of energy has to be gained from renewable sources together with a 20% reduction of the overall energy consumption. Today, approx. 40% of the total energy consumption in higher developed countries stems from buildings. Thus, aiming at a reduction of energy consumption in homes and public buildings is an important factor in the fulfillment of these objectives. This requires the development of new building energy management concepts. Accordingly, in this article, a novel cognitive architecture for building energy management based on advanced recognition, decision-making, and control strategies is introduced. Furthermore, a PV supplied, storage augmented, grid connected test bed is presented, which is suitable for flexibly testing the performance of building energy management systems in future renewable energy scenarios. The article shall be understood as the first part of a series of work in progress reports of our research.

2.4 Renewable Energy Self-Consumption versus Financial Gain Maximization Strategies in Grid-Connected Residential Buildings in a Variable Grid Price Scenario

Author:

R. Velik

Publication:

IJARER International Journal of Advanced Renewable Energy Research, Volume 2, Number 6, 2013

Abstract:

The currently ongoing change of residential buildings from passive energy consumers to active prosumers via the integration of PV (photovoltaics) and storage systems and the putting in place of variable grid prices require the development, implementation, and evaluation of novel energy management concepts and strategies. In this article, we investigate and compare (1) a “PV self-consumption maximization” strategy with (2) a “financial gain maximization” strategy in terms of local PV energy consumption/supply and obtainable financial gain. Analyses are based on real-world household load data, solar irradiance data, and computationally simulated grid prices. Results are analyzed for different storage sizes for both a summer and a winter period. Results show that the achievable PV energy self-consumption/supply is significantly higher for the “PV self-consumption maximization” strategy and reaches a “plateau” at a storage size that equals the average amount of daily PV-production and load consumption. On the contrary, the obtained financial gain over the two investigated seasons is significantly higher when employing the “financial gain maximization” strategy and reaches a plateau at a storage size equaling 50% of the average amount of daily PV-production and load consumption.

2.5 East-West Orientation of PV Systems and Neighbourhood Energy Exchange to Maximize Local Photovoltaics Energy Consumption

Author:

R. Velik

Publication:

International Journal of Renewable Energy Research, Volume 4, Number 3, pp. 566-570, 2014

Abstract:

Increasing local photovoltaics (PV) utilization can reduce energy transportation losses and mitigate overvoltages and transformer overloadings. Strategies so far investigated and applied for this purpose are load shifting, the use of electricity storages, and the installation of east-west instead of south-oriented PV systems. In this article, we investigate and analyze the potential of a novel concept for the purpose of local PV consumption maximization based on neighbourhood energy exchange in combination with different cardinal directions of PV systems installed on buildings within a neighbourhood. Results demonstrate that this novel concept can lead to significantly increased local PV consumption rates in relation to today's default configurations without considerable extra costs or control efforts.
Algorithms for Automatically Finding Optimal Energy Management Strategies for Building Microgrids (Storage, PV System, Loads, Grid-Connection) and Neighbouring Microgrid Clusters are evaluated.

2.6 Energy management in storage-augmented, grid-connected prosumer buildings and neighbourhoods using a modified simulated annealing optimization

Author:

Velik, R., Nicolay, P.

Publication:

Computers & Operations Research, accepted, 2015

Abstract:

This article introduces a modified simulated annealing optimization approach for automatically determining optimal energy management strategies in grid-connected, storage-augmented, photovoltaics-supplied prosumer buildings and neighbourhoods based on user-specific goals. For evaluating the simulated annealing optimizer, a number of test scenarios in the field of energy self-consumption maximization are defined and results are compared to a total state space search reference method. Results show that the simulated annealing approach managed to find in all test scenarios a solution equal or very close to the global optimum with significantly less computational effort and processing time than the reference method.

2.7 Grid-Price-Dependent Energy Management in Microgrids Using a Modified Simulated Annealing Triple-Optimizer

Author:

Velik, R., Nicolay, P.

Publication:

Applied Energy, Volume 130, pp. 384-395, October, 2014

Abstract:

This article introduces a modified simulated annealing triple-optimizer for finding the optimal energy management strategy in terms of financial gain maximization in grid-connected, storage-augmented, photovoltaics-supplied prosumer building microgrids in a variable grid price scenario. For evaluating the performance of the optimizer, a number of test cases are specified offering different trading options to the prosumers. Obtained results are compared to a total state space search reference method and demonstrate that the simulated annealing approach was for all test cases able to find a globally optimal or close to optimal solution in significantly less computation time than the total space search reference method.

2.8 A Cognitive Decision Agent Architecture for Optimal Energy Management of Microgrids

Author:

Velik, R., Nicolay, P.

Publication:

Energy Conversion and Management, Volume 86, pp. 831-847, October 2014

Abstract:

Via the integration of renewable energy and storage technologies, buildings have started to change from passive (electricity) consumers to active prosumer microgrids. Along with this development come a shift from centralized to distributed production and consumption models as well as discussions about the introduction of variable demand-supply-driven grid electricity prices. Together with upcoming ICT and automation technologies, these developments open space to a wide range of novel energy management and energy trading possibilities to optimally use available energy resources. However, what is considered as an optimal energy management and trading strategy heavily depends on the individual objectives and needs of a microgrid operator. Accordingly, elaborating the most suitable strategy for each particular system configuration and operator need can become quite a complex and time-consuming task, which can massively benefit from computational support. In this article, we introduce a bio-inspired cognitive decision agent architecture for optimized, goal-specific energy management in (interconnected) microgrids, which are additionally connected to the main electricity grid. For evaluating the performance of the architecture, a number of test cases are specified targeting objectives like local photovoltaic energy consumption maximization and financial gain maximization. Obtained outcomes are compared against a modified simulating annealing optimization approach in terms of objective achievement and computational effort. Results demonstrate that the cognitive decision agent architecture yields improved optimization results in comparison to the state of the art reference method while at the same time requiring significantly less computation time.