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Sustainable Energy Planning and Management with PV, Waste Heat, Positive Energy Districts and CO_2 Accounting

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ABSTRACT

This 41st volume of the International Journal of Sustainable Energy Planning and Management includes three categories of articles: Regular articles, articles from the 2023 Smart Energy Systems Conference held in Copenhagen, Denmark, and an article originating from the 2023 Sustainable Development of Energy, Water and Environmental Systems (SDEWES) conference series. The work presented address photo voltaics (PV) in the Arctic and in Sweden and electricity system scenarios of Indonesia based on, e.g. PV. Staying with PV a study investigates the interplay between PV and electric vehicles in Denmark. Moving to district heating, two articles address waste heat utilisation and positive energy districts respectively, and finally a study probes into unavoidable carbon dioxide emissions in Austria and accounts for carbon capture and storage (CCS) and carbon capture and utilisation (CCUS) needs and possibilities.

Keywords

Photo voltaics;
Electric vehicles;
Waste heat utilisation;
Industry;
CCU and CCUS

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1. Regular Articles

The opening section of this 41st volume of the International Journal of Sustainable Energy includes three ordinary articles. In the first, Fitriani and coauthors [1] address power generation in Indonesia; a country aiming for net zero emission (NZE) by 2060. A NZE scenario is developed and compared to a Business as Usual (BAU) scenario. Results suggest NZE could be reached by 2075, with PV playing a key role. By 2100, NZE predicts a 28% increase in electricity demand, and PV is expected to contribute 32.8% to power supply by 2075, with battery storage providing 198.8 GW. Indonesia has traditionally been a focus country for research presented in this journal, with studies on energy for road transportation [2,3], the impact of COVID-19 on renewable energy implementation [4], and generation expansion [5].

Moving further north [6], Reindl and Palm follow up with PV in Scandinavia and examine PV adoption among non-residential property owners in Sweden. Using social practice theory, they identify key elements for PV adoption. Twenty-five interviews were conducted with property owners in southern Sweden of which about half had established PV adoption practices, including energy goals, tenant interaction, company routines, knowledge aggregation, and trusted installer relationships. Conversely, first-time installers and non-adopters lacked these elements. Previously, Kozarcanin [7] investigated PV for apartment buildings in Sweden, while further south, Ugulu [8] investigated the uptake of PV in Nigeria, Miraj [9] investigated decision-making for PV, Schaefer [10] addressed business networks for PV, and Oloo [11] and Gunawan [12] investigated PV in Kenya and Indonesia respectively.

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Finally, in this issue, in [13] Asplund and Nilsson take the readers above the Arctic Circle and investigate PV in the Arctic region of Scandinavia – more explicitly Northern Norway and Sweden - with a starting point in two trends which are transforming the PV landscape in high latitudes: falling costs and rising industrial electricity demand. Historically limited by low sunlight and summer electricity needs, Arctic PV is becoming viable, and this article explores utility-scale PV in Northern Scandinavia, where costs are projected to drop from 51 EUR/MWh to below 35 EUR/MWh by 2030. Utility-scale PV could complement wind and hydro to meet rising industrial electricity demands above the Arctic Circle by 2030. This is the first Arctic article in the journal – and logically also the first Arctic PV article in the journal. Previous studies on renewable electricity generation in Norway and Sweden have targeted hydro power [14,15], wind power [16] and PV further south in Sweden [7].

2. Smart Energy Systems Conference 2023

From the Smart Energy Systems conference, Jeannin and coauthors [17] address the electrification of transportation, but the combination of electrification and additional variable renewable energy sources (RES) in the electricity system strains this. Thus, charging of electric vehicles (EV) must match system demands. In their work, the authors address a case in Copenhagen, Denmark focusing on EVs and PV. Their analyses showed that only 11% of the EV battery capacity was used for daily mobility – leaving the remainder as a potential flexibility to be exploited. Thus, the PV focus of the issue ends in the southernmost part of Scandinavia. Other authors have also previously looked into EV charging such as Juul [18] and of course, Lund [19] previously showed how storage outside the electricity sector should be given priority – albeit – for EVs the situation is different, as the investment cost has already incurred for mobility reasons.

Moving to heating, Jürgens and coauthors [20] address the significant potential for heating sector decarbonization though exploitation of waste heat from data centres. They examine its feasibility for meeting the heat demand of two districts in Frankfurt, Germany. Proposed is a near-exclusive coverage of the total heat demand (144 GWh/a) through waste heat integration. High-capacity heat pumps, gas boilers, and thermal energy storage can cover 97.5% of the heat demand, economically favourably compared to individual heat pumps. Their work indicates that CO_2 emission reductions of 78 % for the district heating (DH) network are possible. In this journal, Mezzera [21] previously looked into waste heat from hydrogen production, Divkovic looked into industrial waste heat in Germany [22], Pieper [23] used geographical information systems (GIS) to locate heat sources, and several other authors also include waste heat as a source for DH systems.

In [24], Blumberga and coauthors investigate positive energy districts based on a case addressing a Riga university campus. This article explores a smart energy system with PV, various storage options, and waste heat use. Improved building management could boost efficiency. The area could reach a 80% RES self-consumption using wind turbines, solar, heat pumps, and waste heat recovery with optimal storage. This complements previous work published in the journal where Edtmayer [25] looked into positive energy districts in Germany, Rankinen [26] focused on stakeholders and Maestosi discussed them from a funding perspective [27].

In [28], Ghionda and coauthors address industrial energy use from which roughly a quarter of global CO_2 emissions originate. In their study, the authors focus on a cost-effective decarbonization plan for an Italian pharmaceutical company, aligning with Horizon Europe FLEX Industries goals. Using a tailored simulation framework and MOEA, it explores energy mixes for 2024. Thirteen technologies are assessed across three scenarios, revealing Pareto optimal solutions balancing emissions reduction and cost. Hybrid solutions show promise, driven by factors like available land for RES and local biomass supply chains. Viesi previously looked at multi objective optimisation [29], and Roberte [30] used to approach to analyse storage. Other work outside the present journal stress electrification as a path forward for the industrial sector [31,32].

3. SDEWES 2023 Special Issue

Hochmeister and coauthors take a starting point in the hard-to-abate emissions from e.g. industry and agriculture – and track unavoidable emissions in Austria along with 2050 projections. The accounting of sources is coupled with surveys of demands for CCU and CCS. Projections show a 2050 need for CCS for 4 Mt annually in Austria. Previously, Chlela [33] looked at water use implication of CCUS in this journal.

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