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# Zero emission office building in Bergen: Experiences from first year of operation

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## Abstract

The Visund office building is a pilot project within the Research Centre on Zero Emission Buildings (ZEB) in Norway. The building has been in operation since January 2016. The design aimed at meeting the ZEB-criterion of net zero energy balance, excluding energy for appliances. The energy performance has been closely monitored and the energy measurements during the first year corresponds well with the predicted and required performance. A high focus on shared goals, contract based economic incentives, building design and technology choices, energy monitoring and follow-up measures have been key-factors to achieve the goals.

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## 1. Introduction

The Visund office building is a pilot building project within the Research Centre on Zero Emission Buildings (ZEB). The building, which is owned by the Norwegian Defence Estates Agency (Forsvarsbygg), was constructed in 2015. It is located at Haakonsværn naval base, about 15 km from Bergen at the west of Norway (latitude 60°N).

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The building design aimed at meeting the ZEB-criterion of net zero energy and GHG emission balance for building operation during a year [1]. The energy for appliances (computers, printers, etc.) is not included in the balance. This paper presents the design of the building, the method for energy monitoring and results from the first year of operation.

### 1.1. Building design

The Visund office building has three floors and a heated floor area of 2031 m<sup>2</sup>. A compact and simple building form was chosen in order to minimize heat losses, avoiding air leakages, and minimizing costs [2]. Good daylight conditions in the occupied spaces were obtained by placing offices and primary rooms along the facades, while secondary rooms were placed in the interior. Windows were designed to maximize daylight conditions.

Table 1. Building and climate data for the Visund office building in Bergen, Norway.

Heated floor area	2031 m <sup>2</sup>
U-values: External walls/roof/floor on ground/windows and doors	0.13 / 0.09 / 0.08 / 0.73 W/m <sup>2</sup> K
“Normalized” thermal bridge value (per m <sup>2</sup> heated floor area)	0.03 W/m <sup>2</sup> K
Air tightness, air changes per hour (at 50 Pa), measured value	0.11
Yearly mean ambient temperature / winter design / summer design	7.5°C / -11.7°C / 18.9°C

### 1.2. Energy system design and energy budget

A local seawater-based heat pump provides thermal energy to the building. It was predicted that the heat pump will deliver 90% of the heating and domestic hot water (DHW) need with a seasonal coefficient of performance (SCOP) of 3. The predicted efficiency of the 10% heating and DHW need delivered by electricity is 88%. All the cooling need will be covered by the seawater pump, with a predicted SCOP of 10. The thermal energy losses in the waterborne circuits are including in the estimated SCOP-values. The lighting system consists of T5 fluorescent tubes and LEDs, equipped with occupancy and daylight controls. The ventilation system encompass active terminal devices with built-in controls, which automatically measure and control the air volumes and temperatures at room level.

The predicted net energy need and delivered energy is shown in Table 2 [3], using terms from prEN 15603 [4] and NS3031 [5]. The total net energy need of the office building is 54.1 kWh/m<sup>2</sup> and the required delivered energy is 42.1 kWh/m<sup>2</sup> electricity. Excluding appliances of 15.7 kWh/m<sup>2</sup>, a photovoltaic (PV) system has to generate minimum 26.4 kWh/m<sup>2</sup> solar electricity to satisfy the ZEB-criterion. This solar electricity is supplied by an 84.58 kW<sub>p</sub> PV-system installed on the roof, facing east/west. The predicted energy production is 55,320 kWh/year or 27.2 kWh/m<sup>2</sup> heated floor area, providing a margin of 0.8 kWh/m<sup>2</sup>.

Table 2. Predicted annual net energy need and delivered energy for the Visund office building, per net heated floor area. Calculations are based on statistical weather data for Bergen and is according to NS 3031, using the simulation tool SIMIEN ([www.programbyggerne.no](http://www.programbyggerne.no)).

	Net energy need	Delivered energy
Space heating	8.4 kWh/m <sup>2</sup>	3.5 kWh/m <sup>2</sup>
Ventilation heating	2.8 kWh/m <sup>2</sup>	1.1 kWh/m <sup>2</sup>
Domestic hot water	5.0 kWh/m <sup>2</sup>	2.1 kWh/m <sup>2</sup>
Fans	6.0 kWh/m <sup>2</sup>	6.0 kWh/m <sup>2</sup>
Pumps	1.0 kWh/m <sup>2</sup>	1.0 kWh/m <sup>2</sup>
Lighting	12.5 kWh/m <sup>2</sup>	12.5 kWh/m <sup>2</sup>
Appliances	15.7 kWh/m <sup>2</sup>	15.7 kWh/m <sup>2</sup>
Space cooling	2.8 kWh/m <sup>2</sup>	0.3 kWh/m <sup>2</sup>
Total	54.1 kWh/m <sup>2</sup>	42.1 kWh/m <sup>2</sup>

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