The ZEB Living Lab: a multi-purpose experimental facility

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ZEB The Research Centre on Zero Emission Buildings

FME FORSKNINGS-SENTER FOR MILJØVENNLIG ENERGI

Aims and Experiments

- The primary aim of the Living Lab is to realize a building that is representative, as a typology, of the most common Norwegian dwelling – the single family house – and to demonstrate how CO_2-neutral construction can be realized in the Norwegian climate

- Carry out research on how users interact with state-of-the-art technologies and low-energy buildings
  - People are thus expected to live (for shorter or longer periods) in the Living Lab

Zero emission building level

- Energy converted by the PV system is expected to cover the energy need of the building and to balance energy embedded in the materials and components used to realize the Living Lab

Test Building Localization – NTNU Gløshaugen

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Urban (and snow'y) surroundings

Construction

- The test facility is a single family house with a gross volume of approximately 500 m^3 and a heated surface (floor area) of approximately 100 m^2
- Designed to have low energy demand during its operation

- Key envelope properties:

U-value wall	0.11	W/m²K
U-value floor	0.10	W/m²K
U-value roof	0.10	W/m²K
U-value windows (south façade)	0.65 / 0.69 (when ventilated)	W/m²K
U-value windows (north façade)	0.97	W/m²K
U-value windows (east-west façade)	0.80	W/m²K
U-value skylight	1.0	W/m²K
g-value	0.5	-
Air tightness	0.5	ach
Thermal bridges (normalized)	0.03	W/m²K

Layout


A
B
C
D
E
F
1
2
3
4
bedroom
studio/bed2
entrance
living room
kitchen
deck
access ramp 6%
0.54
429.2
429.2
1422.6
429.2
135.0
300.0
135.0
300.0
135.0
300.0
135.0
300.0
300.0
300.0
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300.0
300.0
60.0
240.0
60.0
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240.0
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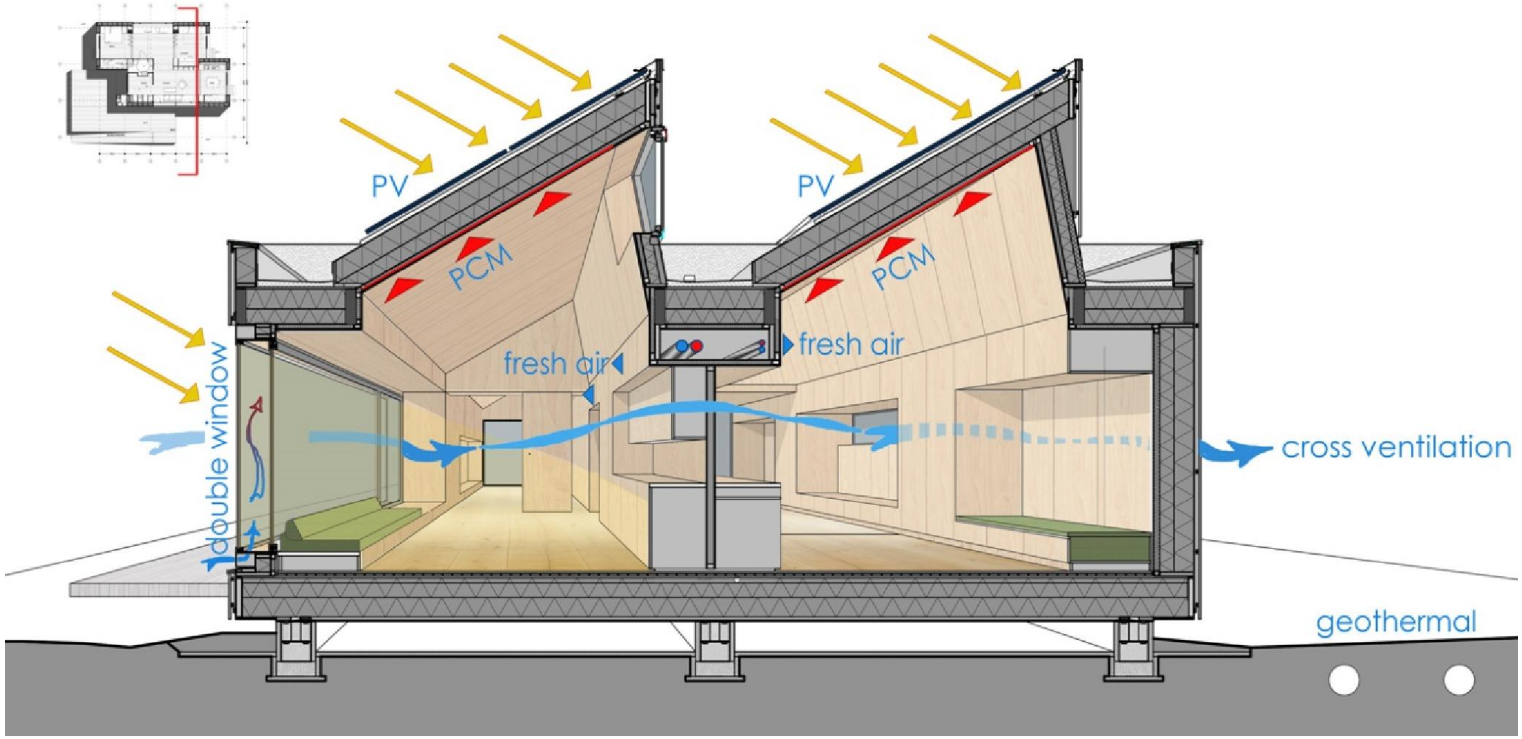
240.0
60.0
240.0
60.0
1260.0
0
1

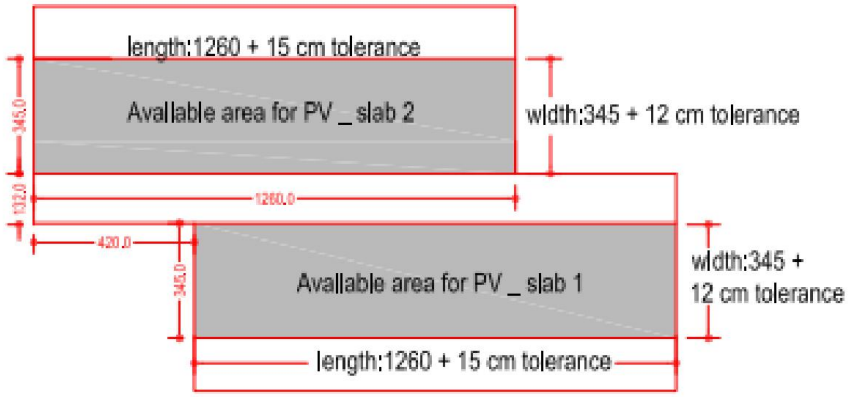
Technical installations

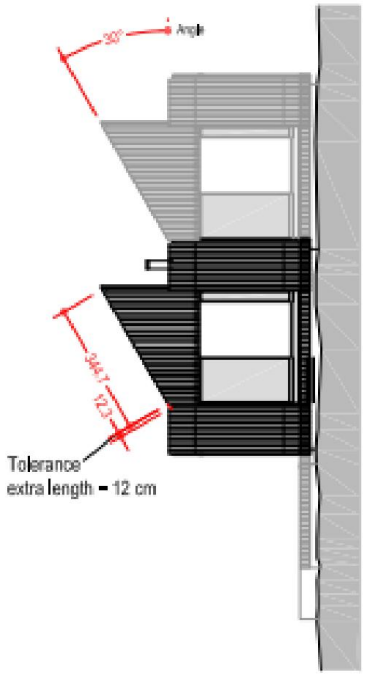
- Heating, ventilation and domestic hot water demands are met with water-to-water heat pump, coupled to ground heat-exchanger
- Heat pump connected to two-stage heat storage tank
  - hot water for both DHW and space heating is stored.
  - The storage tank has two auxiliary electric coils that can be activated when the storage temperature falls under the set-point.
  - Solar thermal panels are also connected to this storage
- Floor heating and low-temperature radiator
- Balanced, VAV-ventilation with nominal air flow of 120 m^3/h

Cross section of the Living Lab



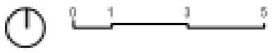
BIPV and solar thermal

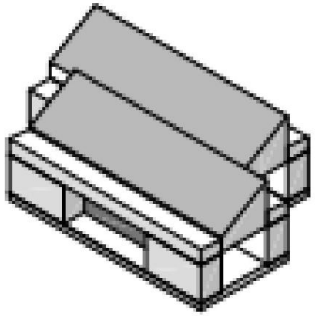




Lighting analysis were performed in RADIANCE, and PV-SYST

Building integrated solar thermal unit





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Instrumentation and DAQ

- Evaluate the total energy behavior of the building
  - i.e. to reach a measurement accuracy similar to that of a laboratory test facility might be out of the scope of the Living Lab
- Sensors are chosen so that they could have been installed in a real-world application
  - More sensors can be installed than in a conventional building due to research demands
- The measurement system will be flexible and allow for a following upgrade to be easily realized
- Can be performed according to the relevant technical standards for energy and comfort assessment (e.g. EN 15251, IEC 62053)

Monitoring system

- Sensors for the assessment of the different energy demands located in technical room where HVAC equipment and electric switchboard are installed

- Sensors for indoor and outdoor environmental physical quantities are distributed in the entire test facility.

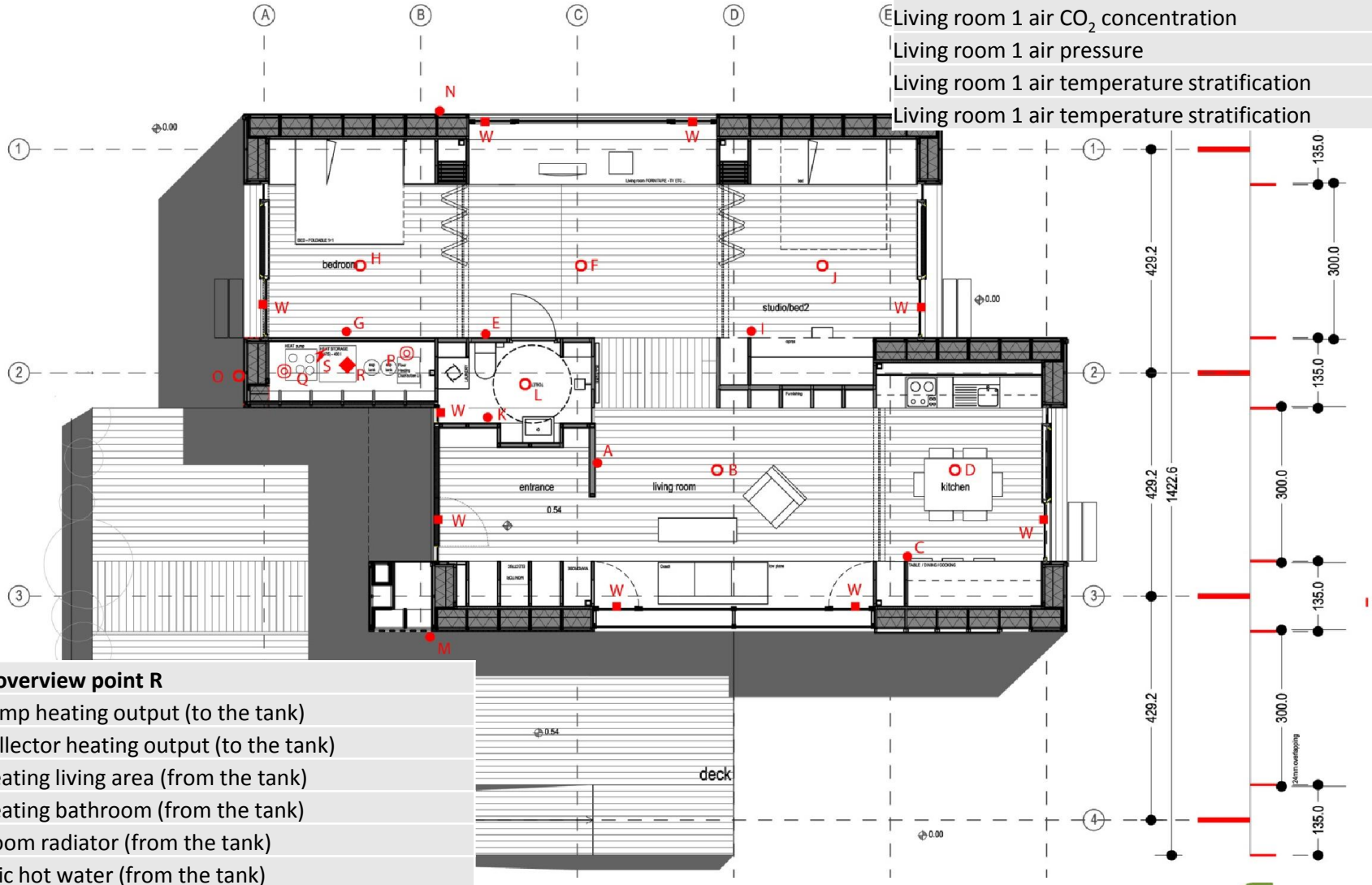
- Indoor air temperatures, difuse illuminance and CO_2-levels are measured in every room

Outdoor environmental physical quantities

- Outdoor air temperature and humidity
- Outdoor air pressure (two sensors on the north-facing façade)
- Solar irradiance on the horizontal (roof-top) and vertical (south-façade) plane is measured by means of two pyranometers
- wind speed and direction are measured with *weather station*
- Care taken to avoid shades on the building integrated PV

Sensor locations

Sensor overview point A
Living room 1 air temperature stratification
Living room 1 air temperature stratification
Living room 1 air temperature and humidity
Living room 1 air CO_2 concentration
Living room 1 air pressure
Living room 1 air temperature stratification
Living room 1 air temperature stratification



Sensor overview point R
Heat pump heating output (to the tank)
Solar collector heating output (to the tank)
Floor heating living area (from the tank)
Floor heating bathroom (from the tank)
Living room radiator (from the tank)
Domestic hot water (from the tank)

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Energy demand for HVAC and DHW

- Thermal energy measured for the 6 hydronic circuits
  1) heat pump heating output
  2) energy delivered by the floor heating in the living area
  3) energy delivered by the floor heating in the bathroom
  4) energy delivered by the radiator installed in the living room
  5) energy for domestic hot water
  6) energy for the water-based coil of the ventilation plant
- Mechanical ventilation and heat recovery
  - Enthalpy flux will be calculated during the acquisition, based on air temperature, humidity ratio and air speed in ventilation ducts

Electrical energy demand

- Electrical energy demand measured on every power line within the Living Lab
- 22 power lines have been planned, amongst others:
  - Every room will have one line for power transmission and one for artificial light
  - Heat pump electric input and tank coils power input.
  - Power to all the auxiliaries (e.g. fans, pumps) of the HVAC and solar thermal panel
  - Powering of windows' drivers

Data acquisition and analysis

- National Instrument compactRIO platform.
  - based on a modular structure, where controllers, chassis, devices/modules can be freely combined in order to suit the requirement of the measurement layout
- Future expansion of the measurement layout can be implemented
- controlled using the National Instrument LabVIEW programming code

Stand-alone and integrated control systems

- Heating and mechanical ventilation control by means of conventional, stand-alone devices supplied together with the HVAC equipment
- Indoor air temperature, CO_2-concentration and solar irradiance will be used to control the opening of the windows

Conclusion

- The Living Lab at the Norwegian University of Science and Technology (NTNU) is a test facility, currently under construction, that is representative of a solar-powered single family house in the Nordic climate.

- The following goals have been defines:
  - Assess the whole-building performance of a Zero Emission Building
  - Carry out tests on different building elements and equipment
  - The monitoring system has been designed in order to be flexible, expandable and easily reconfigurable.

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For more information, please navigate to:

www.zeb.no