Upgrade of the Solar Radiation Monitoring Station at DTU Lyngby

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2024

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Version:
1.0.0

Front page photo: Ioannis Sifnaios
Published by: DTU Construct, Koppels Allé 404, 2800 Kongens Lyngby Denmark
https://weatherdata.construct.dtu.dk

1. Introduction

High quality solar irradiance measurements have been made at the solar radiation monitoring station at the Technical University of Denmark's (DTU) since 1989. The station, also known as the DTU Climate Station, is located on a platform on the roof of building 119 at the Lyngby campus. The last major upgrade of the station was made in 2017, after which only regular instrument upkeep and minor maintenance activities have been carried out. The station website serving data to users was reaching its end-of-life and was shut down in 2023 due to security issues. The work in this report was initiated to provide a much-needed upgrade of the station infrastructure in order to ensure the continuation of high-quality measurements at the site,

As part of the upgrade, a new electrical cabinet and a new datalogger were installed, future-proofing the station for the coming years. Additionally, ventilator units were installed on the main domed radiometers to improve data availability and accuracy. Last, the station's website, where data is provided freely, was redesigned to increase usability and provide more supporting information to users. Free data retrieval is available from the new website weatherdata.construct.dtu.dk. The remainder of this report documents the individual improvements.

The authors would like to acknowledge the Saxhof Foundation which financially supported the upgrade of the station and made it possible to keep supplying high-quality data to scientists, students, and industry partners.

2. Station upgrade

2.1 Cabinet

A new cabinet was installed on the station platform, which had the benefit of reducing wire lengths to 5 – 10 m. In comparison, wire lengths were previously more than 25 m, as the old datalogger cabinet was located inside the building on which the station is located. Keeping wire lengths to a minimum is important to ensure high accuracy as many of the instruments output noise-sensitive low-voltage (mV) analog signals. The change also greatly reduced the effort needed when adding new sensors. Furthermore, having the datalogger located on the platform allowed for routing the wiring of DC and AC wires separately, which is beneficial as alternating current induces noise in adjacent signal wires.

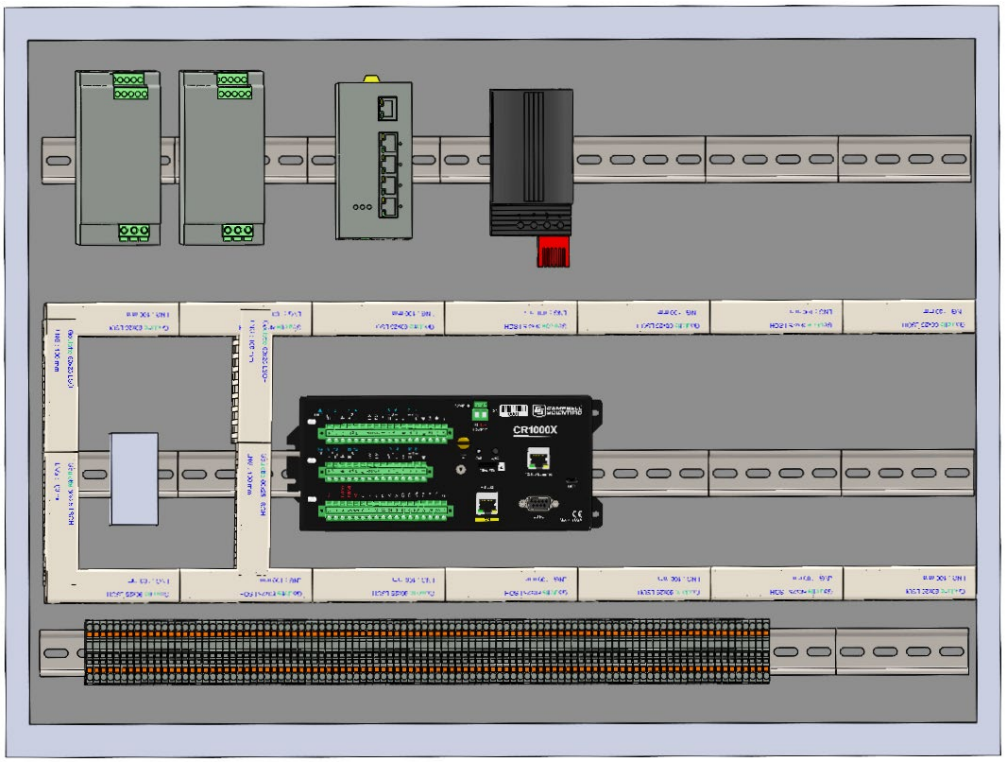

Figure 1. 3D CAD model of the cabinet interior.

The cabinet was an IP66-rated painted steel cabinet with dimensions of 800 x 600 x 300 mm (see Figure 1). The components in the cabinet are attached to three DIN rails, allowing for easy installation and simplifying future modifications. For organization, all wires are labeled with a two-digit number and are routed in cable trays.

The cabinet houses a two-pole circuit breaker connected to an external 230 VAC cable. The circuit breaker is connected to two power supplies (12 VDC and 24 VDC), which power the datalogger and digital sensors. Data logging is made by a CR1000X datalogger placed in the center of the cabinet (see Section 2.2) and the four-port power-over-ethernet switch. As the cabinet is located outside, condensation is a potential issue. To limit potential condensation issues, a 100 W cabinet heater was installed which is connected to a thermostat set at a temperature of 20 °C.

Last, all wires enter the cabinet from the bottom through cable glands and are connected to terminal blocks, which run the bottom length of the cabinet. This makes it easy to exchange a sensor or wire and provides a faster overview of the connections in the cabinet for maintenance personnel.

2.2 Datalogger

A Campbell Scientific CR1000X datalogger was installed, replacing the National Instrument CompactRIO, which has been operating since 2014 (Andersen, 2014). The CR1000X is the standard choice for meteorological stations because of its ease of use, high reliability, and compatibility with a large range of sensors.

The CR1000X datalogger is relatively easy to program and is thus easier to maintain in the long run (changing or adding new instruments, software upgrades, etc.). In contrast, the existing CompactRIO unit was programmed using the graphical LabVIEW programming language, which makes version control difficult. While the CompactRIO offered more advanced outputs (e.g., for hardware control) these features are not needed for applications only involving data monitoring.

2.3 Ventilation units

Three CVF4 ventilation units from Kipp & Zonen were installed to reduce thermal offsets and dew on the domed instruments on the solar tracker (i.e., the two pyranometers measuring global and diffuse horizontal irradiance and the pyrgeometer measuring downwelling long-wave irradiance). For thermopile-based instruments, ventilation ensures a more stable temperature of the radiometer, thus decreasing thermal offsets (an error which can be several W/m^2).

Installing ventilation units also has the potential to minimize instrument soiling from dust and dirt, due to the consistent airflow over the instruments (incoming air is passed through a filter). Moreover, activating the integrated heater in the ventilation units also significantly reduces dew formation, evaporates precipitation quicker, and melts frost, ice, or snow on the domes. By employing ventilation and heating, the data quality and fraction of usable data are significantly enhanced.

2.4 Other

Several additional enhancements were made to the station infrastructure, including:

- Replacement of the ethernet cable to the tracker, which had reached end-of-life.
- Replacement of AC power cables.
- Installation of cable trays underneath the station platform.
- Lid installation on the cable trays that run from the platform to the entry point of the roof, thus limiting UV exposure of cables.

3. Website

The new station website is hosted at the address https://weatherdata.construct.dtu.dk/. The website was redesigned to increase usability and provide more information to users while providing an easy way of downloading measurement data. The old website is described in Andersen et al. (2017). This section provides a brief overview of the pages of the new website.

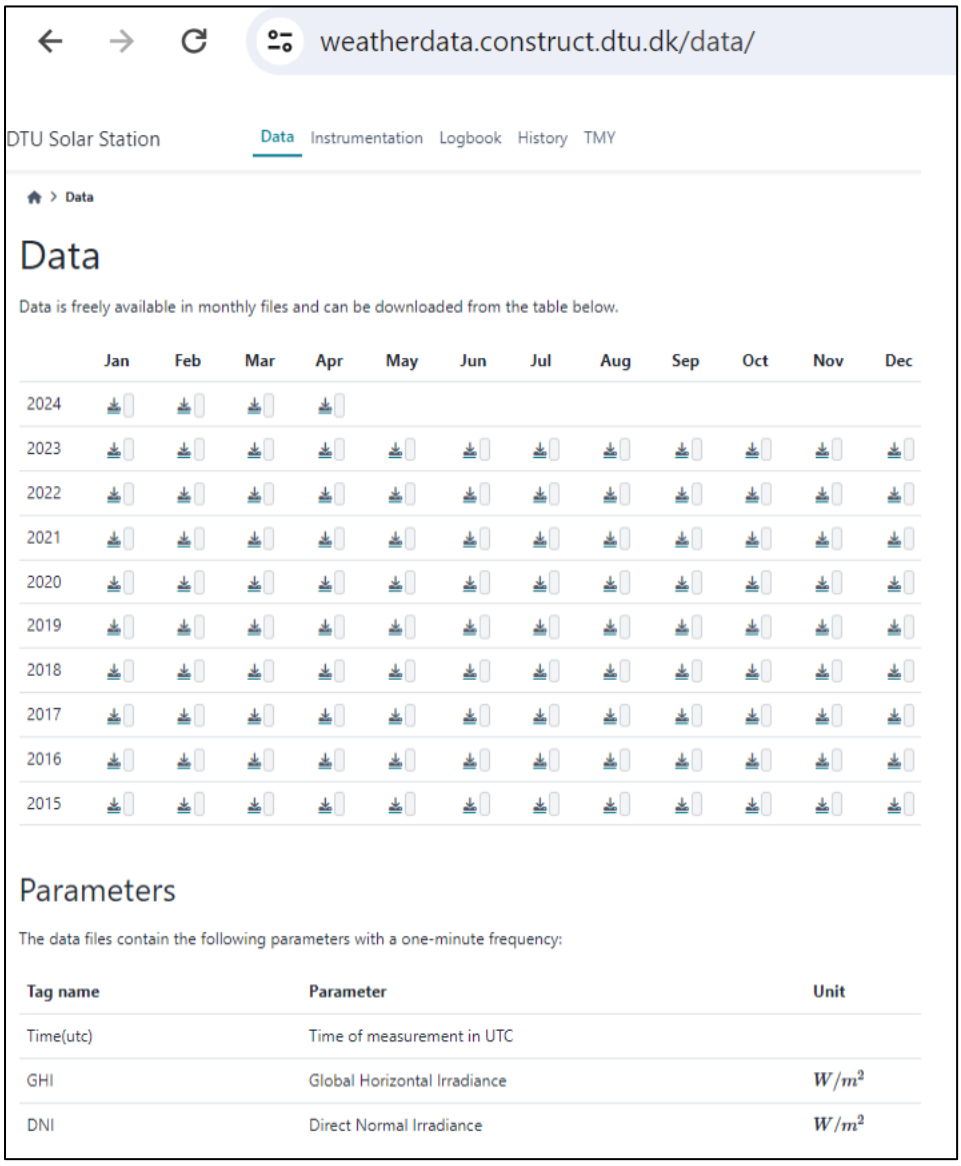

Figure 2. Screen-shot from the data page of the new website.

– **Intro**: The landing page provides basic information about the station, including the location (latitude, longitude, and elevation). Knowledge of the exact location of a solar radiation measurement station serves as a foundational element for reliable and meaningful data collection, analysis, and application in various fields, including renewable energy, climate science, and environmental monitoring.

- **Data**: Station measurements from 2015 – 2024 can be freely downloaded from the website. The measured parameters are:
    - Global Horizontal Irradiance (GHI)
    - Direct Normal Irradiance (DNI)
    - Diffuse Horizontal Irradiance (DHI)
    - Longwave Downwelling Irradiance (LWD)
    - Wind speed and direction
    - Ambient air temperature
    - Air pressure
    - Relative humidity
    - Rain accumulation
    - Rain intensity
    - Rain duration

- **Instrumentation**: Information about the available instruments (e.g., installation date, instrument type, and calibration dates).

- **Logbook**: All maintenance events related to the monitoring station are logged. This includes cleaning, calibration, and changes to instrumentation. The logbook is based on a survey form, which is filled out during every visit to the station and ensures consistent reporting. A link to the updated logbook entries in an intuitive spreadsheet interface is provided.

- **History**: A summary of the history of the station is provided on this page, explaining the changes since the station was first installed in 1989 (see Lund (1994)). References are provided to documentation of past station upgrades, two of which have also been funded by the Saxhof Foundation.

- **TMY**: DTU has contributed to the development of the Danish Design Reference Year (DRY). The DRY dataset is a type of Typical Meteorological Year (TMY), which is used for calculations according to the Danish building regulations. The updated version of the 2001-2010 DRY dataset can be downloaded from the website and is available in both CSV and EPW formats.

4. References

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