

# Unmanned Aerial Vehicles (UAVs) in the energy and heating sector: a review of monitoring applications and emerging technologies

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## Unmanned aerial vehicle (UAV) – UAV Drone

**The aircraft** that does not require a crew on board to fly, piloted remotely or flying autonomously.

**A flying platform controlled:** manually, semi-automatically, autonomously, or in combinations of the above variants.

**Unmanned Aerial System - UAS** system consisting of:

- an unmanned aerial vehicle,
- a support system,
- all personnel and equipment necessary to control the UAV /NATO AAP-6, 2014/



## Multi-rotor UAVs

- high mobility,
- take off and land vertically,
- precise flight,
- ability to hover in one spot,
- shorter flights (20-40 min)



**Multi-rotor UAV**  
DJI Matrice 600

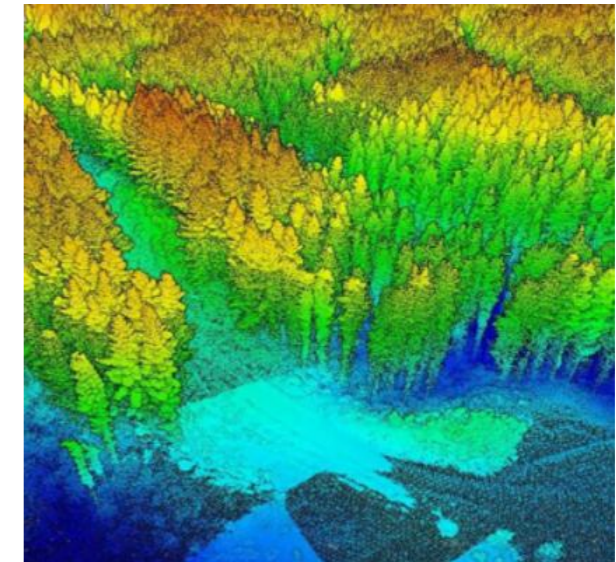
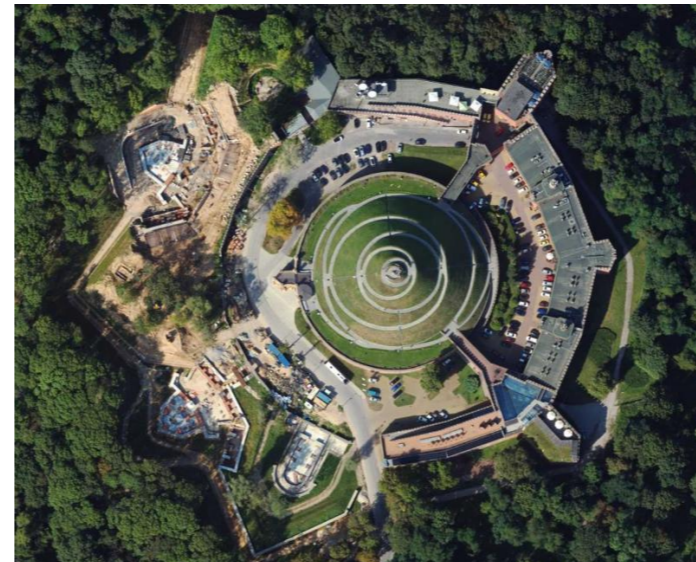
## Fixed-wing UAVs

- longer flight times (up to a several hours),
- greater range (suitable for longer missions e.g. monitoring of power lines),
- need for a suitable take-off and landing area
- limited maneuverability in narrow spaces



**Data collection** - the primary professional application of civilian UAVs

- aerial photographs and high-resolution videos,
- photogrammetric data for orthophotomap development,
- point clouds from laser scanning (LIDAR) for 3D model development.



## The development of professional, civilian UAVs applications

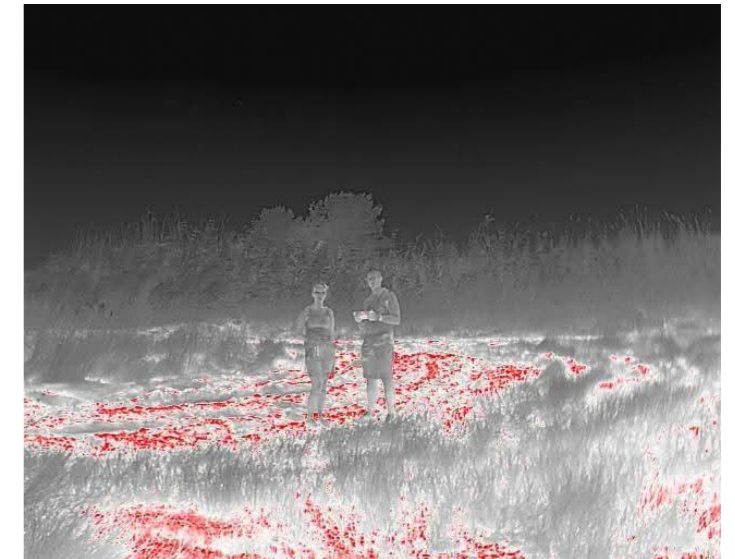
- relatively low purchase and operating costs (decreasing prices),
- development of new technologies:
  - **miniaturization,**
  - new, light materials,
  - more efficient batteries,
  - reduction of energy demand,
  - extension of flight time.



## The development of professional, civilian UAVs applications

### ➤ development of new technologies:

- sensor availability,
- multispectral and thermal imaging cameras availability,
- availability of various image processing software
- development of AI implementation in image analysis



## Why use UAVs for monitoring in the energy and heating sectors?

- allows for inspection of every element of infrastructure from any perspective,
- significantly reduces costs,
- increases the safety of inspections,
- the inspection process is recorded (digital photos or videos, including thermal images); it allows to return to the analysis of the inspected object).
- use of AI for image analysis allows more accurate detection of anomalies and defects.



## Use UAVs for monitoring in the energy and heating sectors:

- energy infrastructure (e.g. high-voltage power lines),
- wind farms,
- solar power plants,
- underground and above-ground heating networks (e.g. detection of pipe breaks),
- thermal bridges in buildings,
- tall structures (e.g. cooling towers).

## Use UAVs for monitoring energy infrastructure (e.g. high-voltage power lines),

- general monitoring of long power lines (fixed-wing UAVs)
- detailed monitoring of key installation components (multi-rotor UAVs)



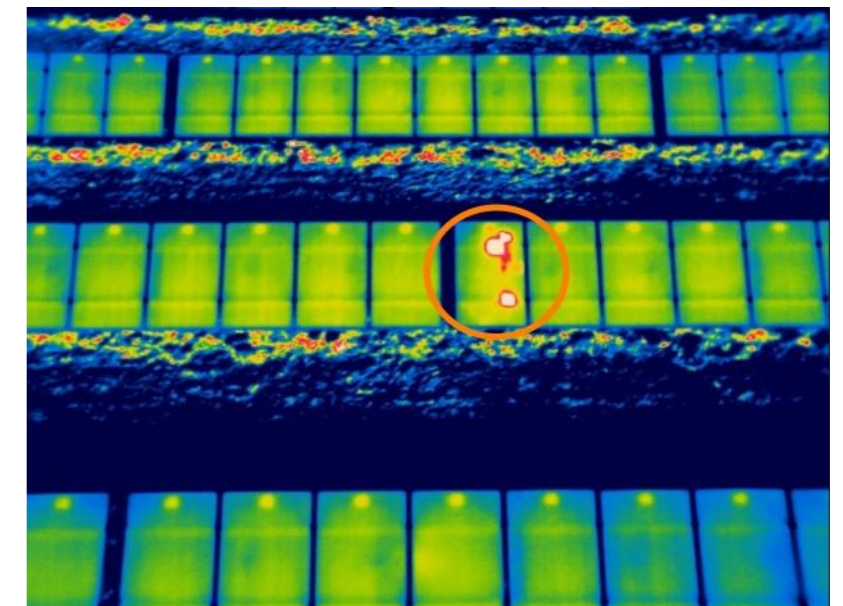
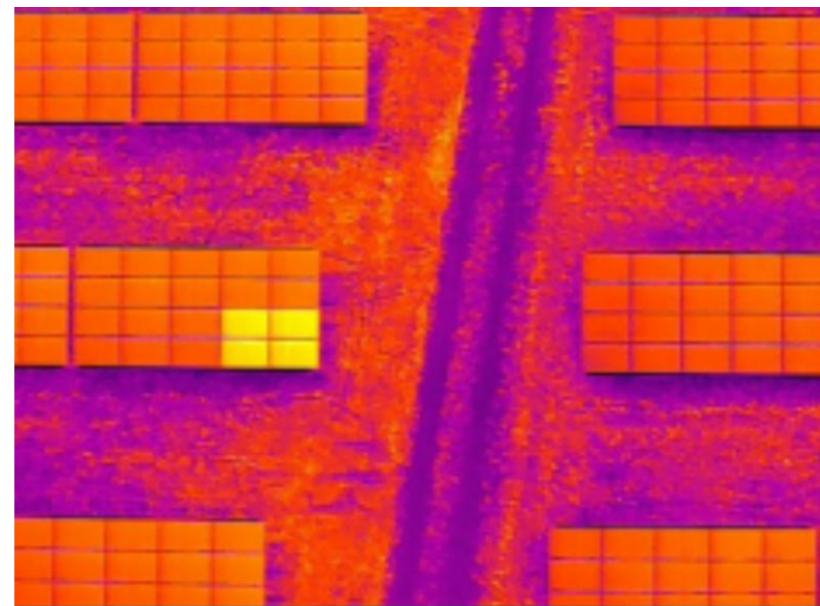
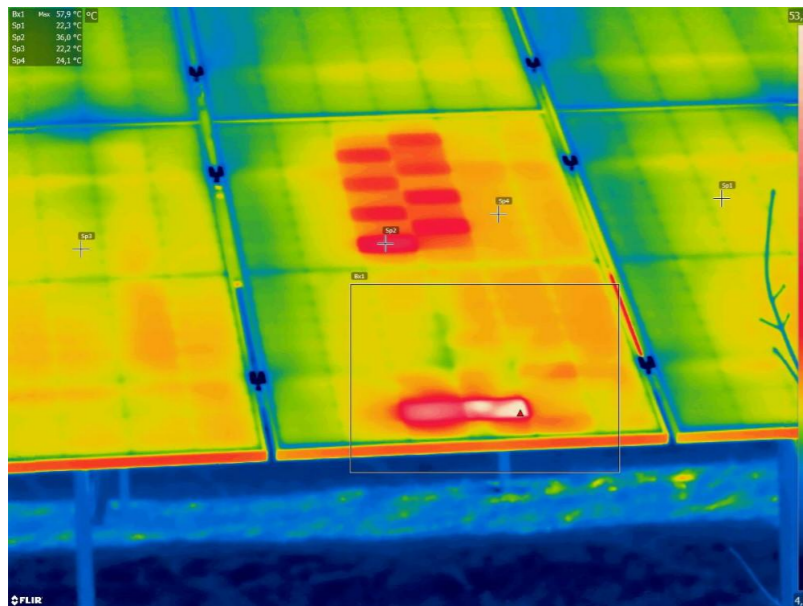
## Use UAVs for monitoring of wind farms

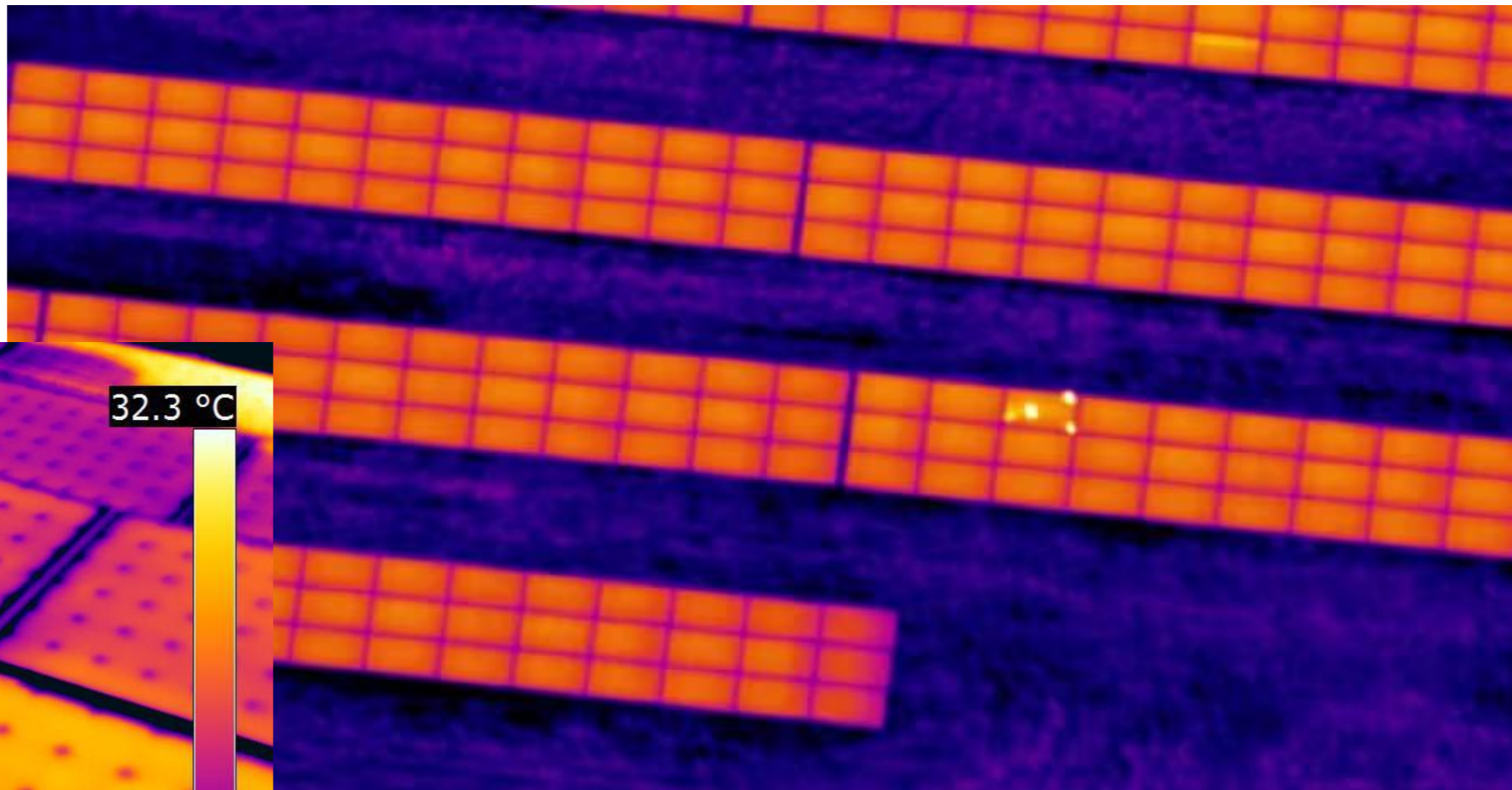
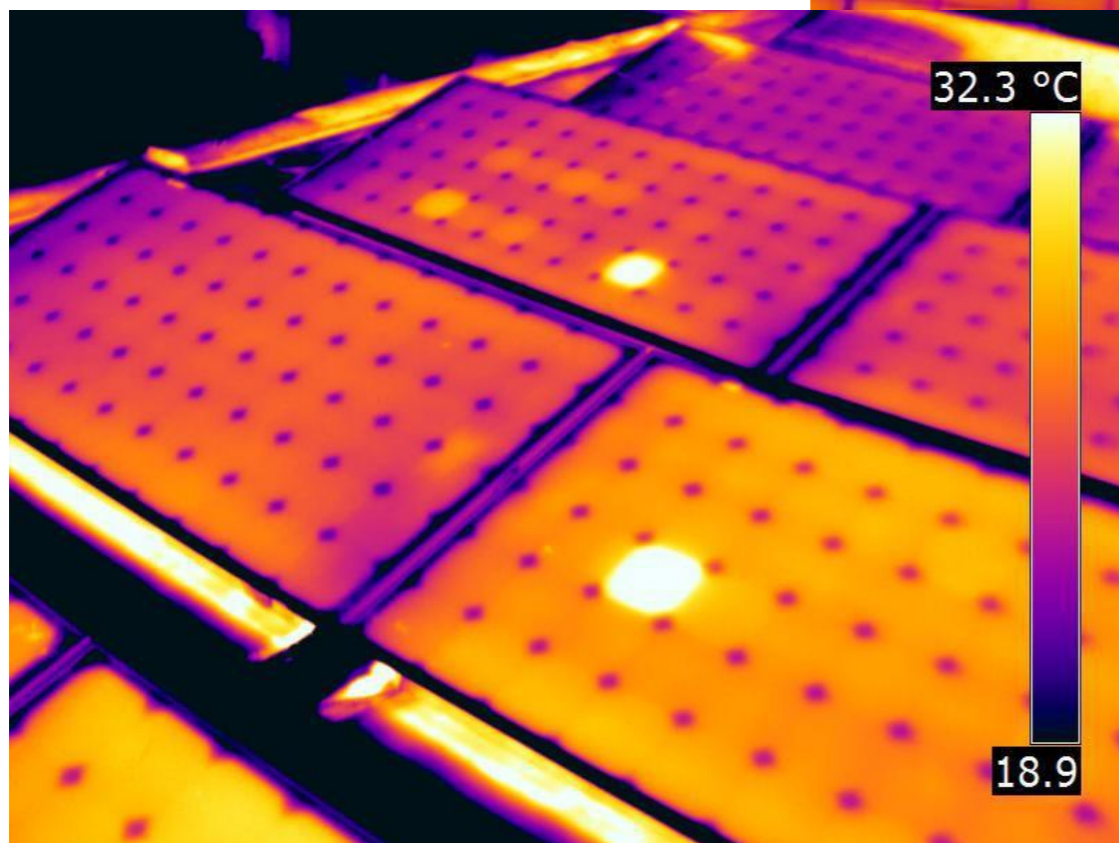
- visual monitoring of wind turbine blade condition (high accuracy),
- assessment with use of automated algorithm for analyzing camera images,
- quality control of wind turbine operation based on acoustic analysis of turbines,
- accuracy in finding defects on wind turbine blades.



## Use UAVs for monitoring of solar power plants

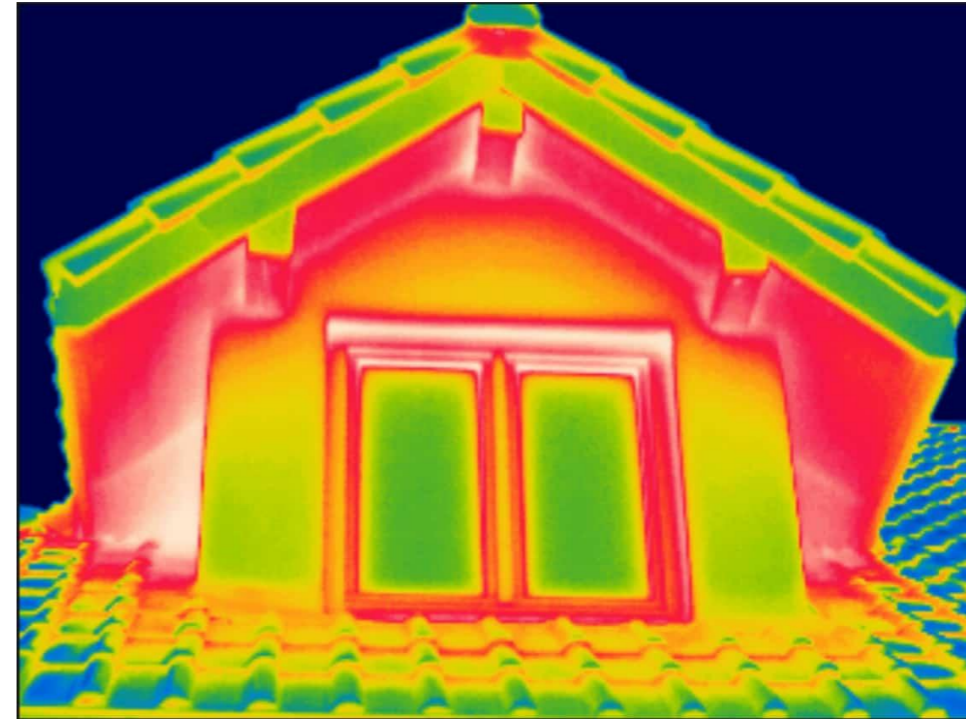
- thermal imaging to identify problems in a photovoltaic module or the entire photovoltaic installation (e.g., hot spots, panels with reduced efficiency, disconnected panels, shading, contamination),
- monitoring of panel aging proces.





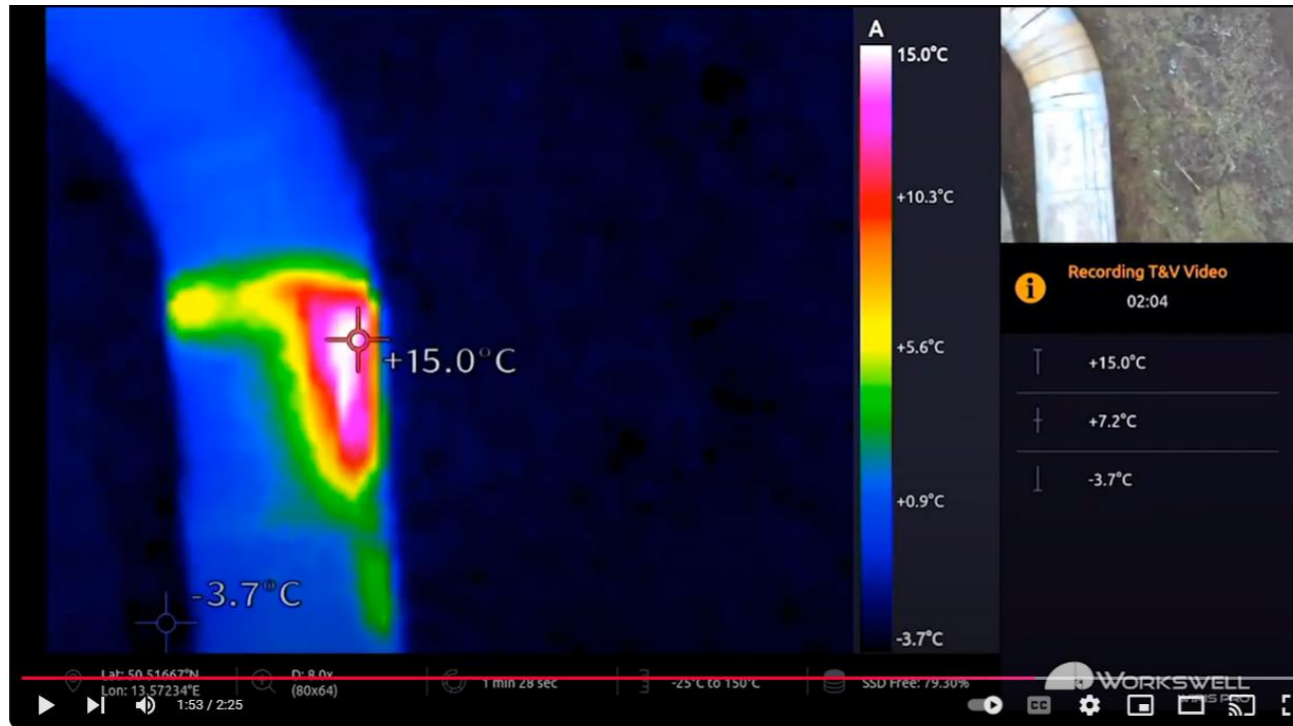
## Use UAVs for monitoring of thermal bridges in buildings

- Thermal imaging inspection of the roofs and walls for the purpose of assessing the building's energy efficiency and identifying the need for modifications/repairs.

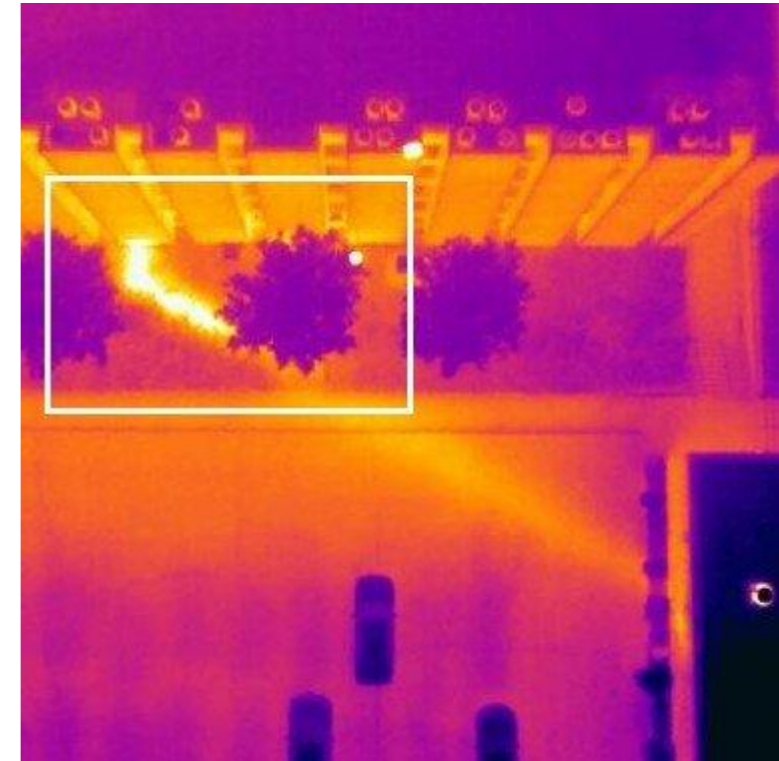


## Use UAVs for monitoring of underground and above-ground heating networks (e.g. detection of pipe breaks),

- high sensitivity and resolution of the thermal imaging camera allows to detect leaks and network failures.



Pipeline Inspection Workflow | Using Drone and Thermal Imaging Camera WIRIS Pro



## Use UAVs for air quality testing

- so-called “anti-smog drones” equipped with dust sensors (e.g., PM1, PM2.5, and PM10), nitrogen oxide and sulfur sensors, and sensors for other hazardous gases.



## Use UAVs for air quality testing

- for real-time air pollution testing or for collecting gas samples into a dedicated bag (for further laboratory analysis),
- testing smoke from chimneys,
- smog monitoring in cities.



