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TELEDYNE FLIR

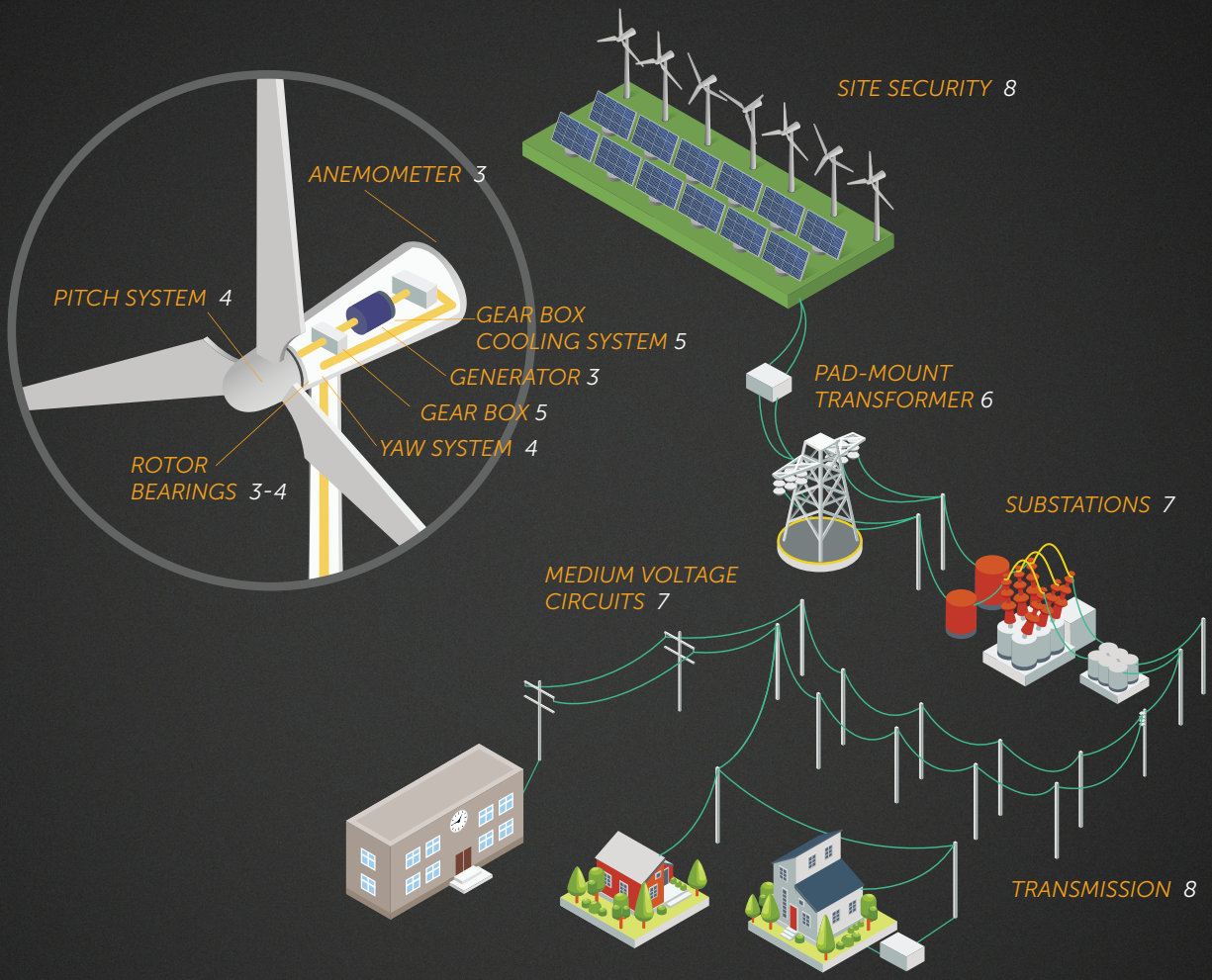
TELEDYNE FLIR RENEWABLE ENERGY SOLUTIONS

Wind power sites can be large and remote, posing a great challenge for maintenance work: inspections are often expensive and time-consuming, with mechanical and electrical systems difficult to access. Wind turbine components can be up high, in confined spaces, or may lock-out or tag-out. They're also susceptible to environmental challenges such as heat and changing weather conditions that can cause breakdowns. When this happens, the end result may be costly downtime or a bad accident. That's why preventive maintenance and periodic inspections are so important.

Unfortunately, the cost can be high, so you always want to make the most out of every inspection. In this brochure, we will talk about how Teledyne FLIR's solutions can help maximizing uptime and reducing maintenance costs.

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TABLE OF CONTENTS



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WIND TURBINE COMPONENTS

Anemometers

Wind turbine anemometers are critical to understanding wind speed and direction, and by extension, optimizing a windmill's energy output. Anemometers can be mounted on the windmill at various heights to collect accurate wind speed data. They transmit rotation data to a control center that's responsible for positioning the turbine into the wind for maximum efficiency. Maintenance professionals can use thermal imaging to check electrical connections and ensure data continues to flow.

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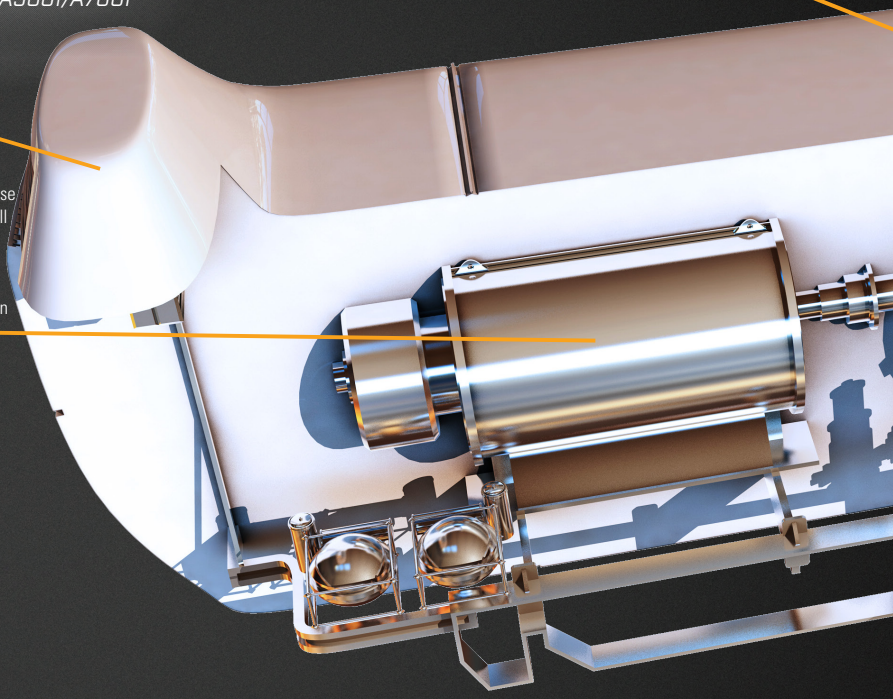
FLIR T1020™



FLIR A500f/A700f™

Rotor Bearings

Wind turbine components are susceptible to wear and can break down, especially the rotor bearings: a series of bearings within the rotor shaft that connect the wind turbine blades to the gearbox. Ensuring proper operation is critical to maintaining operational efficiency and asset health. A thermal videoscope allows maintenance professionals to see into the cramped bearing casing to look for signs of overheating, while a vibration meter or remote vibration monitoring system could detect signs of mechanical failure through vibration analysis.



Wind Turbine Generators

A wind turbine's generator takes output from the gearbox and produces electric power. These complex systems can include commutators, slip rings, coils, cooling systems, and more—all of which require regular inspection to ensure proper operation and asset health. Acoustic imaging allows you to inspect electrical systems to detect problems before breakdowns occur, while a thermal camera and digital multimeter can be used to verify the health of mechanical and electrical components. Finally, test tools such as a phase rotation tester can ensure proper installation and function of three-phase power sources.

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FLIR Si124-PD™



Extech 480400



FLIR E96™



Extech 382357



FLIR IM75™

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FLIR VS80™-IR21



Extech SDL800



FLIR SV87-KIT™

Mechanic/Hydraulic Pitch Control Systems

Pitch control systems control a wind turbine's blade angle, matching it to the direction of the wind in order to adjust speed of rotation. This allows for optimal efficiency and reduces the mechanical load on the wind turbine's systems. The pitch control system includes variable frequency drives (VFDs) that ensure a gradual start/stop to prevent shock loads on blades. The VFD, motors, and hydraulic components of this system should all be checked frequently for voltage levels, electrical hot spots, valve solenoid function, and signs of wear.

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FLIR Si124-PD™



Extech VT30



FLIR AX8™



Extech DV690



FLIR DM93™

Yaw (Nacelle Direction) Systems

Yaw systems within a wind turbine orient the nacelle—or main housing—into the wind, most often by generating torque that rotates the nacelle based on wind sensor signals or from a manual system override. This helps increase the energy capture and maximizes power output as the turbine system isn't constantly working to keep the nacelle steady. The system involves bearings, brakes, brake calipers, and pistons, all of which can overheat as a sign of failure. Continuous monitoring with a fixed thermal smart sensor can provide the early warning needed to avoid system failures that lead to breakdowns.

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FLIR A50/A70™ Smart Sensor



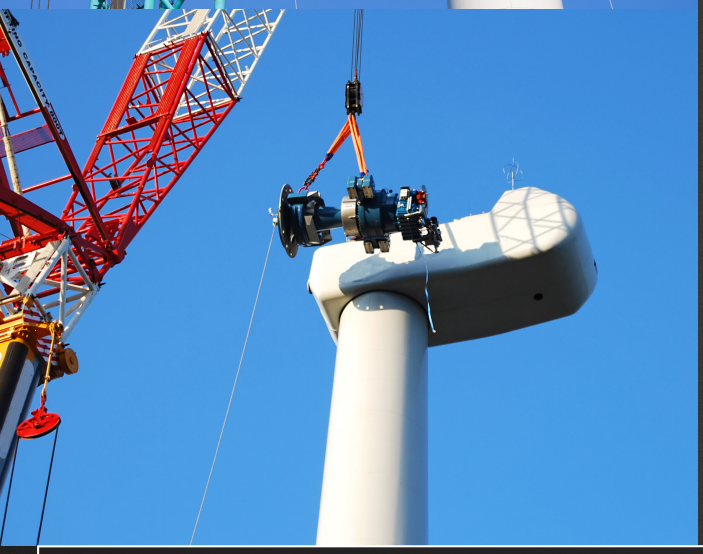
FLIR AX8™



FLIR Bridge Pro™

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WIND TURBINE COMPONENTS

Gearboxes

A wind turbine's gearbox connects the rotor shaft to the power generator and increases the rotations per minute (RPMs) to optimize power generation. This vital component must be able to function efficiently in demanding weather conditions, and under loads, vibrations, and temperatures that continuously change. Checking the temperature and condition of the gearbox's bearings, gears, and other components is essential to operational efficiency and asset health.

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FLIR T800-Series™



FLIR T1020™

Gearbox Cooling Systems

Gearbox cooling systems maintain a consistent temperature within the nacelle to ensure the life expectancy of all the components. The process of energy conversion along with solar radiation can generate heat that could damage the components. Regular inspections with a thermal camera as well as electrical inspections with a digital multimeter can provide several months of warning time before failure, avoiding costly downtime.

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FLIR DM93™



FLIR E8-XT™

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POWER UTILITY MAINTENANCE

Pad-mount Transformers

If a wind farm transformer overheats and fails, it can lead to expensive repairs and potential power outages. Regular temperature monitoring using advanced diagnostic thermal imaging cameras can help you easily inspect and monitor the temperature distribution on the outside surface of each transformer to catch impending failures before they occur. It will show you what the naked eye can't see—hot spots that indicate overheating parts—so you know where to investigate further. Find hidden signs of electrical resistance and mechanical wear so you can begin repairs immediately.

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FLIR E96™



FLIR E8-XT™



FLIR IR Windows

MV Circuit Breakers

Medium voltage (MV) circuit breakers connect the low voltage wind generated power through a step-up transformer to the bus of a high voltage/medium voltage substation. They can be installed either above or below ground. While above-ground MV circuits are easier to access, they require frequent inspections with a thermal camera and test & measurement tools to ensure none of the connections are loose or damaged connections. Below-ground MV circuits are costlier to install but require less maintenance. Inspectors may need to check these breakers occasionally for splice failure or ground faults. The visual inspection of poles and mounting equipment is also need to ensure the collection system is in good working order.

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FLIR IR Windows



FLIR E8-XT™



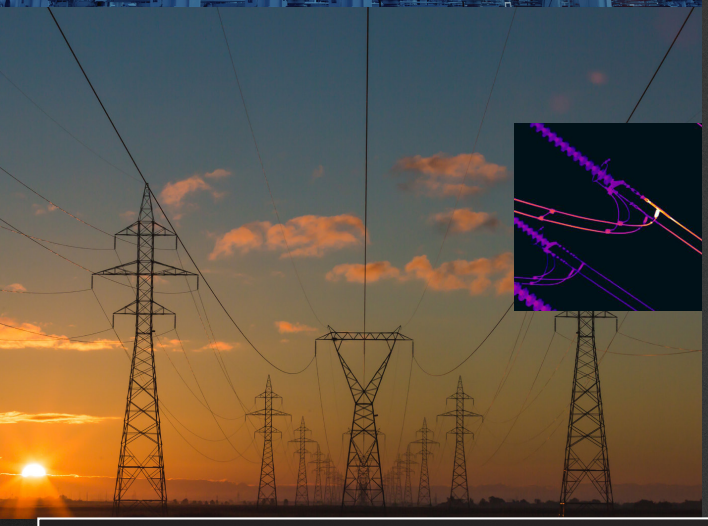
Extech 480400



FLIR DM93™

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Substations

Substations contain the most typical equipment found at a wind farm, including transformers, breakers, switches, and relays. If any of these systems fail, the entire transformer will shut down, costing millions of dollars in added overtime pay for workers and expenses to expedite repairs. Regularly scheduled electrical inspections with thermal imaging cameras along with surveys for SF_6 insulation leaks with a gas detection camera will ensure equipment keeps working and wind farm operators meet safety regulations governing their equipment. Most wind-farms perform these tasks during the low-wind season to reduce their loss of generation and revenue.

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FLIR E96™



FLIR GF306



FLIR IR Windows



FLIR T-Series™ with FlexView™ Dual FOV Lens

Transmission

Unplanned transmission line repairs can easily cost millions, so it's important to regularly inspect every connection to ensure that they are in working order. Every system has a lot of small connections, often located high up out of reach. Connections get hot before they fail. Conducting regular surveys of substations and transmission lines using a thermal imaging camera can give you a full picture of potential problems. You can visualize partial discharge or measure the temperature of overheating connections and diagnose problems before outages occur— minimizing the cost of repairs, maximizing equipment life, and keeping the power on for customers.

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FLIR T1020™



FLIR Si124-PD™



FLIR T-Series™ with FlexView™ Dual FOV Lens

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WIND POWER PLANT PROTECTION

Site Security

Security breaches, environmental hazards, asset failure, and financial loss are some of the challenges that plague wind power plants. It is vital to quickly detect threats, resolve issues, and manage processes across use cases—from perimeter protection and entry control to building diagnostics and condition monitoring.

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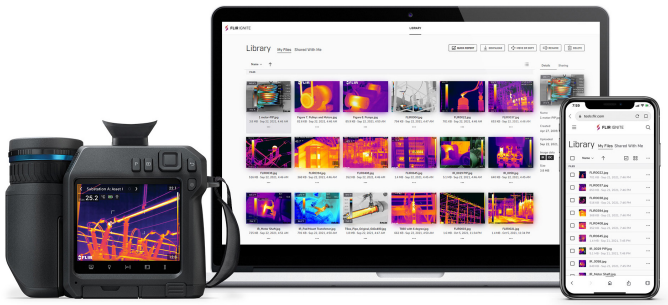
FLIR FH-Series ID™



FLIR R-290™

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FLIR PORTABLE INFRARED AND ACOUSTIC CAMERA SOFTWARE

FLIR helps you work more efficiently and boost productivity with a robust software suite, routing plugins, and cloud storage.

SOFTWARE AND CLOUD SOLUTIONS

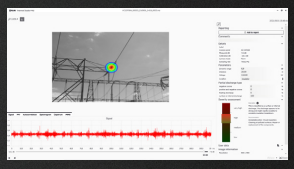
FLIR Thermal Studio Pro, FLIR Ignite Cloud storage, and FLIR route management provide the total solution your team needs to streamline inspections, analysis, and reporting.

FLIR Thermal Studio Pro: Build an efficient survey roadmap with the FLIR Route Creator software plugin, then download and run it using the Inspection Route feature on your camera. Once your inspection is complete, bring the images back into FLIR Thermal Studio for processing, analysis, and reporting.

For acoustic imaging, the FLIR Si124 comes with a software plugin for FLIR Thermal Studio Pro that allows you to calculate critical decision-making data such as leak rates, costs, and level of threat from partial discharge.

FLIR Ignite: Upload images wirelessly to this cloud-based service, which automatically manages the safe and secure back-up of your data and instantly shares the content with authorized team members.





FLIR Software Development Solutions

FLIR's Software Development Kit (ATLAS SDK) allows companies to use their own Computerized Maintenance Monitoring Systems (CMMS) to support read-out of thermal measurements as well as inclusion of METERLiNK® data, GPS, compass, and other important parameters embedded within the image.



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THE INFRARED TRAINING CENTER

Thermal Imaging Value

The greater your knowledge of thermal imaging, the greater the dividends you'll realize for your company and your career. That's why the Infrared Training Center (ITC) offers classes for utility industry applications—from free, online courses to advanced certification training.

ITC courses include:

- *Level I, II, and III Thermography Courses*
- *Electrical Inspection and Level I Electrical Thermography Courses*
- *Optical Gas Imaging Certification Course*

WORLD-CLASS INFRARED TRAINING

ITC thermography certification courses help prepare you to take a leadership role in an infrared inspection program. Level I certifies that you know how a thermal imager works and how to use it. Level II cranks up your credibility with more in-depth concepts and intensive labs. Level III asserts that you have the knowledge and skills to develop and administer your company's thermography program. These certifications offer strong validation to support the work you do as a thermographer.

ITC offers classes at training centers around the globe, at locations within your country, at your company's facility, and even on-line. On-site training is encouraged if your company needs to certify a group of 10 or more. ITC's on-site training courses are the best way to accommodate a large group on a limited budget. Our instructors will travel directly to your facility to limit your travel costs by keeping staff on site, reducing downtime and short staff issues.



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