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Arvind Tiwari, Mission leader -Electrification, leading outcome-oriented research programs focused on technology and concepts in Electrification – grid integration and control domain at GE Research (Vernova), Niskayuna, NY. He received his Ph.D. in Computer Engineering from Indian Institute of Technology, BHU in 2003. Prior to role at GE in 2003, Arvind served at Indian Institute of Technology, BHU, India. Arvind has a distinguished academic record with patents (65+) to credit, international publications (20+) and coauthored a book. Dr. Arvind is a senior member of the IEEE Power Engineering Society and a member of IET UK.



DIGITAL TWINS APPLIED TO INFRASTRUCTURE SENSING

Arvind Tiwari

Mission Leader – Electrification

Vernova Advance Research

GE Vernova Portfolio of Businesses:

ONE-OF-A-KIND

POWER



Gas Power

- Heavy Duty Gas Turbines
- Aeroderivative Gas Turbines
- Steam Turbines/Generators



Steam Power

- US Nuclear, Global Coal
- Steam, Generators, Boilers



Hydro

- Hydro Turbines/Generators
- Pumped Storage



Nuclear

- Boiling Water Reactors
- Fuel
- Small Modular Reactors

WIND



Onshore Wind

- 2 - 3.5 MW platform
- 5 – 6 MW platform
- Services & repowering



Offshore Wind

- Haliade-150 (6 MW)
- Haliade-X (14 MW)



Wind Power

- ONW blades
- Haliade X blades

ELECTRIFICATION



Grid Solutions

- Transmission
- Transformers
- Grid Automation



Power Conversion

- O&G Electrification
- Naval Electrification
- Microgrids



Solar & Storage Solutions

- Inverters
- Energy storage

DIGITAL



- Grid Software
 - Opus One Plat.
- Manufacturing
- Power and O&G

FINANCIAL SERVICES

Financial Services

- 3rd Party Financing Support
- Direct Financing through Equity

ACCELERATORS

Advanced Research

- Differentiated Technologies
- External Partnerships

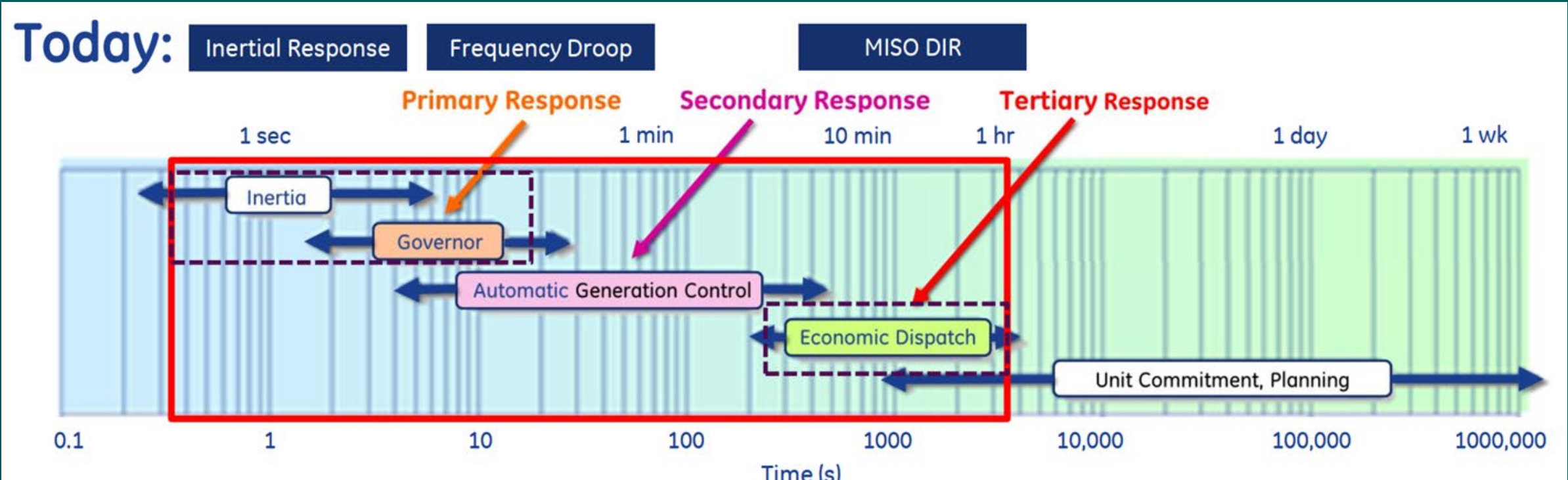
Consulting Services

- Power Market Assessments
- Investment Decision Analysis

Helping our customers generate

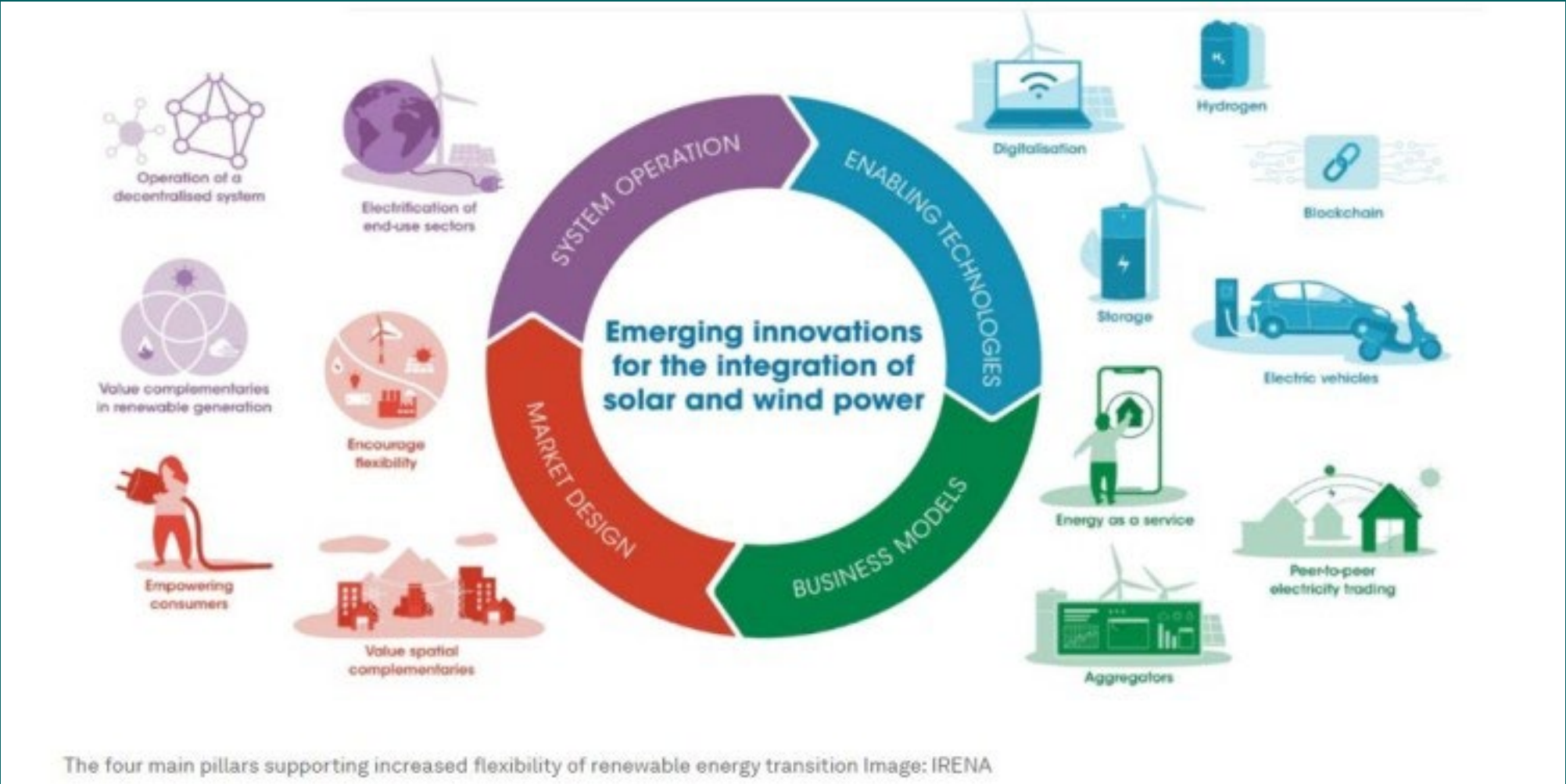
~30% of the World's Electricity

Grid Operations ... A wide range of timescales



Embracing the Energy Transition:

Challenges and Adaptations for Power Utilities



Grid modernization necessary for rapid progress in the energy transition

- Data-driven decision-making helps ensure the world's electric grids are reliable, efficient, and resilient

Electric utility equipment loaded with sensors, automation, data communications and software orchestration, can adapt dynamically to fluctuating sources of energy whether those electrons come from gas-powered generators or wind-powered turbines

Converting a substation from analog to digital brings real-time computing power, data analytics, and actionable intelligence to the management of complex, bi-directional energy flows.



Gain actionable intelligence and unlock new values of your substation data



Reduce CAPEX by eliminating duplicated hardware (CT, VT are no longer required)



Reduce engineering work through simplified system drawings



Improve workforce safety (miles of copper wires are replaced with fiber-optic cables)



Easier, faster and remote commissioning / testing



Reduce substation footprint by up to 50% through a smaller control room



Improve system reliability through increased situational awareness and asset utilization

Integrated cost-effective monitoring and diagnostics solution that leverages existing relay data without need for additional devices or sensors to detect electrical, mechanical or thermal abnormalities before they become critical motor failures

Advanced motor monitoring and trending provides condition-based status of electrical conditions that can affect motor performance and life including:

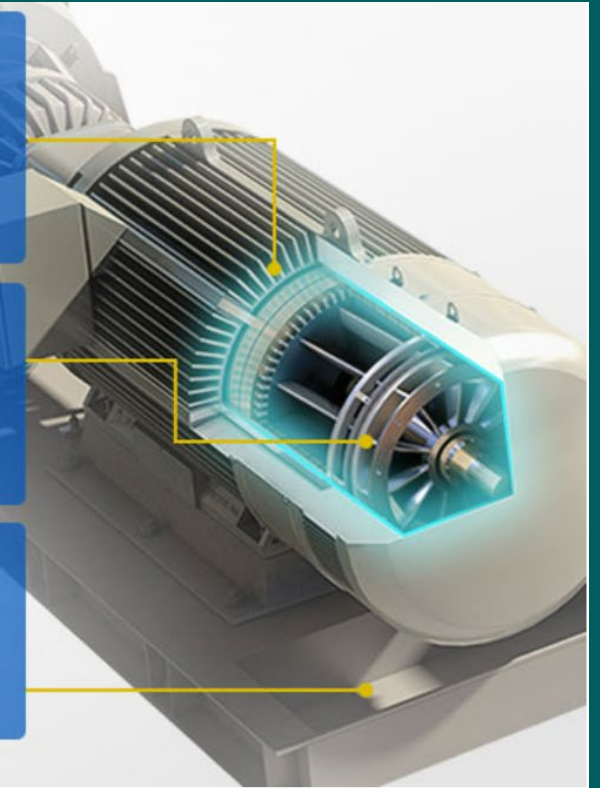
- Stator inter-turn insulation degradation
- Phase-to-phase insulation degradation
- Stator ground fault failure

Continuous, proactive monitoring of **Thermal Capacity Used (TCU)** for early identification of thermal stresses including:

- Extreme starting conditions
- Locked Rotor
- Harmonics
- Unbalance Current

Utilizing Electrical Signal Analysis (ESA) / Motor Current Signature Analysis (MCSA) to identify common mechanical abnormalities including:

- Broken Rotor Bars
- Foundation Looseness
- Bearing Failures
- Misalignments



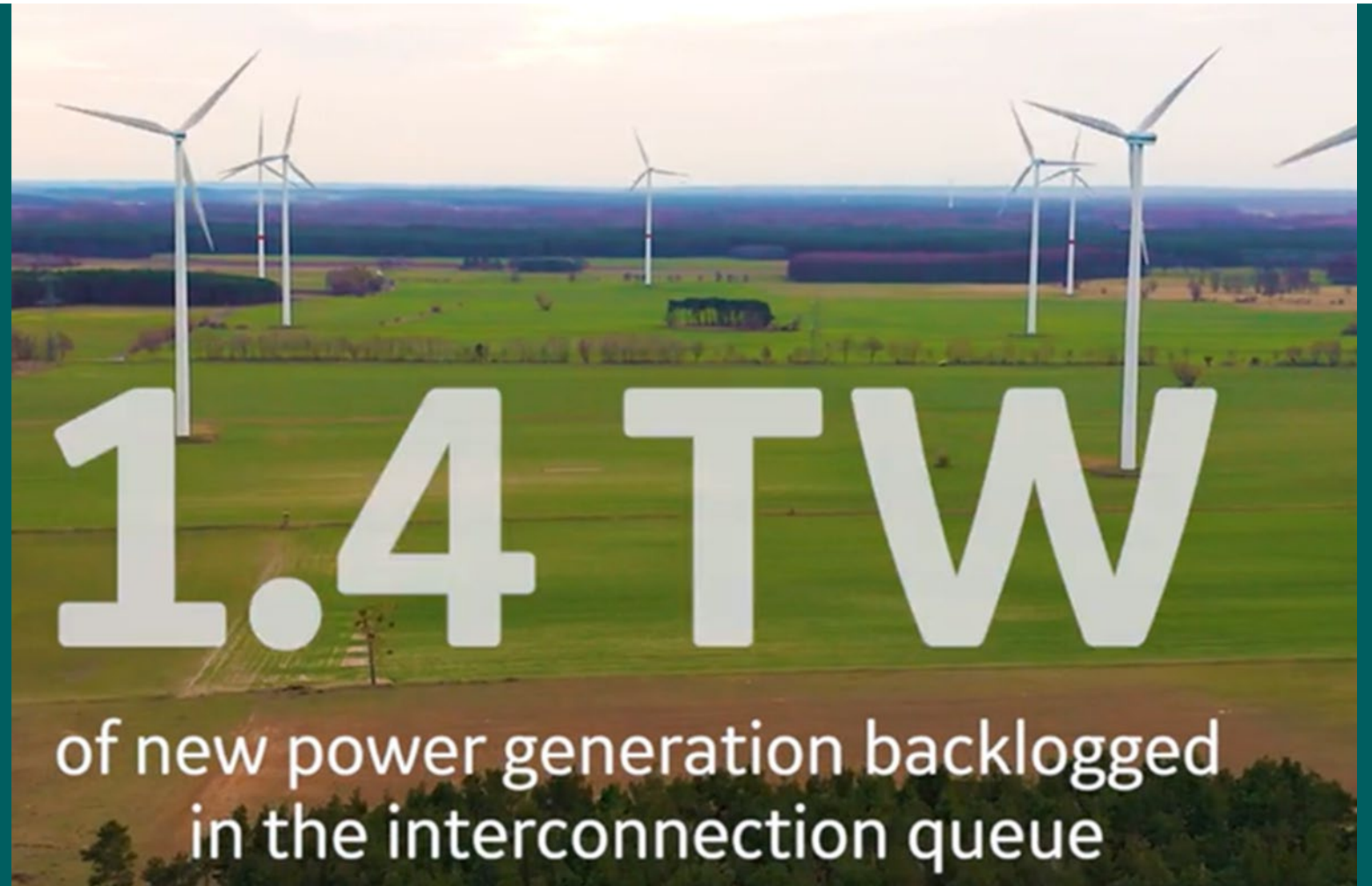
Dynamic System Rating

Reduces grid congestion and increase more renewables onto the grid

To deliver end to end dynamic system rating which will increase capacity and utilization of existing grid by combining

- **Dynamic Line rating**
- **Dynamic Power Rating and**
- **Optimal Power Flow Control**

Dynamic system rating is a process of collecting phasor measurement unit data and determining upper limit of active power that can be safely transmitted preventing network voltage collapse



Wide Area Management System and Control (WAMS-WAMC)



Make visible the invisible – A new vision of the network

Wide Area Management Systems (WAMS) leverage the use of synchronized high-resolution data from phasor measurement units (PMUs) to monitor and improve the performance of transmission and distribution networks.

By providing the fast frequency response needed for low inertia power systems, WAMS can help manage increased renewable penetration in the grid.



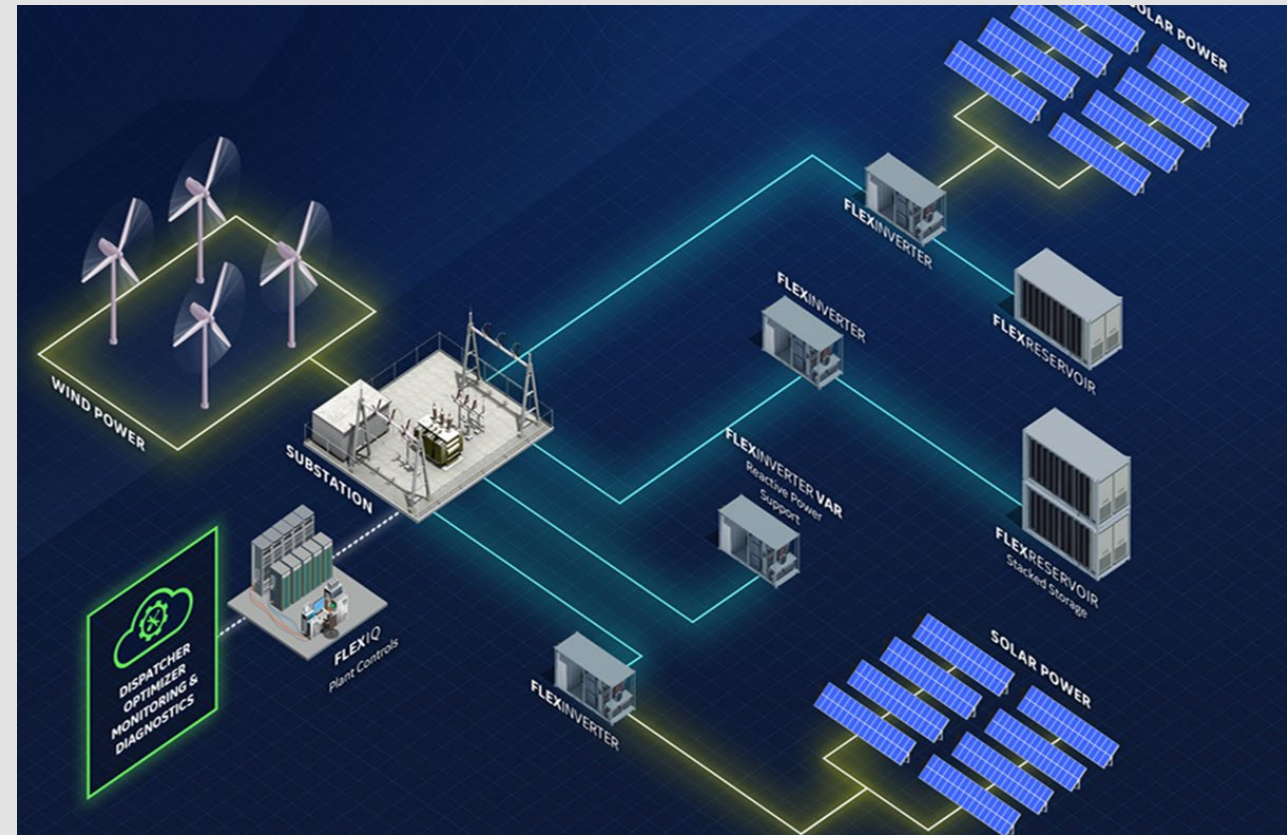
Our FLEX solution set

Flexible. Reliable. intelligent

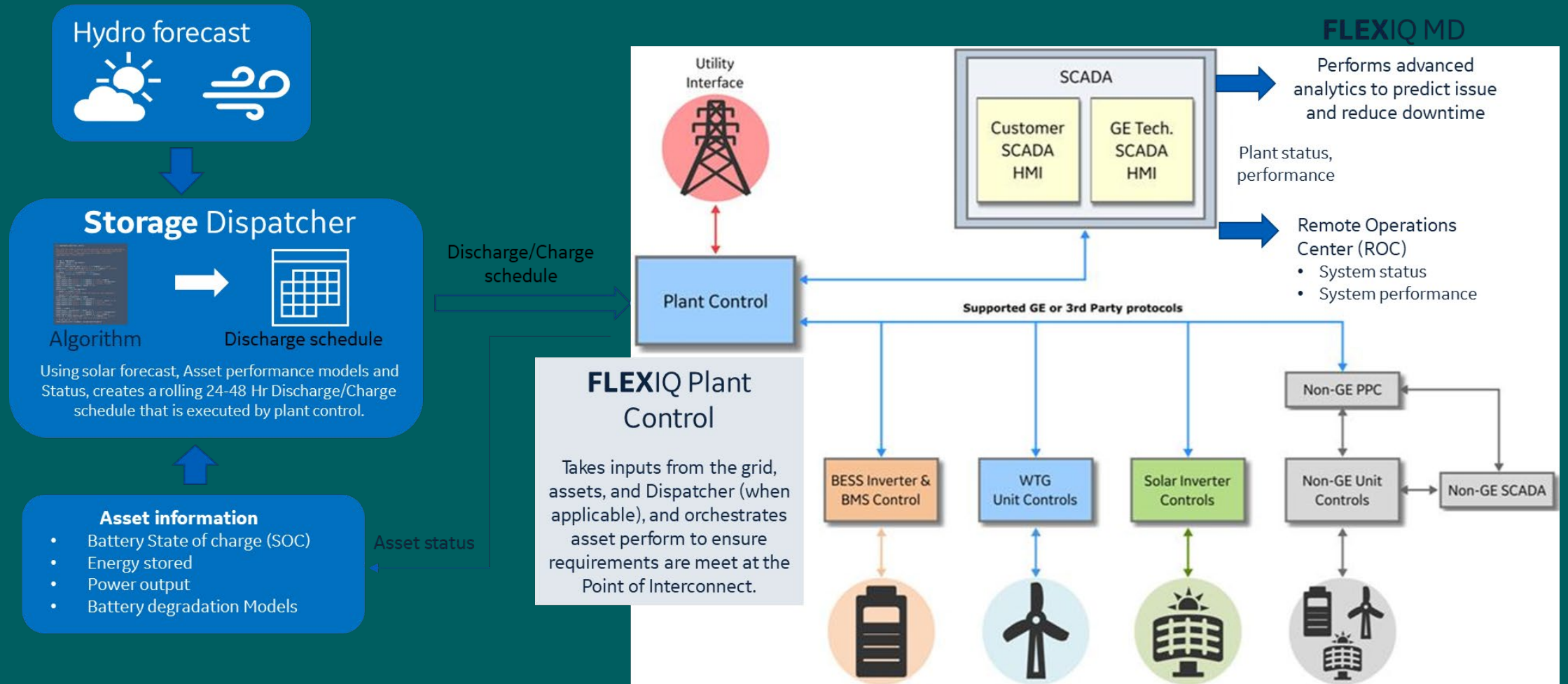
FLEXIQ – digital platform that provides design, operations and fleet management solutions to enable grid compliance and maximize lifetime customer value

FLEXRESERVOIR – systems integrated battery energy storage & power electronics solution, for multiple configurations and market applications

FLEXINVERTER* – containerized solution that delivers a reliable, cost-effective, plug & play, factory integrated power conversion platform for utility scale solar and storage applications



FLEXIQ Control System (Plant Control, Dispatcher, and MD)



Wind PowerUp Turn up. Tune up.

The PowerUp platform uses a suite of performance dials and levers to fine tune a wind turbine's operation and help enhance its energy production.



Speed



Torque



Pitch



Yaw

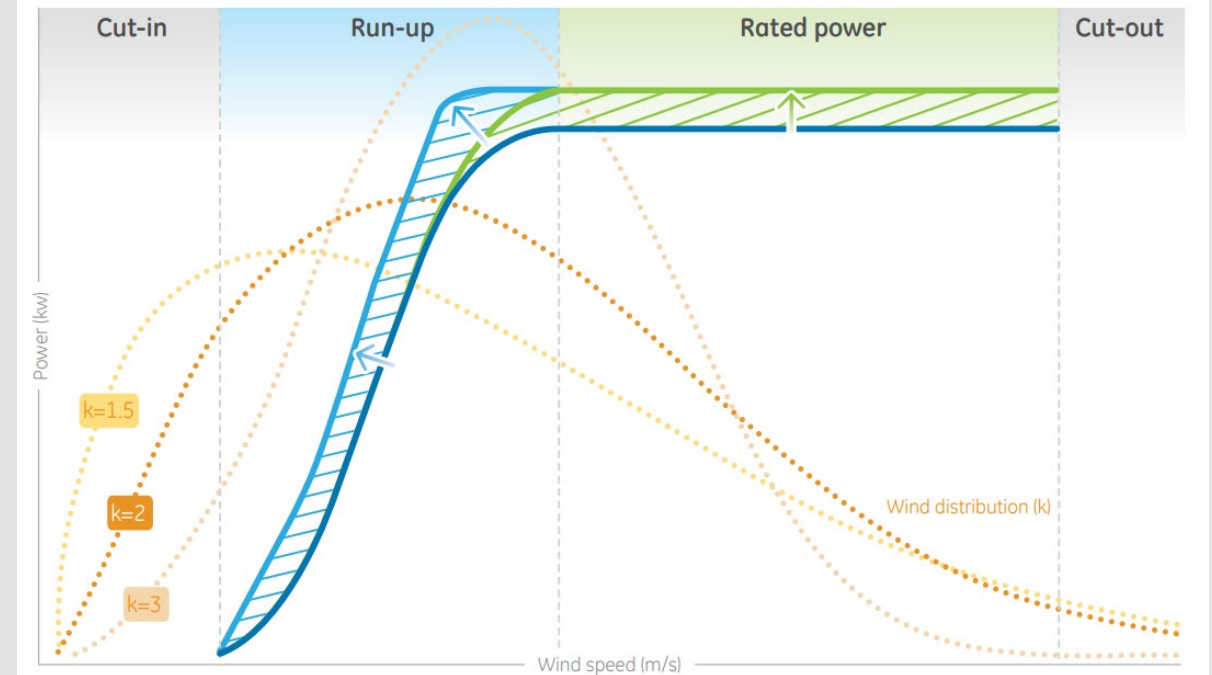


Aerodynamics

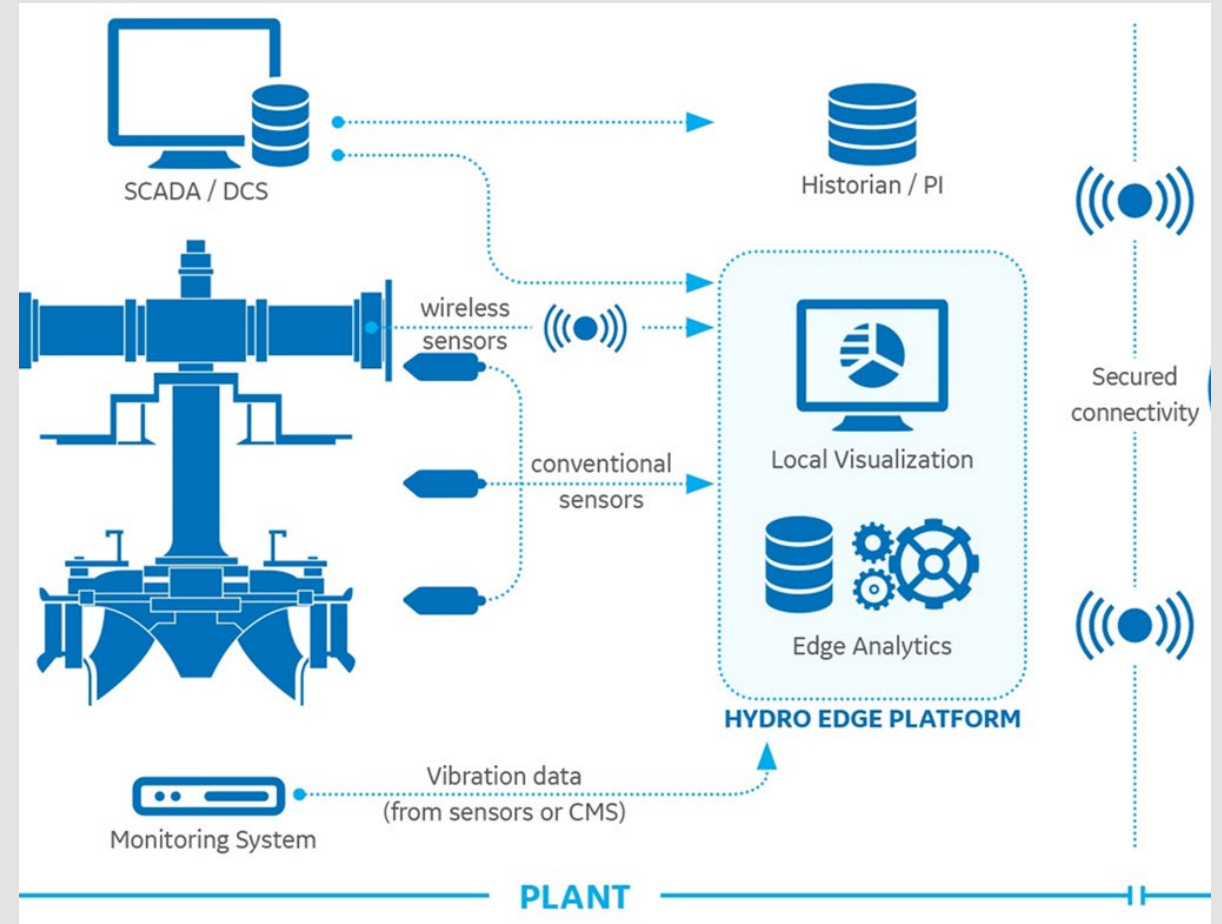


Turbine Controls

PowerUp performance curve

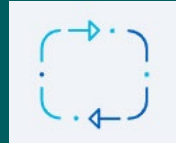


Digital Hydro Solutions



Benefits of Digital Twin

Digital twins are a key piece of the digital transformation puzzle. They create an accurate virtual replica of physical objects, assets, and systems to boost productivity, streamline operations and increase profits.



Increased reliability and availability



Reduced risk



Lower maintenance costs



Improved production



Faster-time-to-value



GE VERNOVA