Digital Twins as Remote Operations Centers (ROCs) for Alternative Energy

Pieter Van Schalkwyk - CEO

Alternative Energy Fun Facts for 2025

Investment in renewable generation by entities outside of the utility sector will surpass investment in renewable generation by utilities.

20% of energy utilities globally will manage periods of negative wholesale energy prices due to oversupply from renewable energy resources.

40% of utility field asset inspections will be performed by autonomous robotic systems automatically updating asset and maintenance conditions.

30% of G20 countries will drive flexibility markets with common process and data exchanges, in response to energy shortages.

2025 is closer than you think

40% of utility field asset inspections will be performed by autonomous robotic systems automatically updating asset and maintenance conditions.

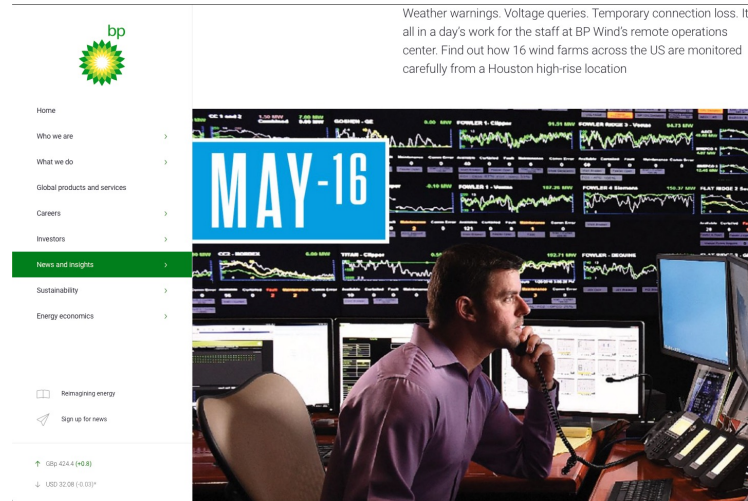Data available in real time at a Remote Operations Center (5G)

AE Remote Operations Centers: The Power Users

### Renewable Control Center

Renewable Control Center

Duke Energy's Renewable Control Center (RCC) in Charlotte, North Carolina, uses powerful and secure technology to monitor wind and solar power plants across the country. Duke Energy entered the wind power business in 2007 and launched its commercial solar power business in 2009. The RCC provides critical monitoring services for all of Duke Energy Renewables' operating assets, which total about 3,000 megawatts (MW).

Weather warnings. Voltage queries. Temporary connection loss. It's all in a day's work for the staff at BP Wind's remote operations center. Find out how 16 wind farms across the US are monitored carefully from a Houston high-rise location

Rio Tinto powers ahead on solar farm to supply Pilbara iron ore mine

Sophie Vorrath   30 July 2021   0
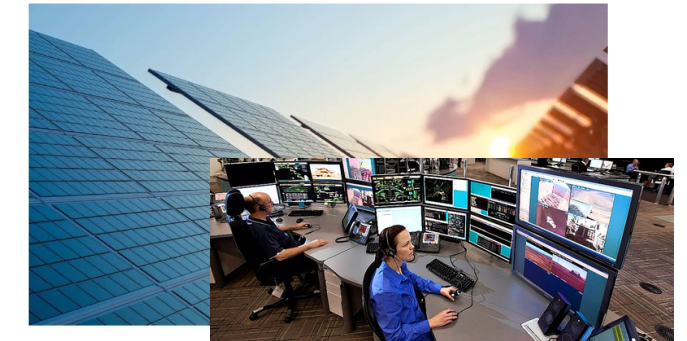
Rio Tinto's first fully-owned solar farm is to begin construction within a few week after the engineering, procurement and construction partner for the project was announced this week.

ASX-listed company NRW Holdings revealed on Friday that it had won the roughly $60 million contract for the delivery the 34MW Gudai Darri (Koodaideri) solar farm, with construction and commissioning scheduled for completion in early 2022.

Rio Tinto announced early last year that it would build a large-scale solar farm at its $2.6 billion Gudai Darri iron-ore mine in Western Australia's Pilbara region, to supply all of its daytime electricity needs and two-thirds of its annual requirements.

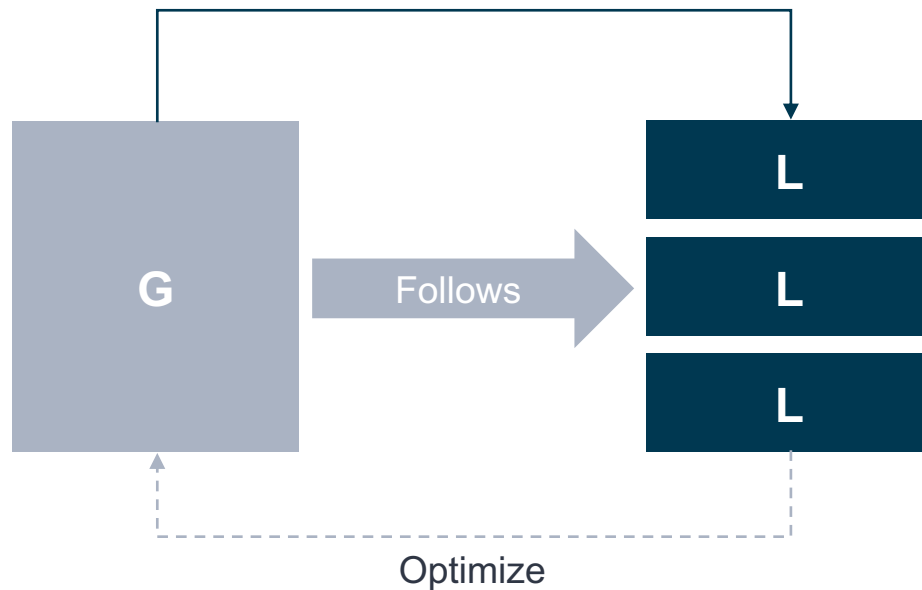| Traditional Energy companies with ROC control room	Oil & Gas companies investing in Alternative Energy with ROCs	Industrial "Prosumers" like infrastructure owners with DOCs

There is a Shift in Power . . .
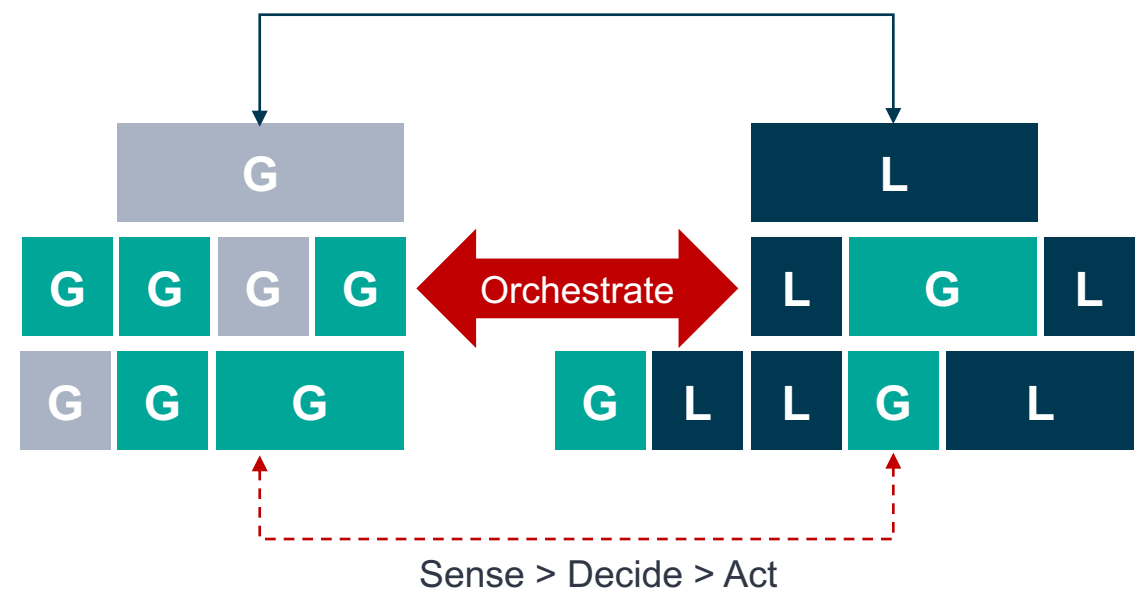

Yesterday — Today/Tomorrow

Predictable Load Matched With Dispatchable Supply
Reliability, Controllability, and Predictability

Centralized with traditional OT and control, and automation systems → Follows → Conventional Distribution Grid

Optimize

Loads Respond to Supply Intermittency
Collaboration, Orchestration, and Flexibility

Distributed Energy Resources with a mix of IoT, Digital Twins, and control, and automation systems ← Orchestrate → Complex Market Driven Grid "front of meter" and "behind the meter"

Sense > Decide > Act
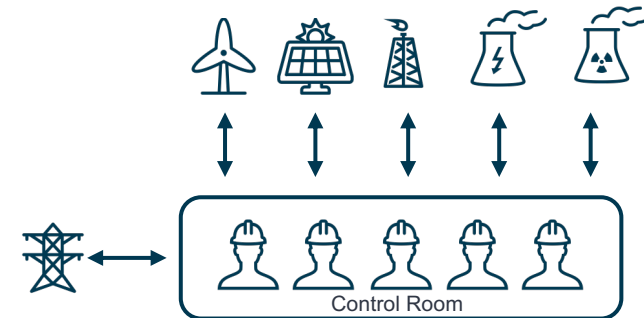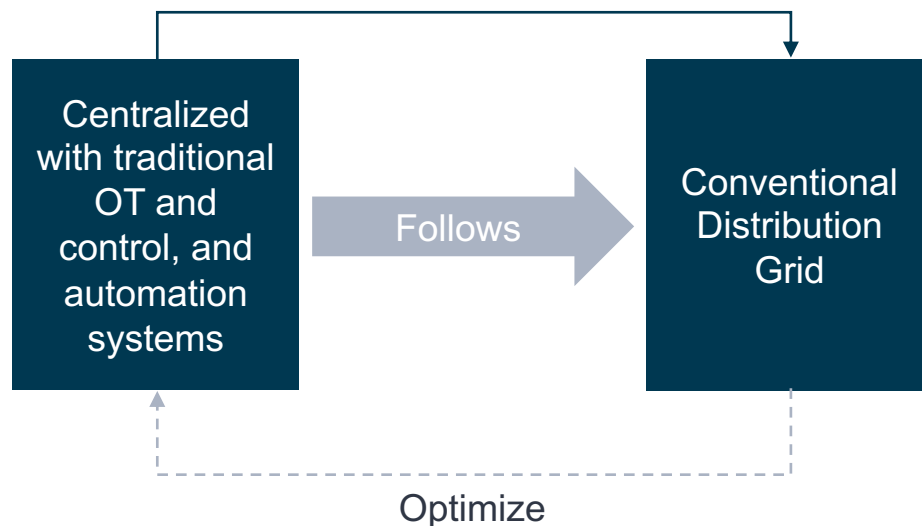
■ Traditional Generation

■ Renewable Generation
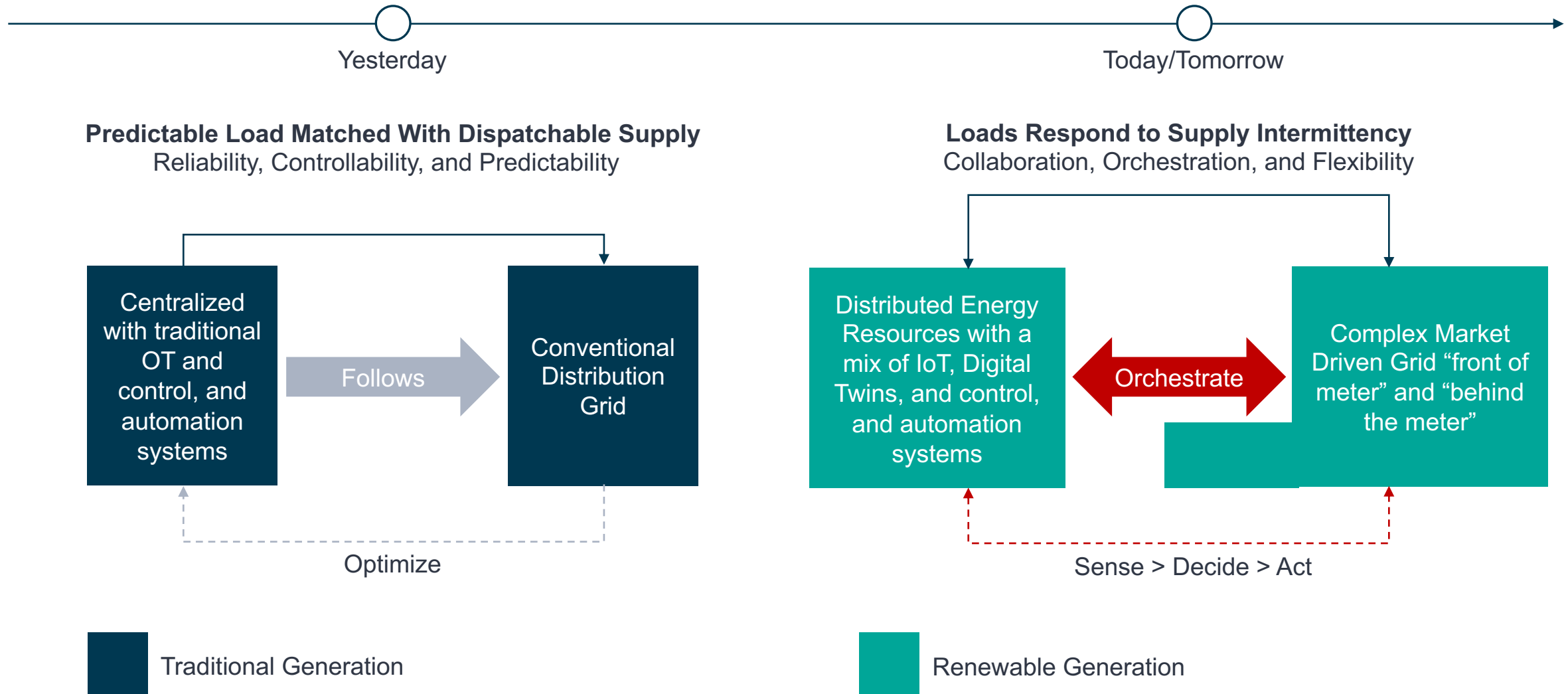
There is a Shift in Power . . .

Yesterday

Predictable Load Matched With Dispatchable Supply
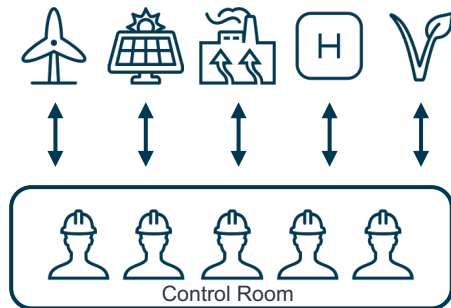Reliability, Controllability, and Predictability

Centralized with traditional OT and control, and automation systems → **Follows** → Conventional Distribution Grid

Optimize

Traditional Generation

Control Room

Operational Control Focused
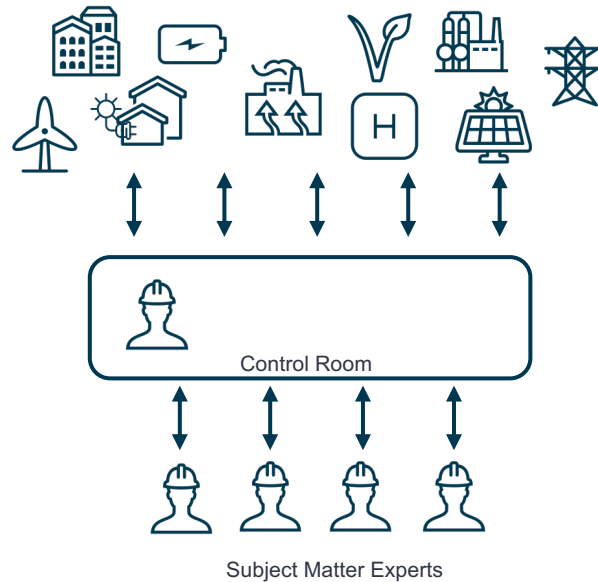
From ROC to DOC : Digital Twins for Value Chain

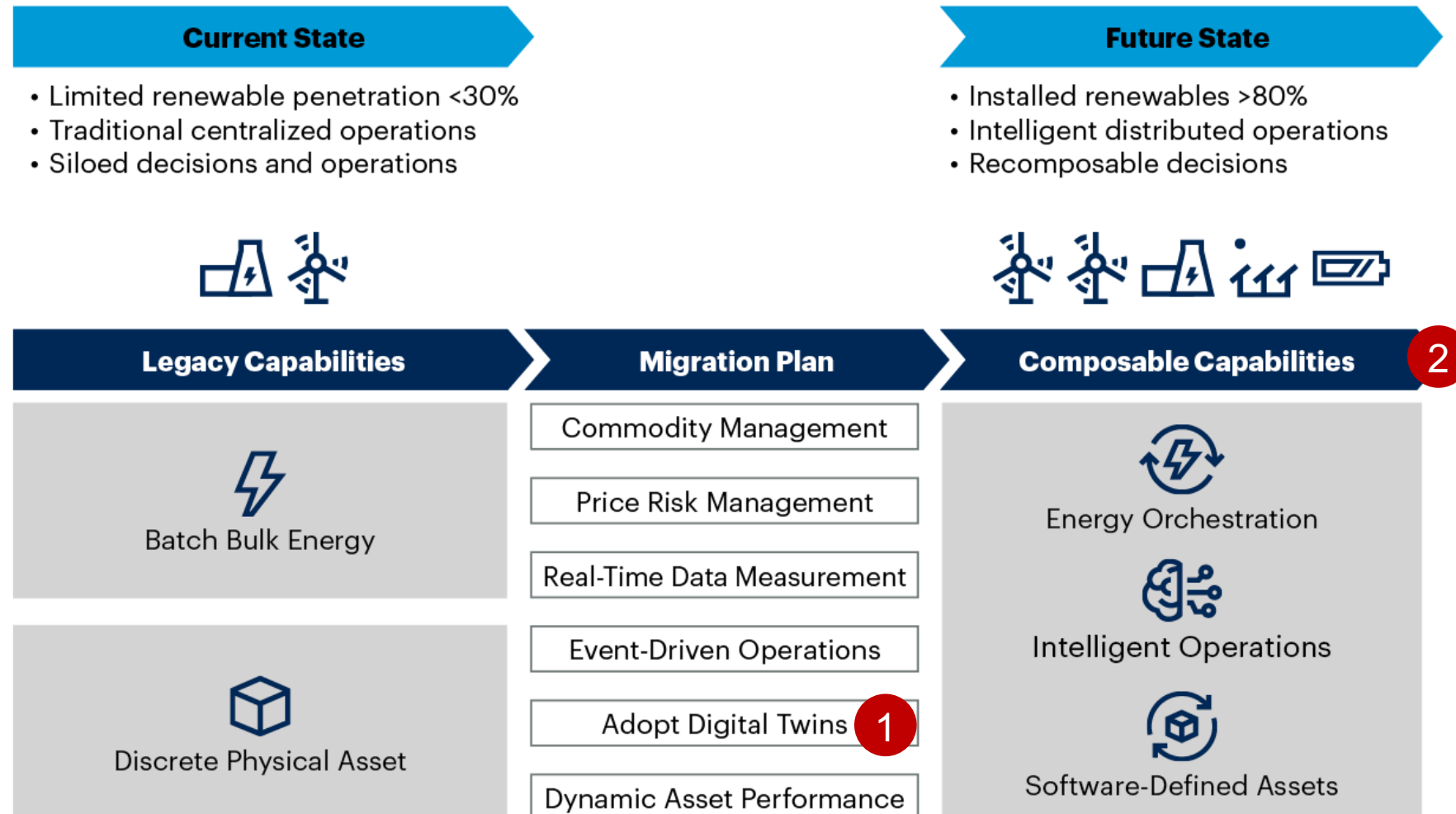| Traditional Command & Control Remote Operations Center	Digital Twin Enabled Remote Operations Center	Digital Twin Enabled Distributed Operations Center
Operational Control Focused	Operational Optimization Focused	Value Chain Optimization Focused
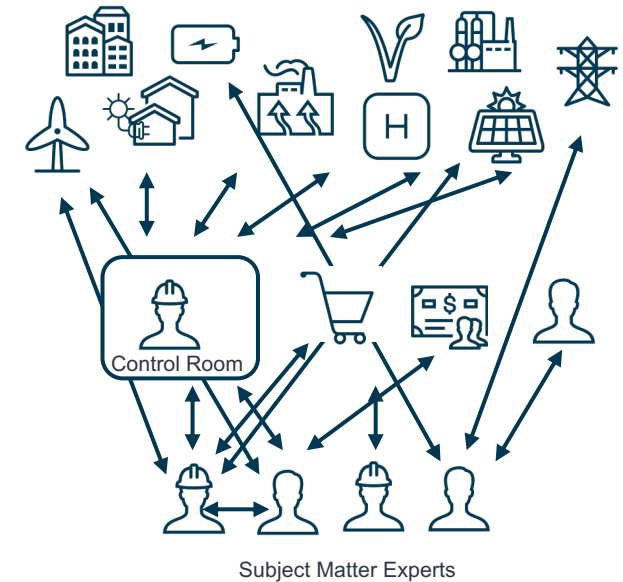
This level summary and doesn't reflect all capabilities of ROC

Deploy and Integrate Renewable Resources at Scale

Current State
- Limited renewable penetration <30%
- Traditional centralized operations
- Siloed decisions and operations

Future State
- Installed renewables >80%
- Intelligent distributed operations
- Recomposable decisions

Legacy Capabilities	Migration Plan	Composable Capabilities 2
Batch Bulk Energy	Commodity Management	Energy Orchestration
	Price Risk Management	
	Real-Time Data Measurement	
	Event-Driven Operations	Intelligent Operations
Discrete Physical Asset	Adopt Digital Twins 1	Software-Defined Assets
	Dynamic Asset Performance	

Source: Gartner

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Gartner.

Digital Twins is a Model-based Approach

Physical Environment

Information

Virtual Environment

Physical Processes

Physical Twin

Synchronization At Twinning Rate

Digital Twin

Synchronization At Twinning Rate

Data

$$x[k] = \sum_{n=0}^{N-1} x[n]e^{\frac{-j2\pi kn}{N}}$$

Virtual Processes

Physical operating State

Digital State Information
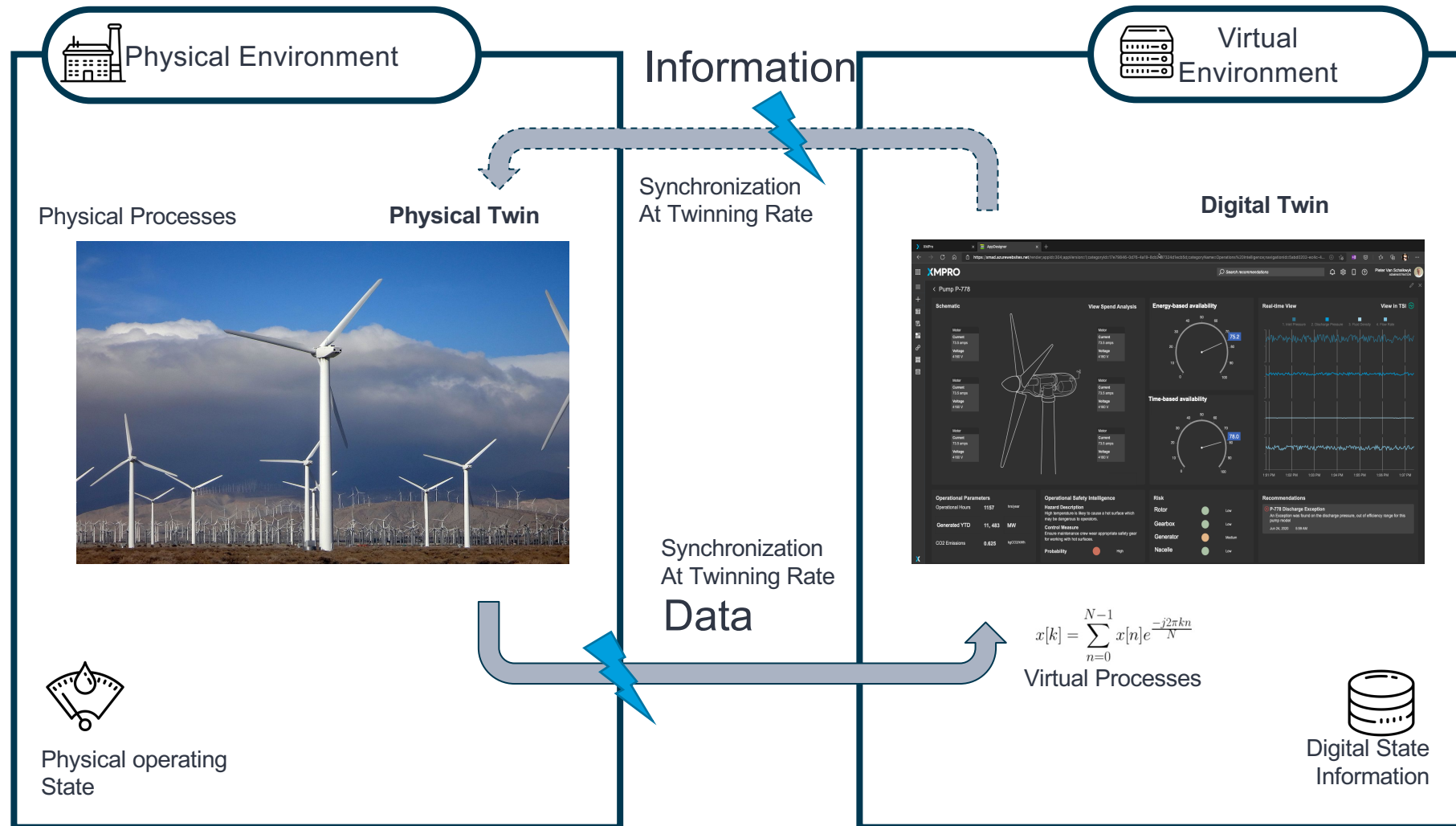
DTP vs DTI vs DTA for Renewable Energy

Digital Twin Prototype
DTP (Template)

Physical Entity

Digital Twin Instance
DTI

Digital Twin Aggregate
DTA (Composite)
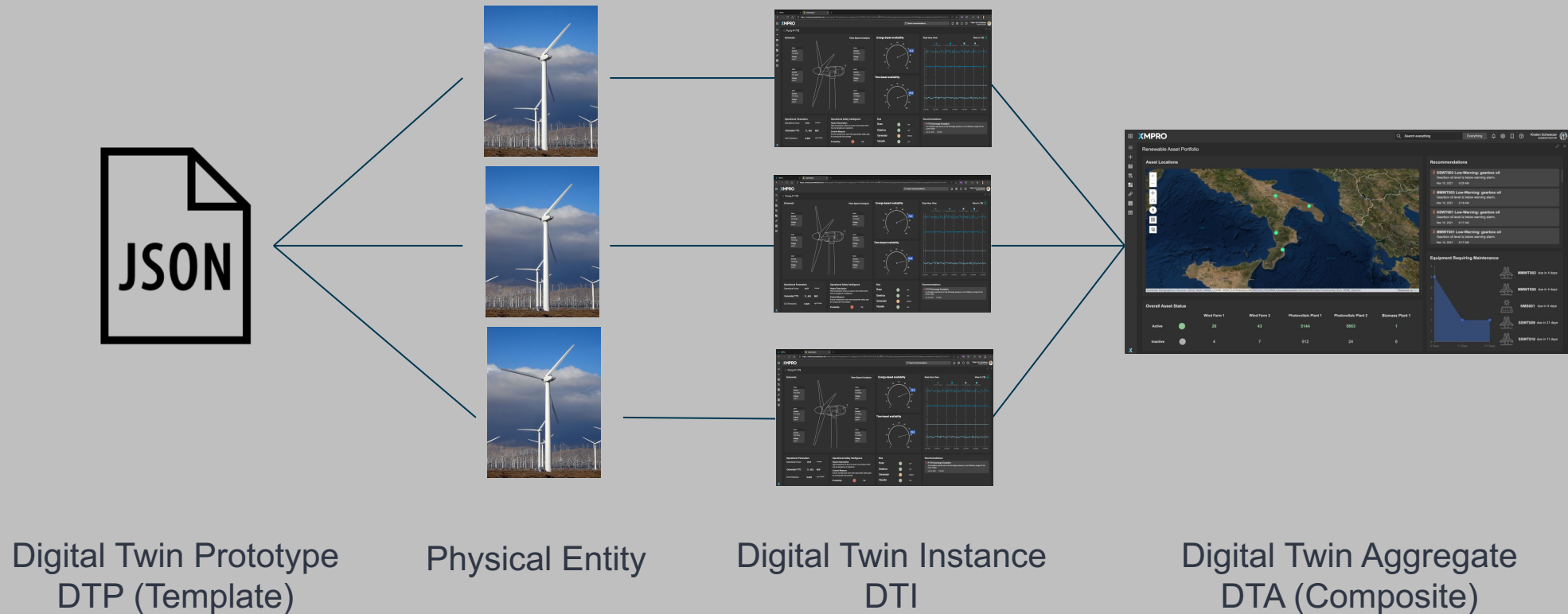
Digital Twin in ROC should focus on Capabilities
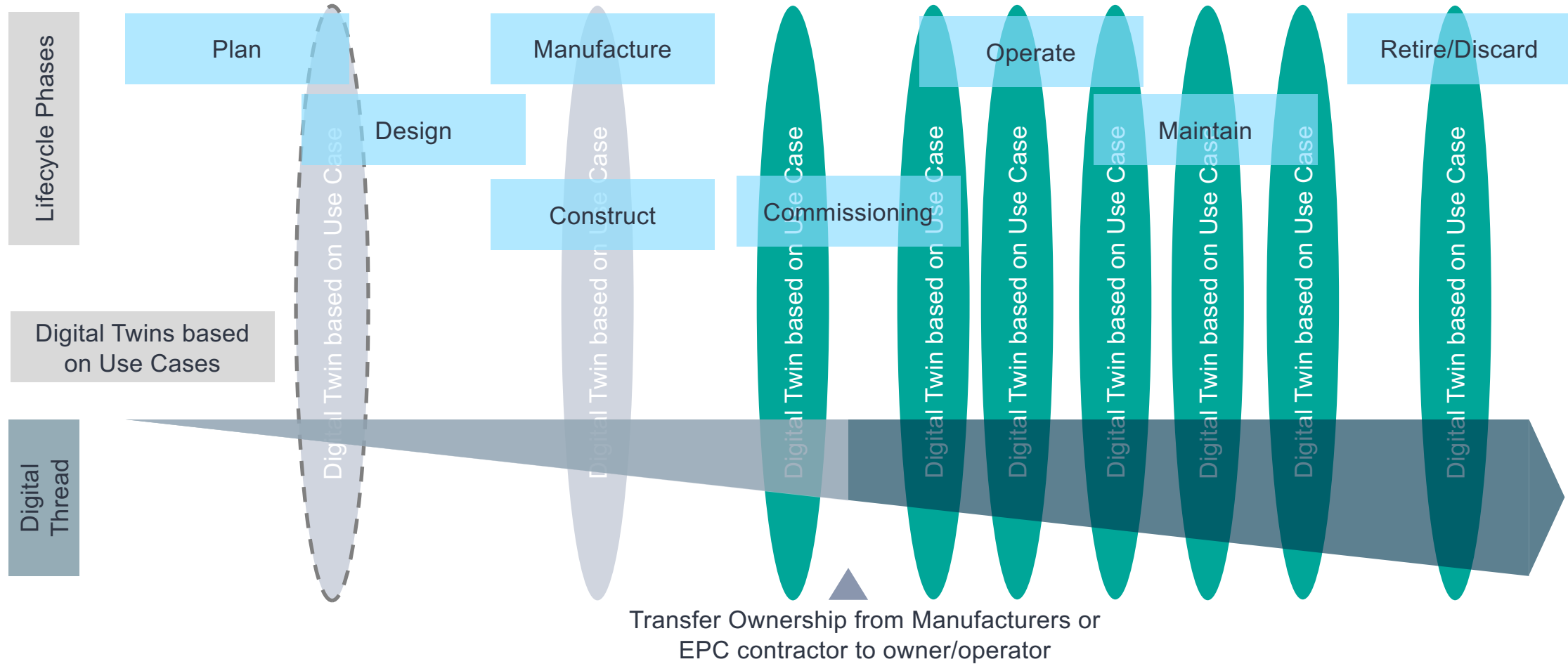
Digital Twin Capabilities Periodic Table

|							
1 Data Acquisition & Ingestion	**9** Synthetic Data Generation	**17** Enterprise System Integration	**23** Edge AI & Intelligence	**29** Prediction		**39** Basic Visualization	**45** Dashboards
2 Data Streaming	**10** Ontology Management	**18** Eng. System Integration	**24** Command & Control	**30** Machine Learning ML		**40** Advanced Visualization	**46** Continuous Intelligence
3 Data Transformation	**11** Digital Twin (DT) Model Repository	**19** OT/IoT System Integration	**25** Orchestration	**31** Artificial Intelligence AI	**35** Prescriptive Recommendations	**41** Real-time Monitoring	**47** Business Intelligence
4 Data Contextualization	**12** DT Instance Repository	**20** Digital Twin Integration	**26** Alerts & Notifications	**32** Federated Learning	**36** Business Rules	**42** Entity Relationship Visualization	**48** BPM & Workflow
5 Batch Processing	**13** Temporal Data Store	**21** Collab Platform Integration	**27** Reporting	**33** Simulation	**37** Distributed Ledger & Smart Contracts	**43** Augmented Reality AR	**49** Gaming Engine Visualization
6 Real-time Processing	**14** Data Storage & Archive Services	**22** API Services	**28** Data Analysis & Analytics	**34** Mathematical Analytics	**38** Composition	**44** Virtual Reality VR	**50** 3D Rendering
7 Data PubSub Push	**15** Simulation Model Repository	**52** Device Management	**54** Event Logging	**56** Data Encryption	**58** Security	**60** Safety	**51** Gamification
8 Data Aggregation	**16** AI Model Repository	**53** System Monitoring	**54** Data Governance	**57** Device Security	**59** Privacy	**61** Reliability	**62** Resilience

○ Data Services ○ Integration ○ Intelligence ○ UX ○ Management ○ Trustworthiness

https://www.digitaltwinconsortium.org/initiatives/capabilities-periodic-table.htm
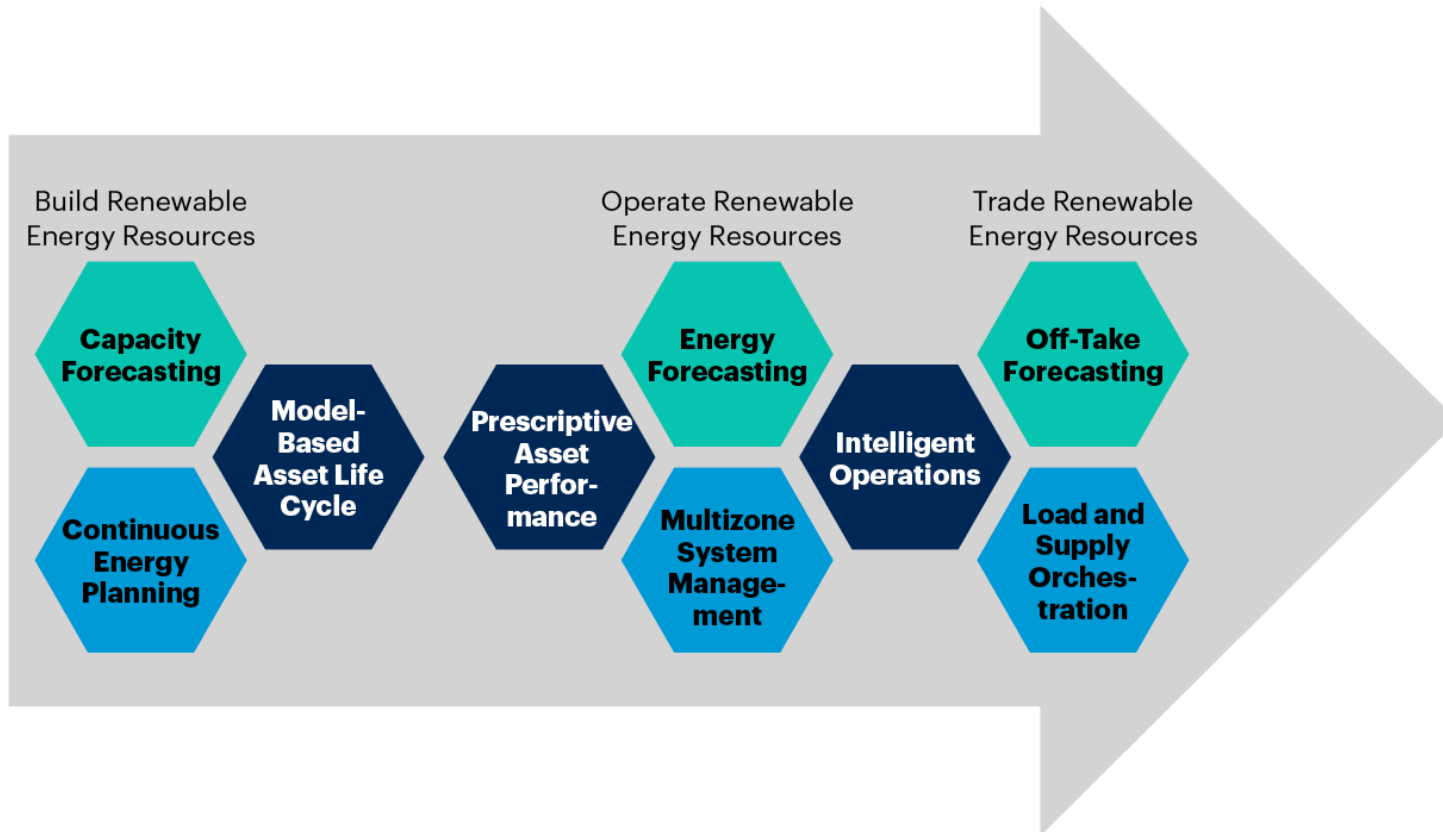
Windfarm Condition Monitoring Use Case

1 Data Acquisition & Ingestion		18 Eng. System Integration				39 Basic Visualization	45 Dashboards
2 Data Streaming	10 Ontology Management	19 OT/IoT System Integration				40 Advanced Visualization	46 Continuous Intelligence
3 Data Transformation	11 Digital Twin (DT) Model Repository		25 Orchestration		35 Prescriptive Recommendations	41 Real-time Monitoring	47 Business Intelligence
4 Data Contextualization	12 DT Instance Repository		26 Alerts & Notifications		36 Business Rules		48 BPM & Workflow
	13 Temporal Data Store		27 Reporting				
6 Real-time Processing	14 Data Storage & Archive Services	22 API Services	28 Data Analysis & Analytics	34 Mathematical Analytics	38 Composition		
			54 Event Logging	56 Data Encryption	58 Security	60 Safety	51 Gamification
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Legend:
- Data Services
- Integration
- Intelligence
- UX
- Management
- Trustworthiness

https://www.digitaltwinconsortium.org/initiatives/capabilities-periodic-table.htm

Windfarm Energy Prediction Use Case
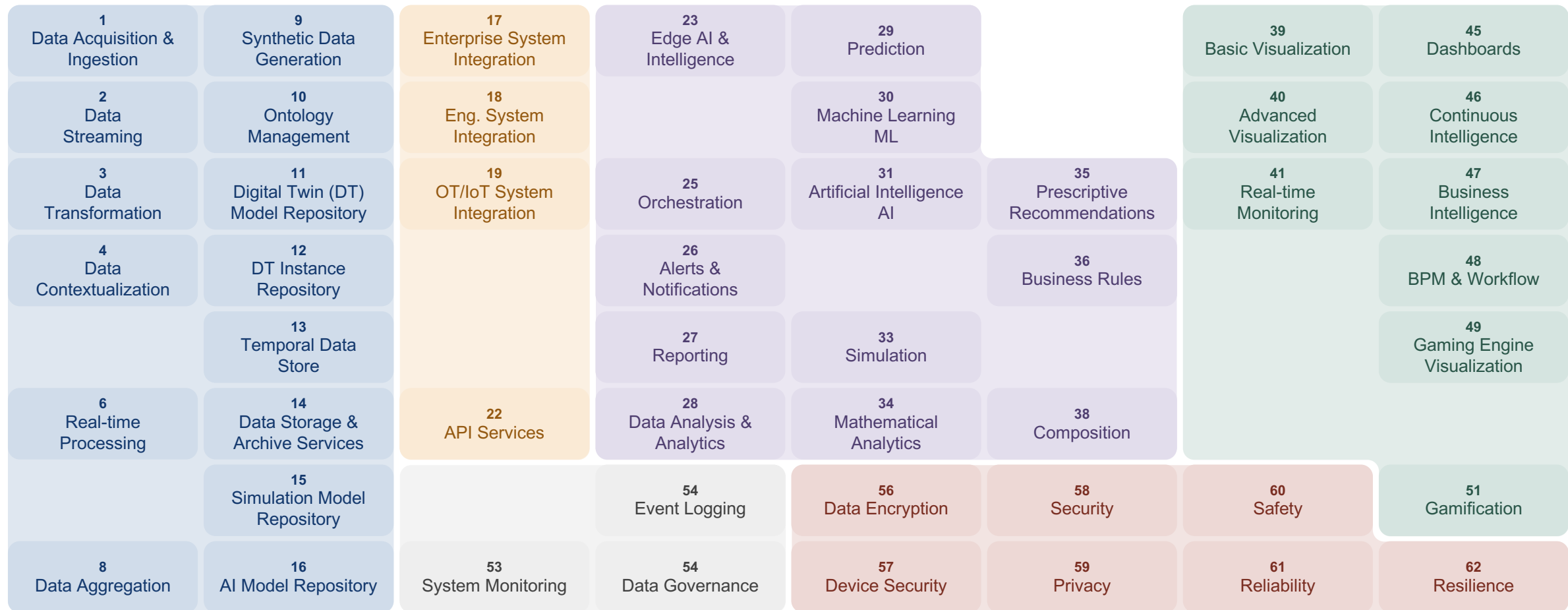
Key Composable Business Capabilities for RE

Asset Capability • **Commodity Capability** • **Forecast Capability**

Build Renewable Energy Resources

- Capacity Forecasting
- Continuous Energy Planning
- Model-Based Asset Life Cycle
- Prescriptive Asset Performance

Operate Renewable Energy Resources

- Energy Forecasting
- Multizone System Management
- Intelligent Operations

Trade Renewable Energy Resources

- Off-Take Forecasting
- Load and Supply Orchestration

Composable Digital Twins as the basis for Distributed Operations Centers for Renewable Energy

Source: Gartner
752309_C

Gartner.

Scenario: Retail group with DERs on properties

Infrastructure owners like retail or property groups are deploying Alternative Energy across assets to reduce cost and carbon. They use AI-enabled Digital Twins to decide when to generate, store, use, or trade energy and carbon

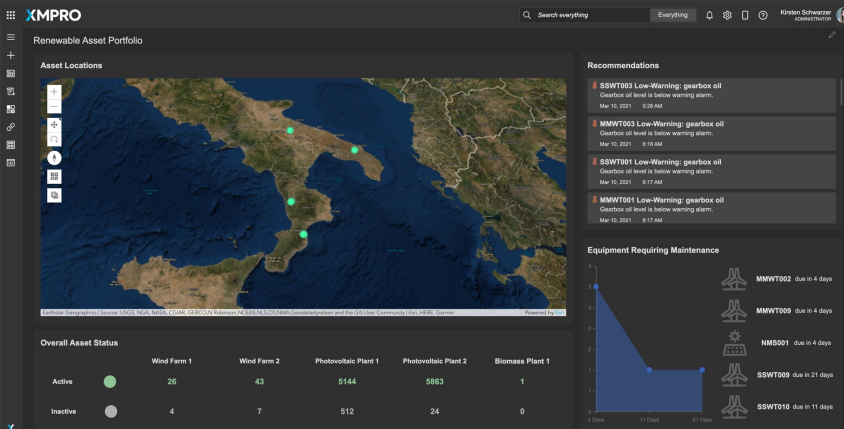Alternative Energy Portfolio
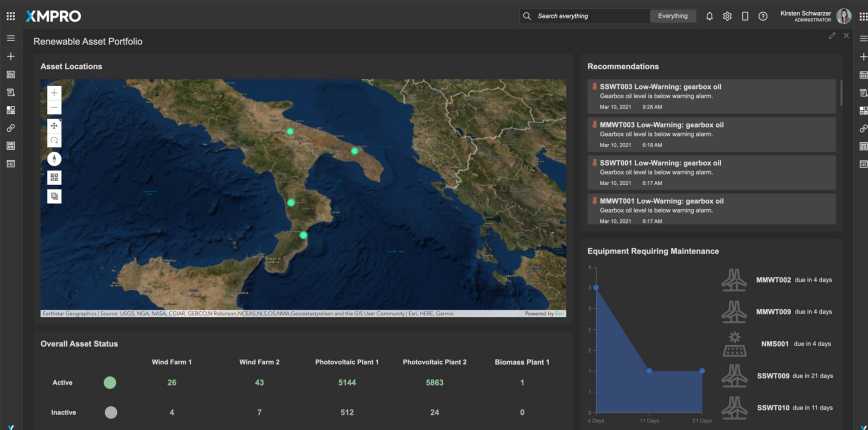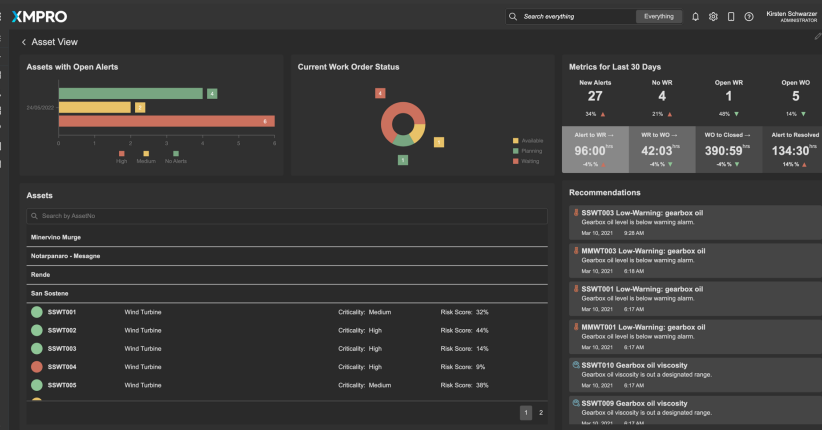
Outcomes Focused

Contextual Meta Data
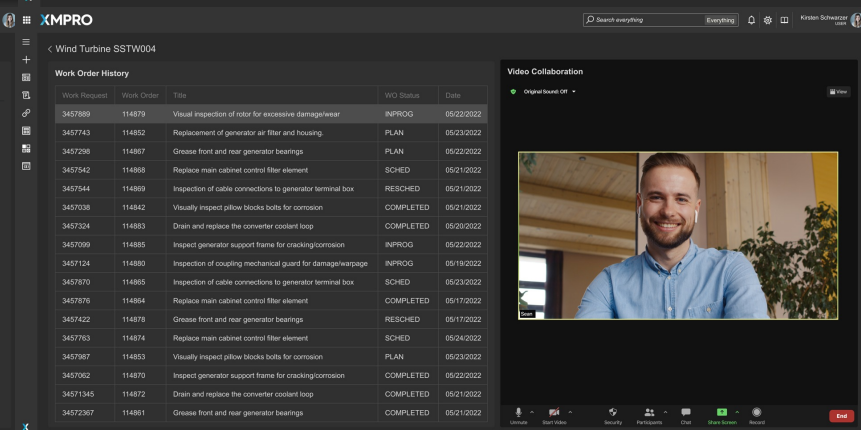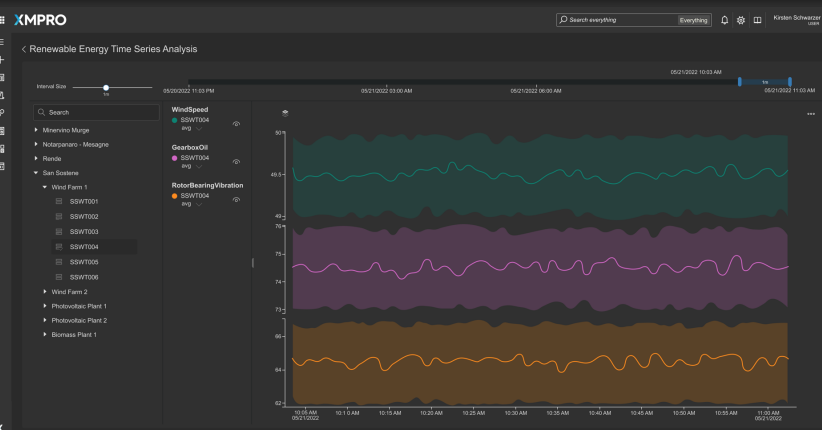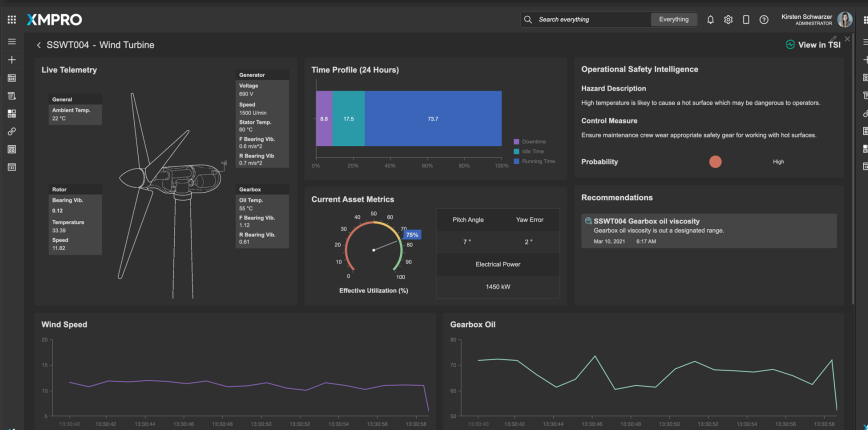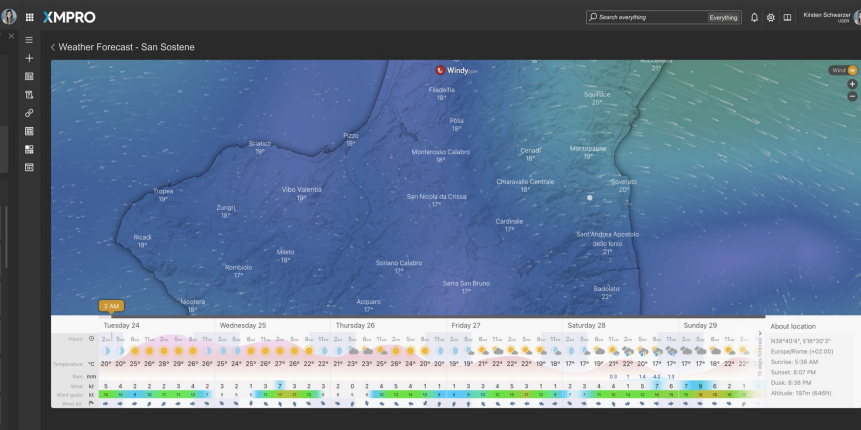
Asset Performance
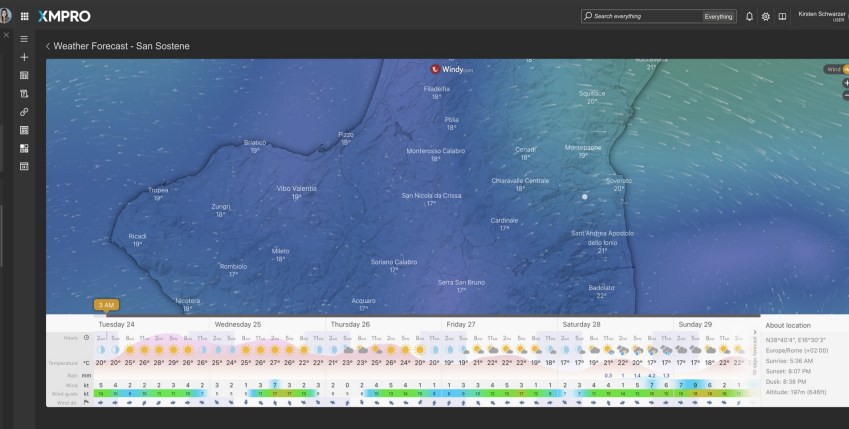
Advanced Analysis

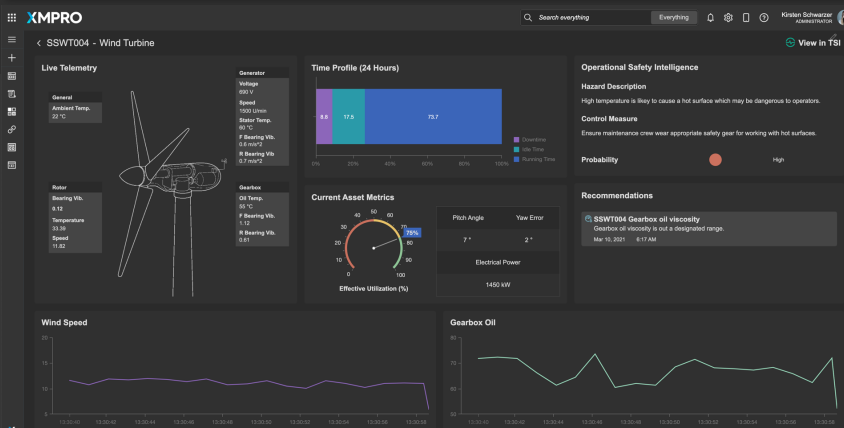Expert Collaboration

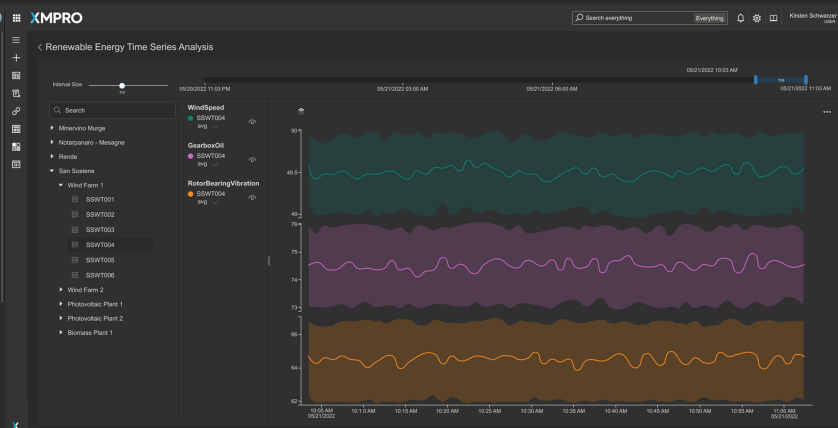SMEs not in-house

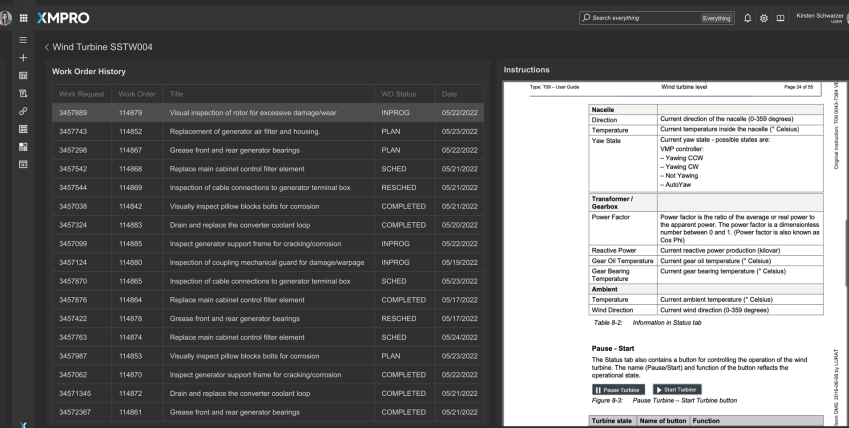Alternative Energy Portfolio

Outcomes Focused
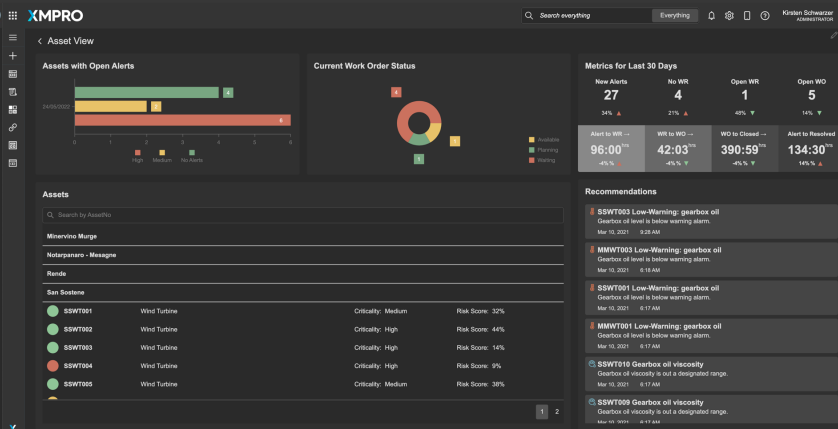
Contextual Meta Data

Asset Performance

Advanced Analysis

Access To Knowlegde

Benefits of Digital Twin ROCs for Alternative Energy

Higher earned revenue from improved yield of renewable generation resources

Improvements in operational performance and reduction in losses

Optimization of asset loading needed for the dispatch scheduling changes as renewable energy grows and maximizing generation from renewable assets becomes a high priority

Maximization of asset valuation through the balancing of operational and economic life