Energy Transition Acceleration with Digital Twins

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WE LIVE IN A WORLD OF INCREASED **ELECTRIFICATION** AND **DECARBONIZATION**

Increased electricity demand from EVs in 2050

5,500 TWh

BENF Electric Vehicle Outlook 2021

Increased renewables capacity by 2050

5,100 TWh

EIA – International Energy Outlook 2021

1/3 OF THE WORLD'S ELECTRICITY

GE

12K
TURBINES

7K+ gas turbines, representing 800+ GW of power generation

Decarbonize: CCUS -> Hydrogen

55K
WIND TURBINES

GE's Haliade™-X turbine, the world's most powerful offshore wind turbine

Grow Renewable Generation

40% World Power
ELECTRIC GRID SOFTWARE

90% of power transmission utilities worldwide have been equipped with GE technology

Connect and Manage More Renewables & DERs

The Energy Transition is Driving Utility Disruption

Industry Drivers

Rise in Renewables

Electrification of Transportation

Prosumer Engagement

Corporate Goals

Legislative, Regulatory & Energy Markets

Global Infrastructure Spending

Distributed Energy Resources (DERs)

PVs, storage, EVs, DR, etc.

Load Growth Via Electrification

Where do we start?
How do we get there?

How can I keep my grid safe, reliable and secure, including and with DERs?

How do I satisfy my customers and keep energy affordable?

Grid Operator Distributed Energy Resource (DER) Pain Points

Utility Pain Points

- Clearing connection queue in time
- Customers dissatisfied with connection denial, time and costs
- Data sharing and privacy

- What DERs? Where are they? What are they doing?
- Does control room or planning know?
- There're a lot of them! Systems and processes scalable?

- Can I control them? Schedule them?
- Go through aggregators? AMI? DR programs and contracts?
- How do I know they actually operated?

- At risk of causing grid violations? Where/when, & how much headroom?
- How do I secure my grid? Can I optimize with DERs?
- What if?

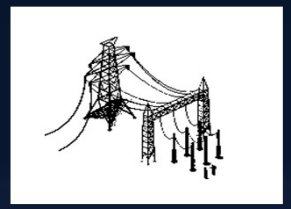
- Non-wires alternative (NWA) requirements
- Stacked value of DER (VDER)
- Flexibility trading marketplace, DSOs

Digital Twin Tech Stack to Drive Renewables/DER Growth

Helping utilities transform to a **sustainable** and **intelligent** energy network

Bulk Generation

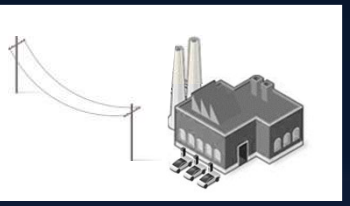
Generation Utilities



WHOLESALE RETAIL

Transmission Utility Operations

Transmission Utility & Market Operators



Distribution Utility Operations

Distribution Utility Operators

- *PV*
- *Wind*
- *EV Charging*
- *Batteries*
- *Heat Pumps*
- *Smart Thermostats*
- *Microgrids*

Behind The Meter

Aggregators & Virtual Power Plants

Applications

- PLAN & MONITOR
- OPTIMIZE
- CONTROL
- TRANSACT (MARKET)

TRANSMISSION/ENERGY MANAGEMENT

Monitoring & Switching | Congestion Management | Volt/VAR Optimization | Stability/ Ineretia Mgmt.

Unit Commitment | SC Economic Dispatch | Automated Gen. Controls | etc...

DISTRIBUTION MANAGEMENT

Monitoring & Switching | Outage Management | Volt/VAR Optimization

Integrated Distributed Planning | Dist. Market Management | etc...

DER MANAGEMENT

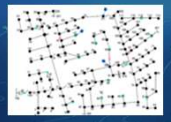
Demand Response | Battery Dispatch Optimization | Energy Management

Microgrid Optimization | etc...

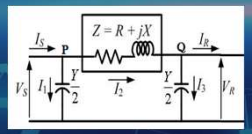
DATA & DIGITAL TWIN FOUNDATION

GIS Model

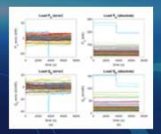
Network Model



Physics Model



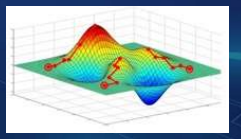
State Estimators



Forecasting Engine

Artificial Intelligence

Optimization Engine



Enabling Electric Grid Reliability, Resiliency, and Affordability

Future of Grid Technical **Challenges to Solve**…

- Building **an accurate digital twin of the network with large scale renewables** and maintaining it as the grid changes
- **Operating** the grid at the scale of renewable penetration shifting from **deterministic to probabilistic**
- **Maintain grid stability** for low inertia grid leveraging **flexible fast balancing controls**
- Tracking **millions** of **Electric Vehicles** and leveraging them **for grid reliability**
- **Modernizing energy markets** and accommodating the speed of renewable energy adoption
- **Preventing bad actors** from disrupting the energy supply with ever increasing **cyber security**
- **Leveraging AI and ML** to operate and optimize the grid of tomorrow **reactive to proactive**

Thank you