

Vertiv's Mission Critical Microgrid

IEEE

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Aspirations!



Look Towards a Sustainable Future

The world is facing a difficult dilemma. Our need for **power grows**, but at the same time we need to cut carbon emissions to combat emissions and set a course towards a **sustainable future**. Hybrid power solutions can solve this dilemma, letting you reduce emissions without putting **reliability and safety** on the line. And the technology to do it is mature and available on the market today.

Market Drivers: Critical Power Infrastructure

Drivers	Trend
Decarbonization / Sustainability	<ul style="list-style-type: none">• Elimination of diesel generators underway• Deploying energy saving operating modes• Evaluating alternative energy sources: Fuel Cell, BESS, Linear-Generator, on-site renewables
Reliability / Service Level	<ul style="list-style-type: none">• “Fail Small” / Reduce impact of equipment failures• Lower system level redundancy while reducing single points of failure• Power quality / harmonic mitigation• Fault Management
Operating Capability / Costs	<ul style="list-style-type: none">• Increase infrastructure utilization / lower physical redundancy• Larger building block architectures, align equipment sizing• Controls: Increase automation, reduce cost of implementation and risk of human error
Deployment / Modularization	<ul style="list-style-type: none">• Deploy in modular chunks vs total build up front• Parallel path design / build activity• Move work from site back into the supply chain (lower cost and quality control)

A Positive Move in Mission Critical Applications

Historical

Lazy Assets (Stranded Assets)

- **Power goes out backup generator fails to start**
 - Backup is not in continuous operations
 - Major events (i.e., Super Storm Sandy) 16% of backup generators failed to operate.
- **Fuel access restrictions**
 - Major storm events
- **Grid Constraints**
- **Air Quality**
 - In a modern grid the majority of outages are under 5 minutes
 - Gensets come on and run for extended time to exercise equipment and burn fossil fuel
 - Onsite storage of fuel

Future?

Always On Assets

- **Hybrid systems are always on**
 - Continuous duty energy storage and DER's are always on
 - Planned maintenance of an always on system allows for higher uptime
- **Leverage various fuel sources**
 - Reliance on high reliable fuel sources like, natural gas, sun, wind, energy storage
 - Increased reliability
- **Outages are normally short term and energy storage fills the void**
 - Grid outages can be handled by energy storage and any backup generation remains idle

Dynamic Power Architecture Evolution

UPS as Critical Energy Controller

- Customer Example: Hyperscale #1
- Adding grid support capability
- The UPS is the source of reliability
- Solution uses a backup system which only comes on in times of need
- Leverage Vertiv leadership in UPS

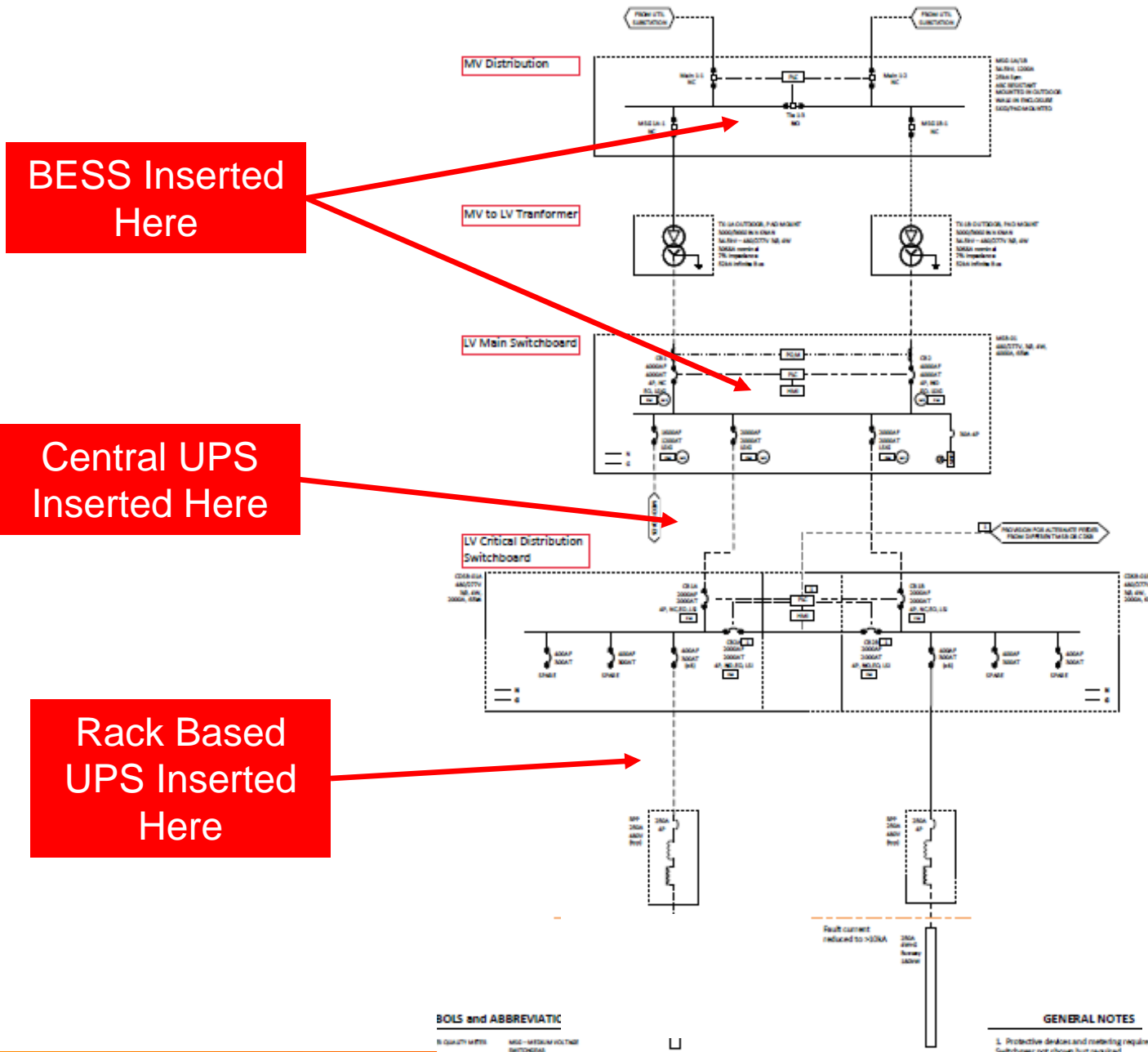
Battery Energy Storage System (BESS)

- Customer Example: Hyperscale #2
- Batteries (distributed or centralized) or BESS are a source of power backup
- Vertiv entering market, leveraging Vertiv mission-critical infrastructure reputation

Mission-Critical Micro-Grid

Microgrid Controls with Bi-Directional UPS and/or BESS using hybrid energy sources.

OCP One-Line



Vertiv Dynamic Power System

Our view of the Microgrid



Vertiv's Dynamic Power Solution

DIGITAL

DECARBONIZED

DECENTRALIZED

- Vertiv™ Dynamic Power EMS System (Optimization)
 - Power Optimization – ERP, Maintenance...
 - Energy Management Controls Application layer
 - Real Time System (site level controls) for:
 - Grid Services, Renewable Integration, Economic Optimization, etc.

Vertiv™ EnergyFlex Family of Products:

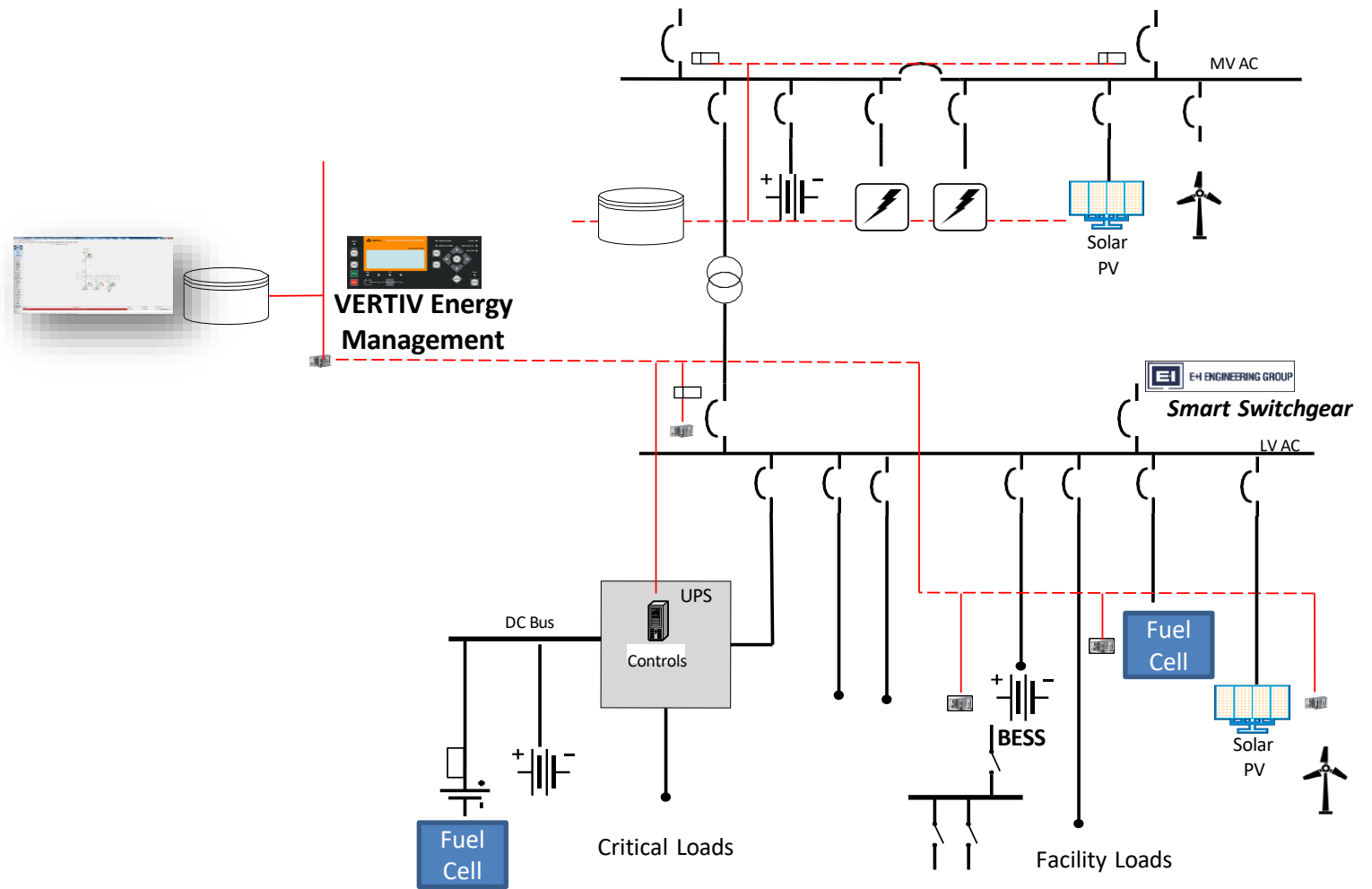
- Vertiv™ EnergyFlex Smart Switchgear
 - UL and IEC rated switchgear MV and LV Solutions
 - Leverage across grid solution to enhance energy efficiency and reliability

- Vertiv™ Microgrid Controllers
 - Onsite Real Time solution for Hybrid Power Plants

- Vertiv™ EnergyFlex BESS
 - Scalable – 15+ Year solution
 - Li-Ion Based – 1+ hour backup time
 - Global Ratings
 - Modular Design

- Vertiv™ UPS
 - Improve and Scale
 - New Tech

Vertiv Dynamic Energy Ecosystem



Challenges We Face in Data Center

Transitioning isn't easy – stuck in our ways

What have we done?!

- **Current infrastructure and processes “get in the way”**
 - 2N, N+1...uptime (5...7-9's)
 - Still highly mechanical designs
- **Institutional rules – good but...**
 - We still think mechanically
- **Coordination of assets**
 - Reduce impact of faults
- **Battery Chemistries**
 - Sometimes we think there is a better option

How do we get there?!

- **Reduce complexity because the AC Bus is “always on”**
 - Power and Data shifting
 - Duplication too high?
- **Use digital controls and power electronics to further enhance grid components.**
- **Li-Ion safe but what's the future of Chemistry?**
- **Stop the idea of a one for one replacement**
 - Can power electronics be distributed?
- **DC**
 - Perhaps there is a bright future?

Battery Chemistries

Li-Ion

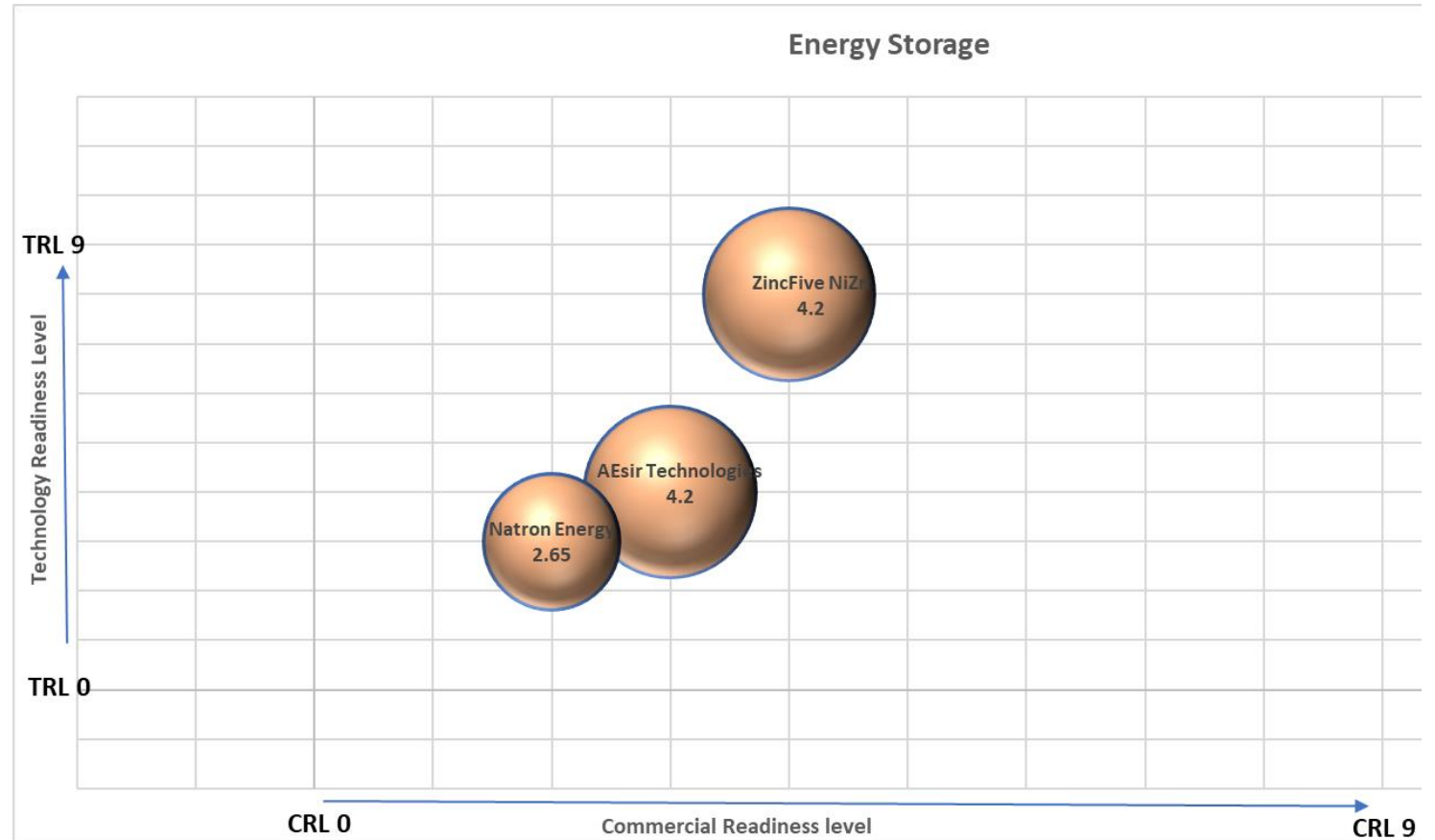
LFP, NMC

Solid State

UL9540A

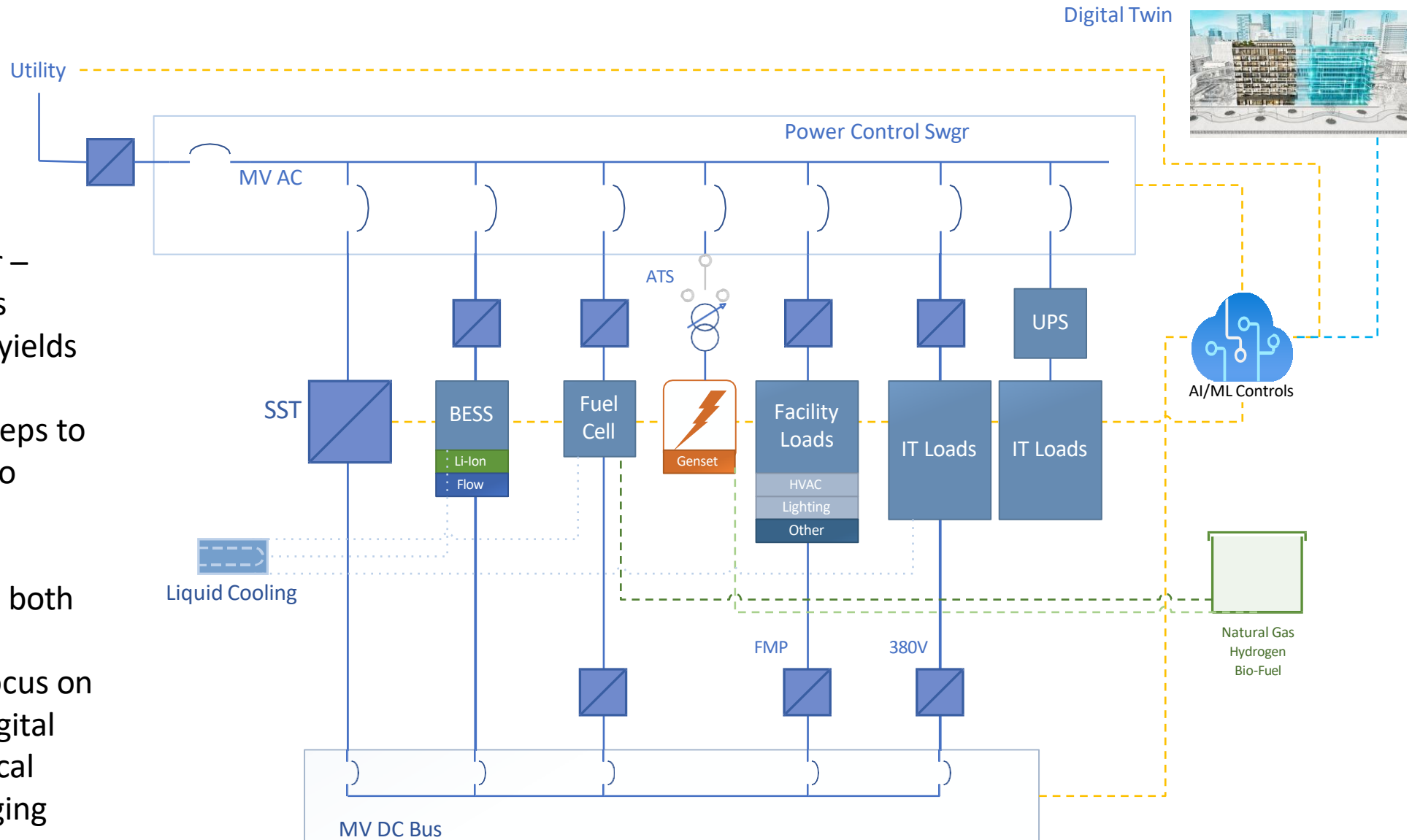
NiZn

Na-Ion



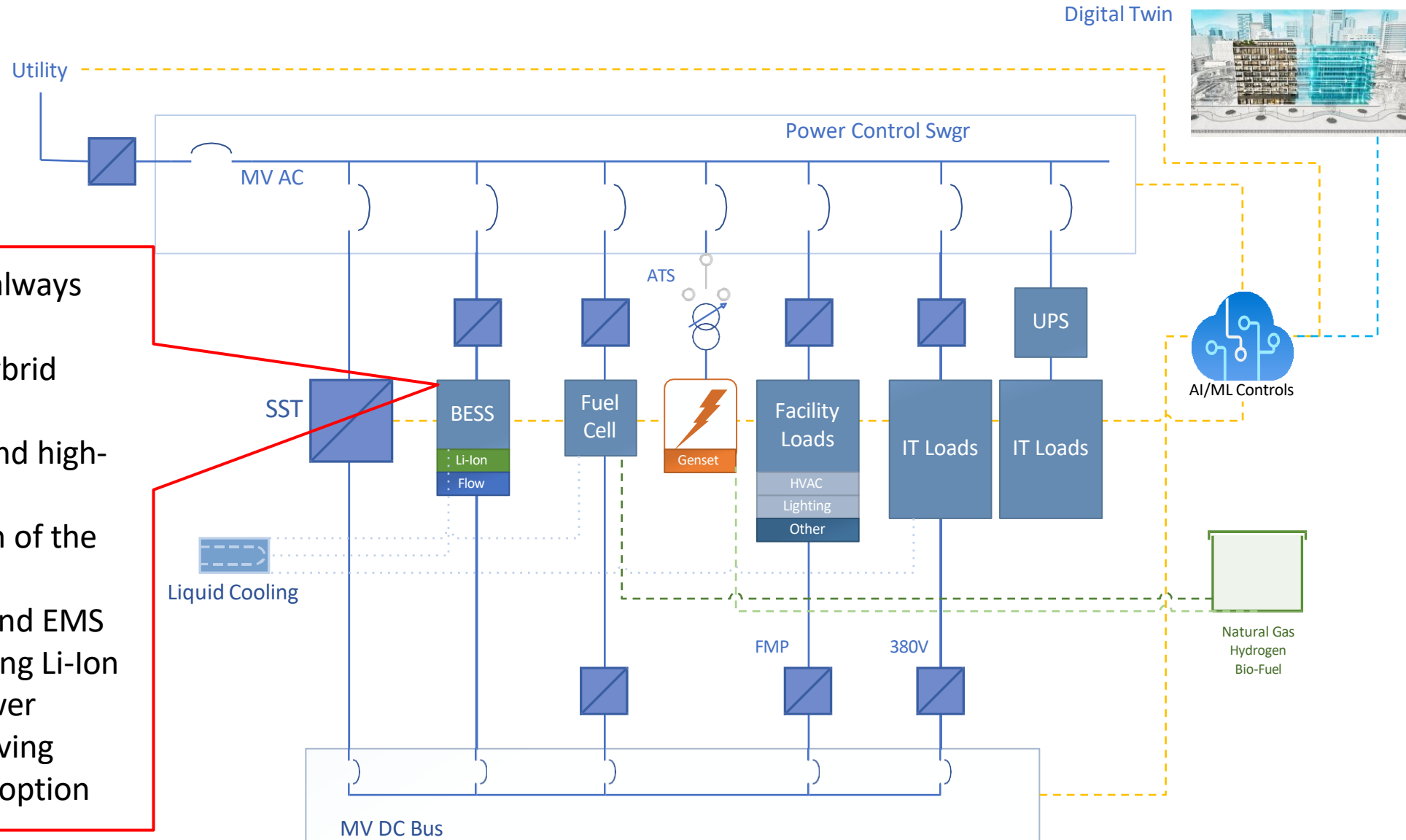
The Idea...

- Sustainable driver –
- Hybrid power plus energy efficiency yields lower carbon
- Developing the Steps to go from Backup, to Always On
- Is the future DC? Customer can use both AC/DC.
- System issues - Focus on CapEx by going digital (remove mechanical steps) and leveraging new tech

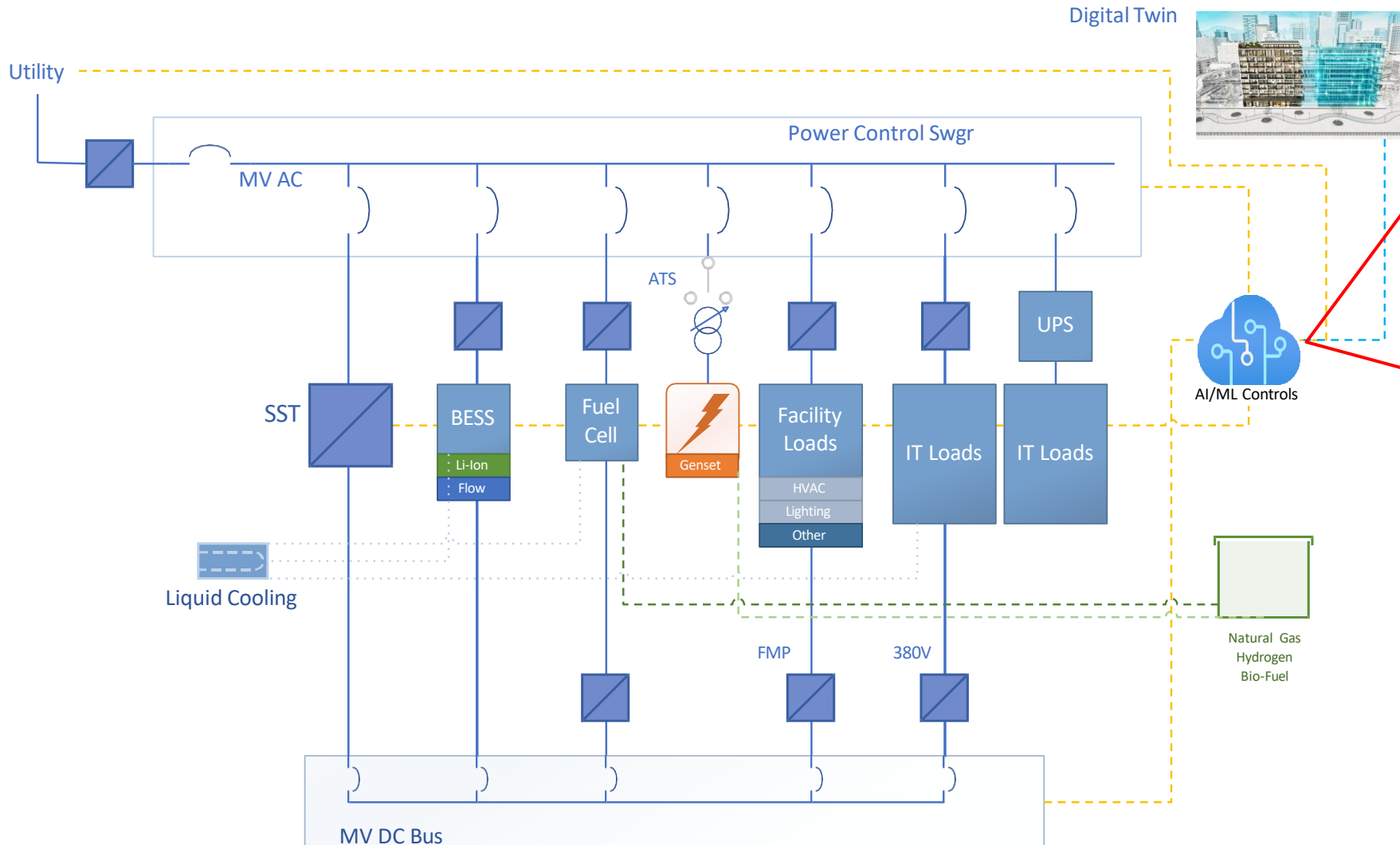


The BESS

- Provides the path to “always on”
- Improves the use of hybrid generation
- Creates high reliable and high-quality power
- Increases monetization of the system
- Vertiv DynaFlex BESS and EMS are a first step leveraging Li-Ion energy and Hybrid Power
 - Other tech is evolving
 - Flow is long term option



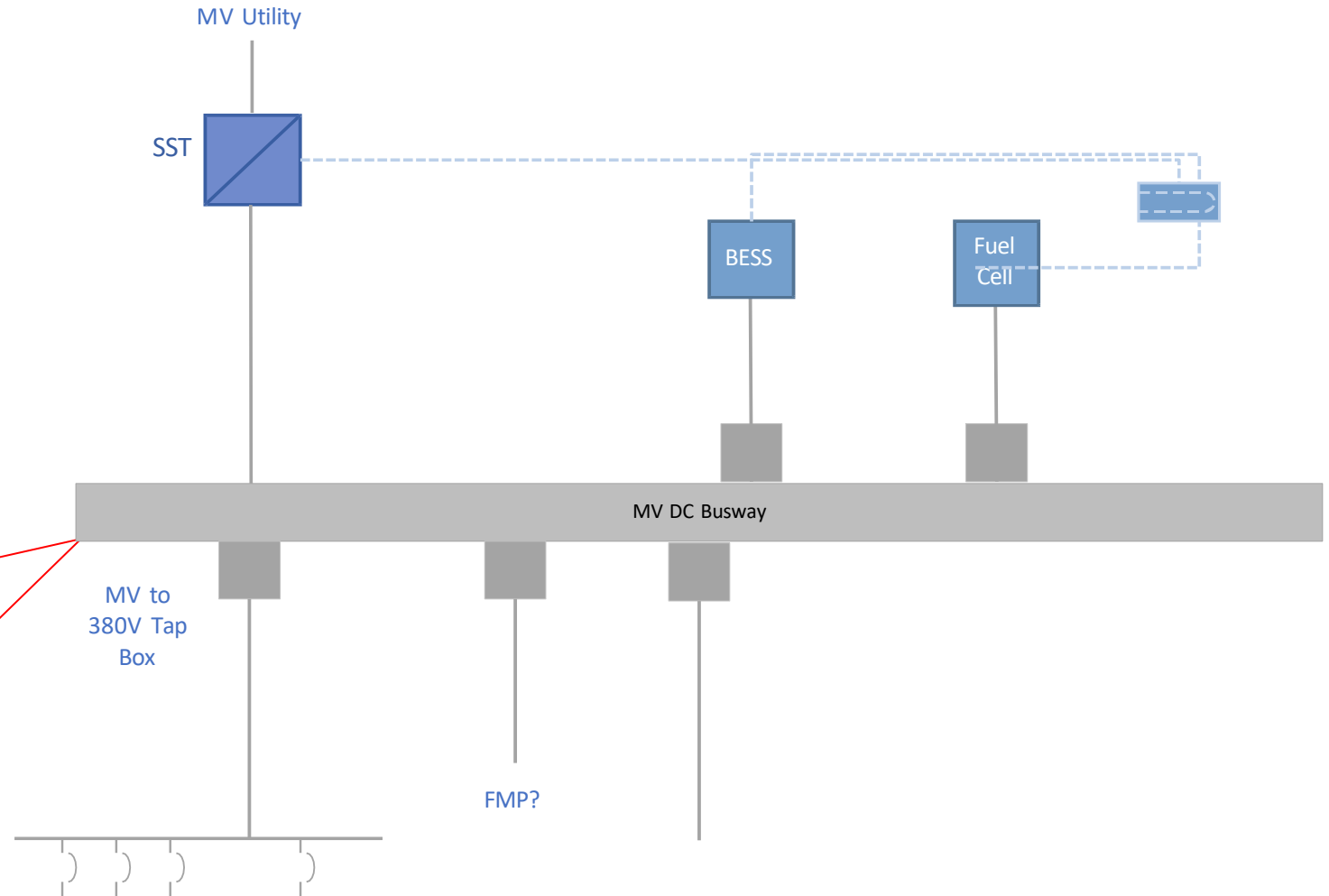
Evolution of Controls and Software



- Vertiv has designed a DynaFlex EMS platform
- Evolution of system is to:
- Develop ML controller with AI overlay
 - Control and engage with:
 - DER
 - IEC61850
 - Thermal Assets
 - AI has a broader cloud-based view:
 - Planning
 - Optimization

The DC Power Distribution

- DC Power is available today, but improvements are necessary
- Improve distribution and maintain safety (personnel and assets)
- Vertiv Fault Managed Power could yield significant improvements in this are.

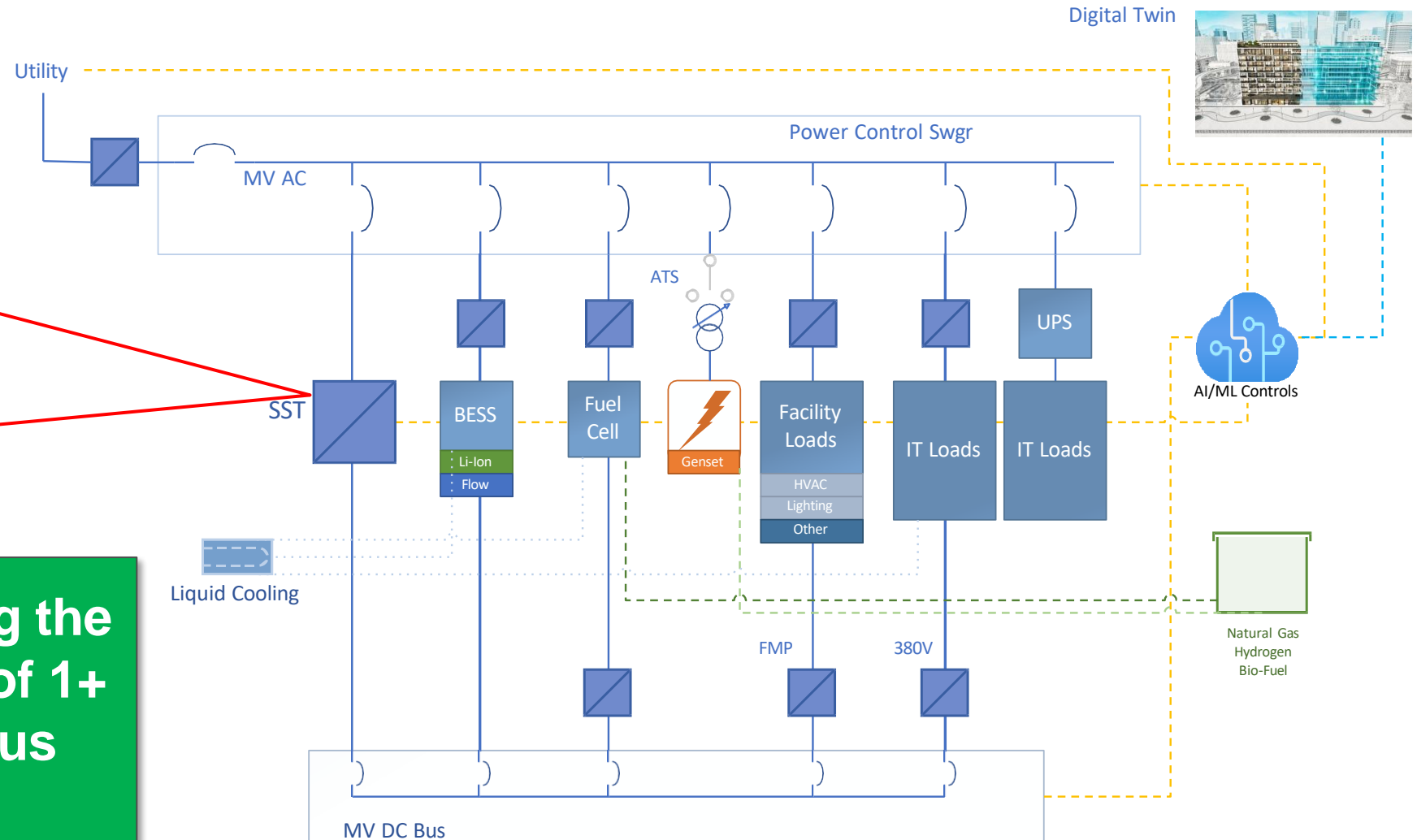


Any Gaps in
Distribution at
380VDC?

The Solid-State Transformer

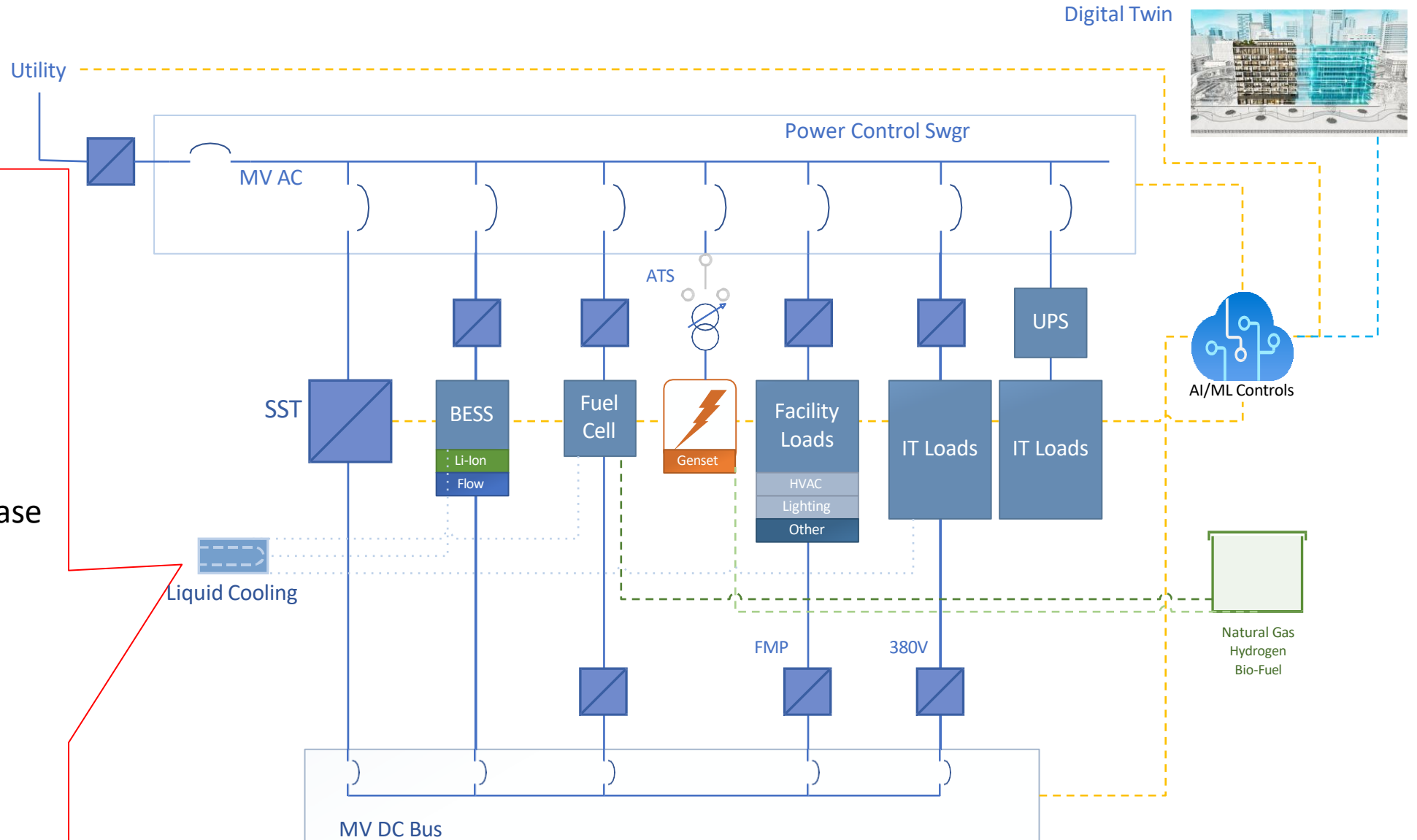
- Solid State Transformers are a Game Changer
- Maximize power flexibility
- Improve power quality
- Improve transient issues
- Potential design includes MV AC direct to DC power

Vertiv is researching the commercialization of 1+ MW SST for various applications

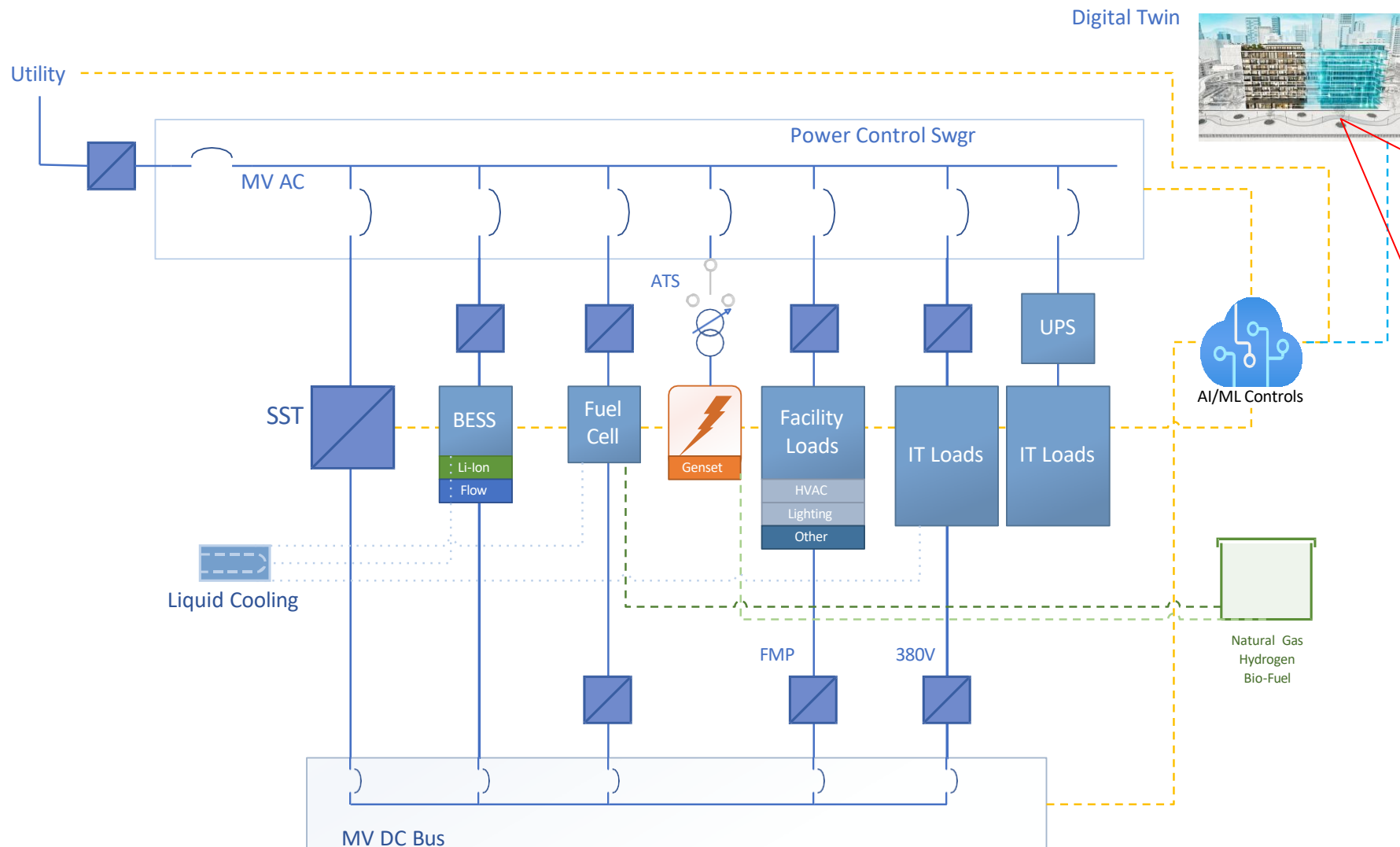


The One Vertiv Technology

- Improve capital investment through common cooling platform for IT and Energy
 - As well as increase efficiencies
- Leverage cooling as source of energy storage



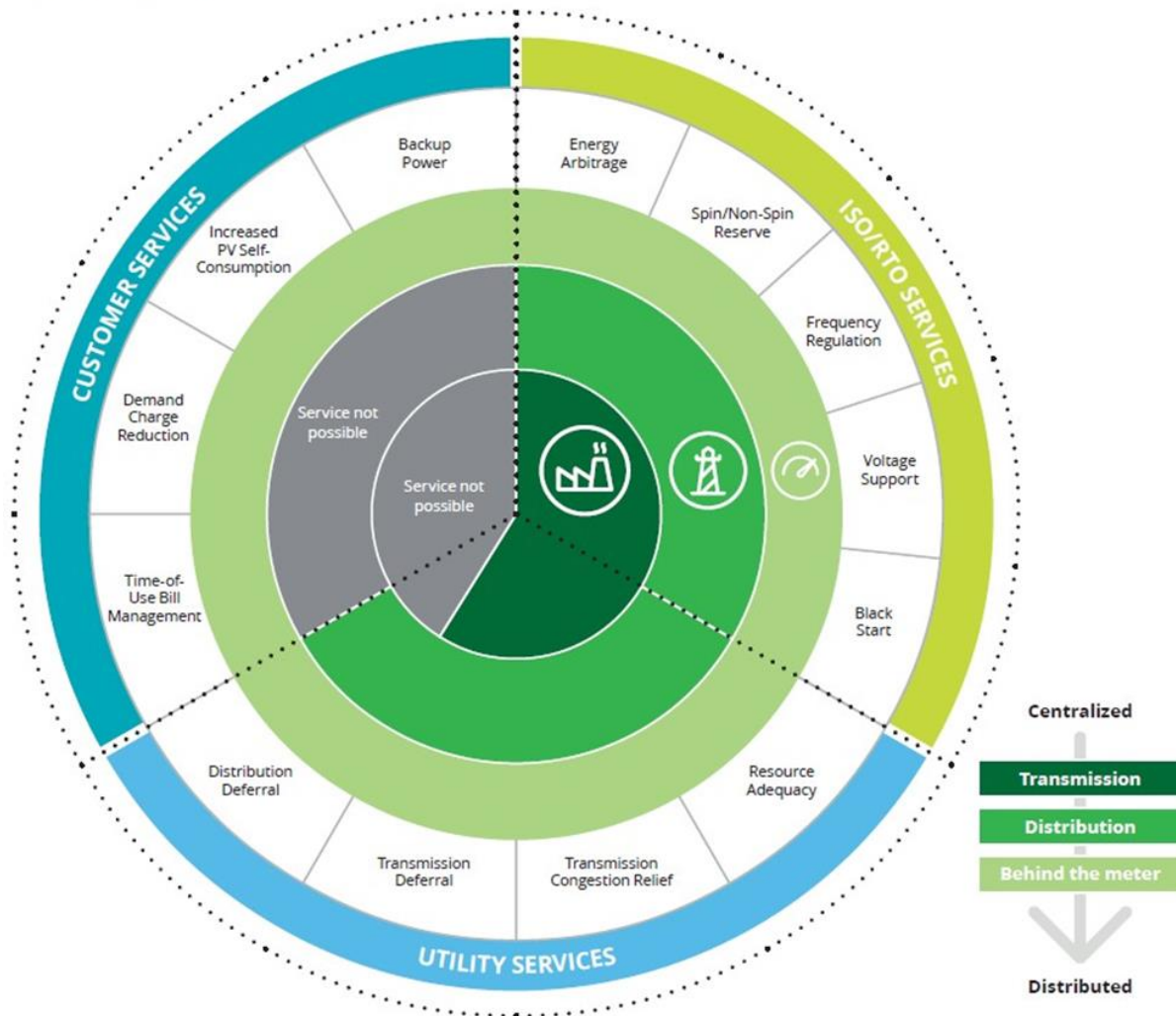
The Digital Twin



- Technology built on a living digital twin where the data and interactions are done in a virtual space that is secured using FinTech solutions
- Need for this technology:
 - Improve speed of integration
 - Security of data
 - No dilution in Single source of truth

Partners are Eager to Help

Figure 2. Energy storage value streams



Source: Mandel and Morris, "The Economics of Battery Storage", Rocky Mountain Institute

- Mission Critical Customers can reduce OpEx and participate in existing or emerging markets
- Grid Operators are having issues stabilizing grid
 - Interest in energy storage means they are opening up new markets and helping to pay for BESS assets.