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The Impact of Self-Generation and Microgrids

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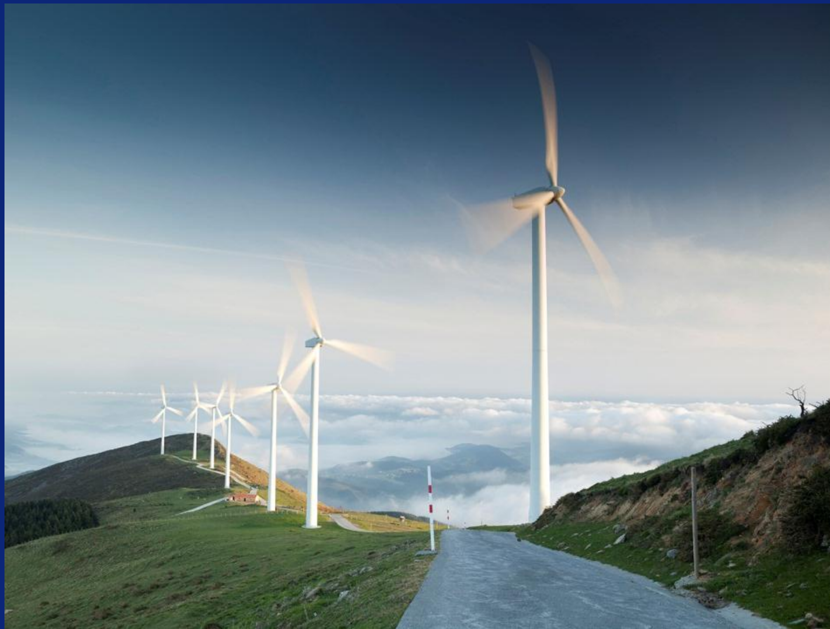

The Impact of Self-Generation and Microgrids

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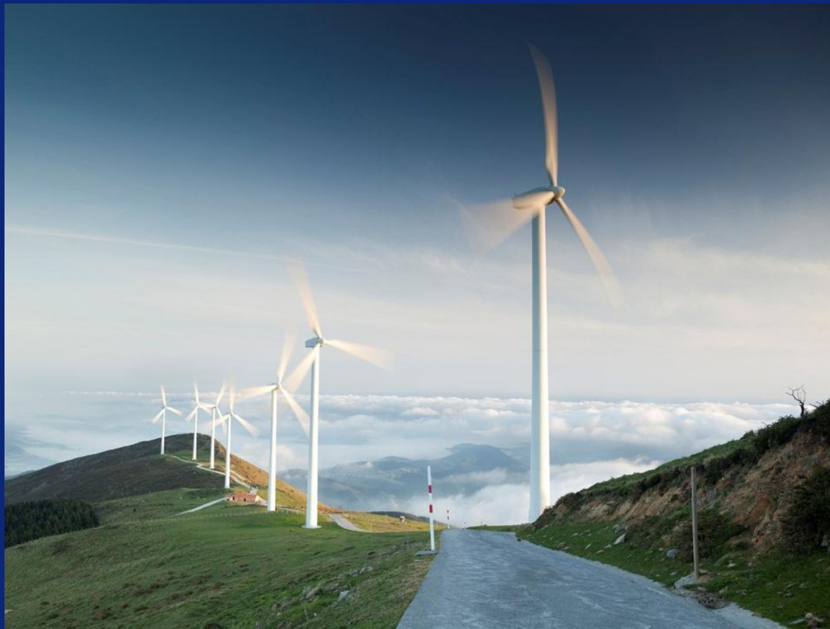

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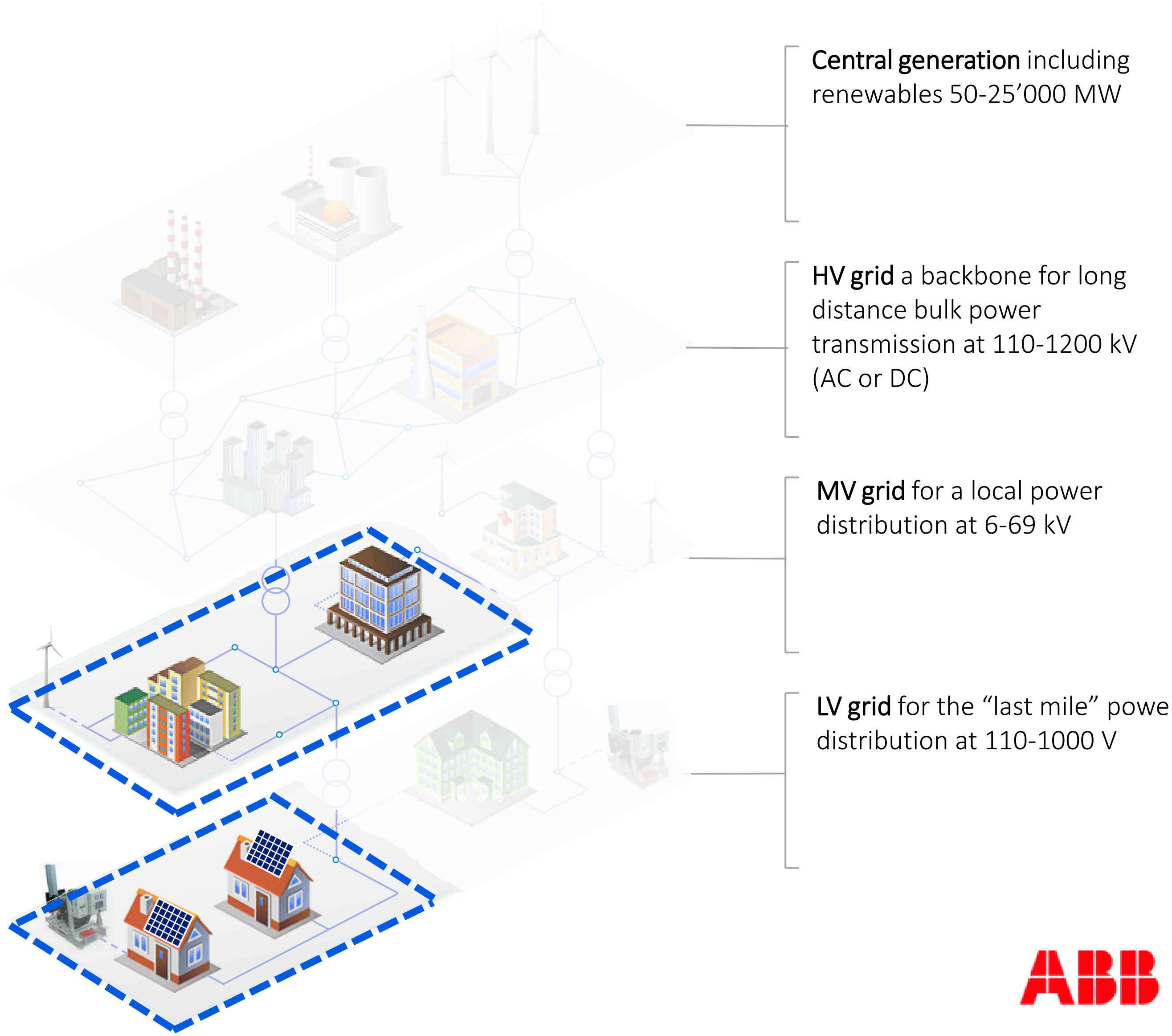
Power & Automation - Microgrids
Reliable and Efficiency

Microgrids
Expected evolution of distribution system

Microgrids
are electricity distribution systems containing loads and distributed energy resources, (such as distributed generators, storage devices, or controllable loads) that can be operated in a controlled, coordinated way either while connected to the main power network or while islanded.

CIGRE C6.22 working definition



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Microgrid landscape

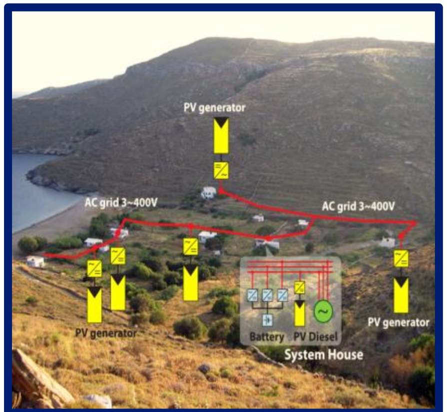
Military

Commercial & Industrial

Institutional & Campus

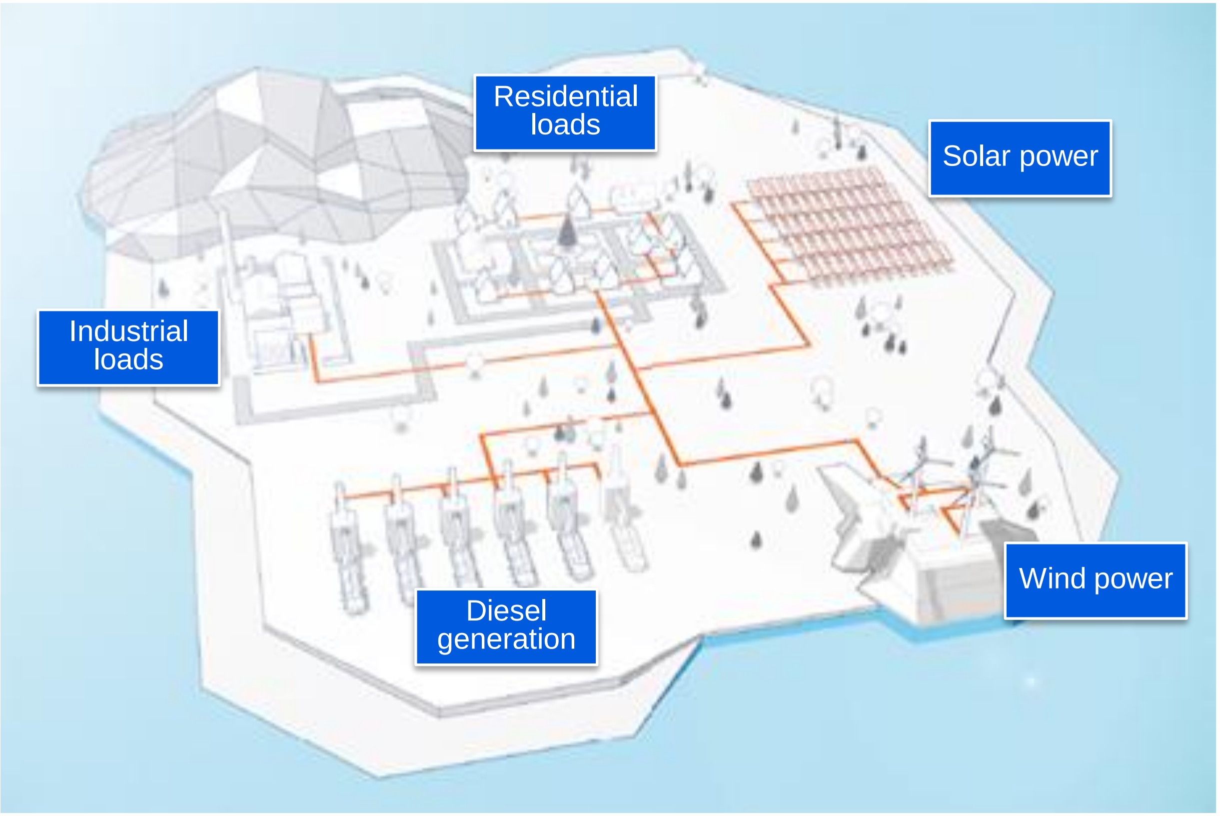
5 most commonly used classes of microgrids

Community & Utility



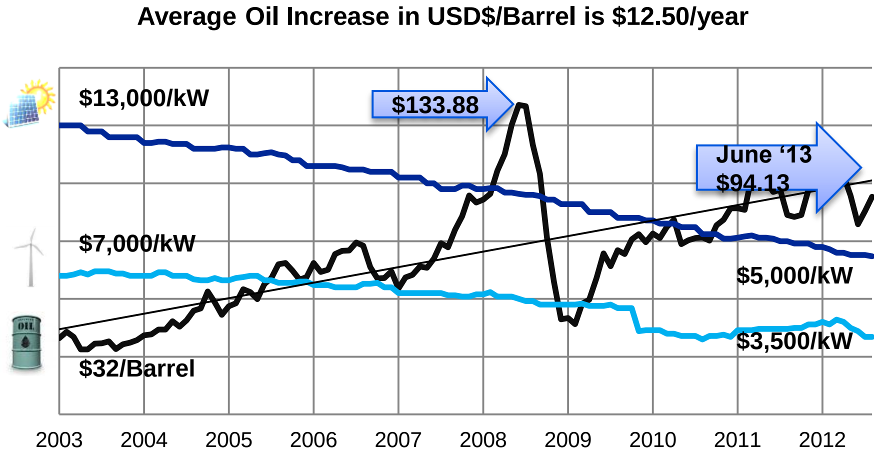
Remote off-grid

Grids powered by fossil-fuel and renewable energy
Diesel microgrids

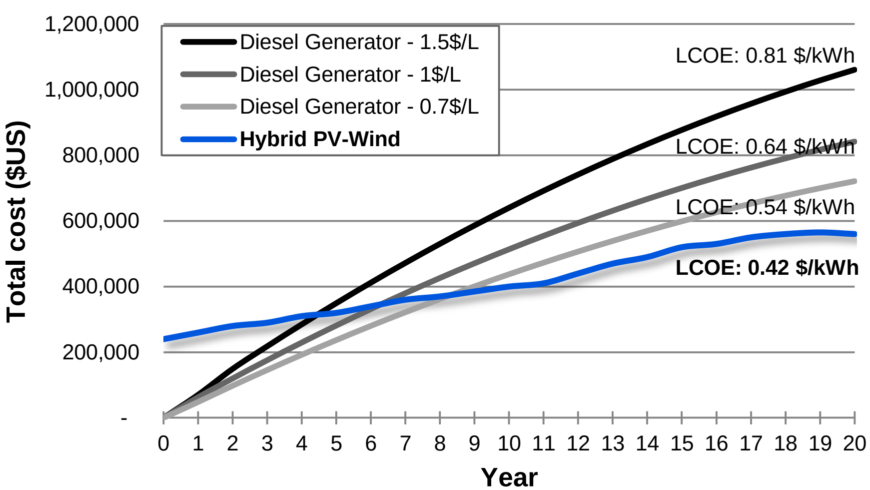


Diesel microgrids have the greatest energy cost savings potential

Integrating renewable energy into microgrids
Secure power generation and fuel cost savings



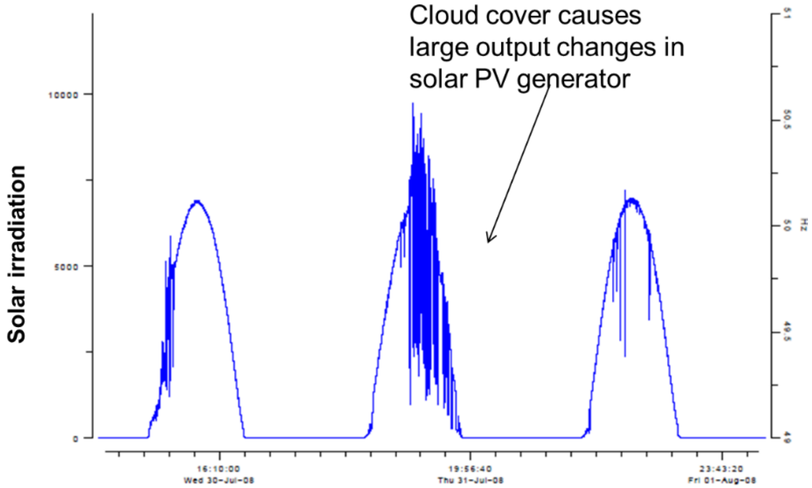
- Diesel fuel cost is volatile and rising over time
- Renewable energy cost is far less volatile and reducing over time
  - Energy source is free

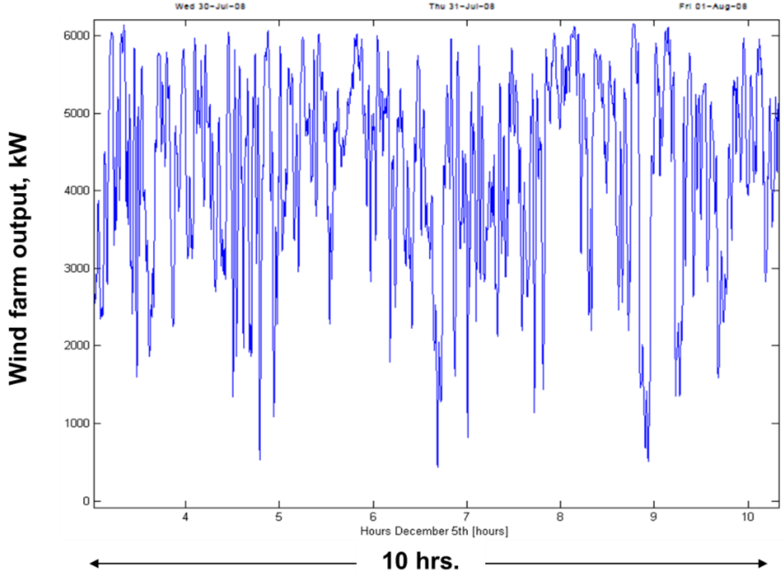


- Renewable energy is economically competitive today
  - Levelized Cost of Electricity (LCOE) lower than diesel fuel generation

Sources: *1) US Energy Information Administration – Independent Statistics and Analysis*
http://www.cleantechinvestor.com/portal/fuel-cells/6422-mining-and-energy.html
2) Alliance for Rural electrification (ARE). Projections made from a case study based in Ecuador with real natural conditions.
http://www.ruralelec.org/fileadmin/DATA/Documents/06_Publications/Position_papers/ARE_TECHNOLOGICAL_PUBLICATION.pdf

Renewable energy integration challenges
Managing power output fluctuations





- Inherent volatility of renewable energy can compromise grid stability
- The renewable energy integration solution must address requirements traditionally fulfilled by diesel generation (base load)
    - Frequency and voltage control
    - Sufficient spinning reserve
    - Sufficient active and reactive power supply
    - Peak shaving and load levelling
    - Load sharing between generators
    - Fault current provision
- Renewable energy generation capacity should be sized to maximize ROI and fuel savings

ROI: *Return on investment*

Microgrid – Remote Community

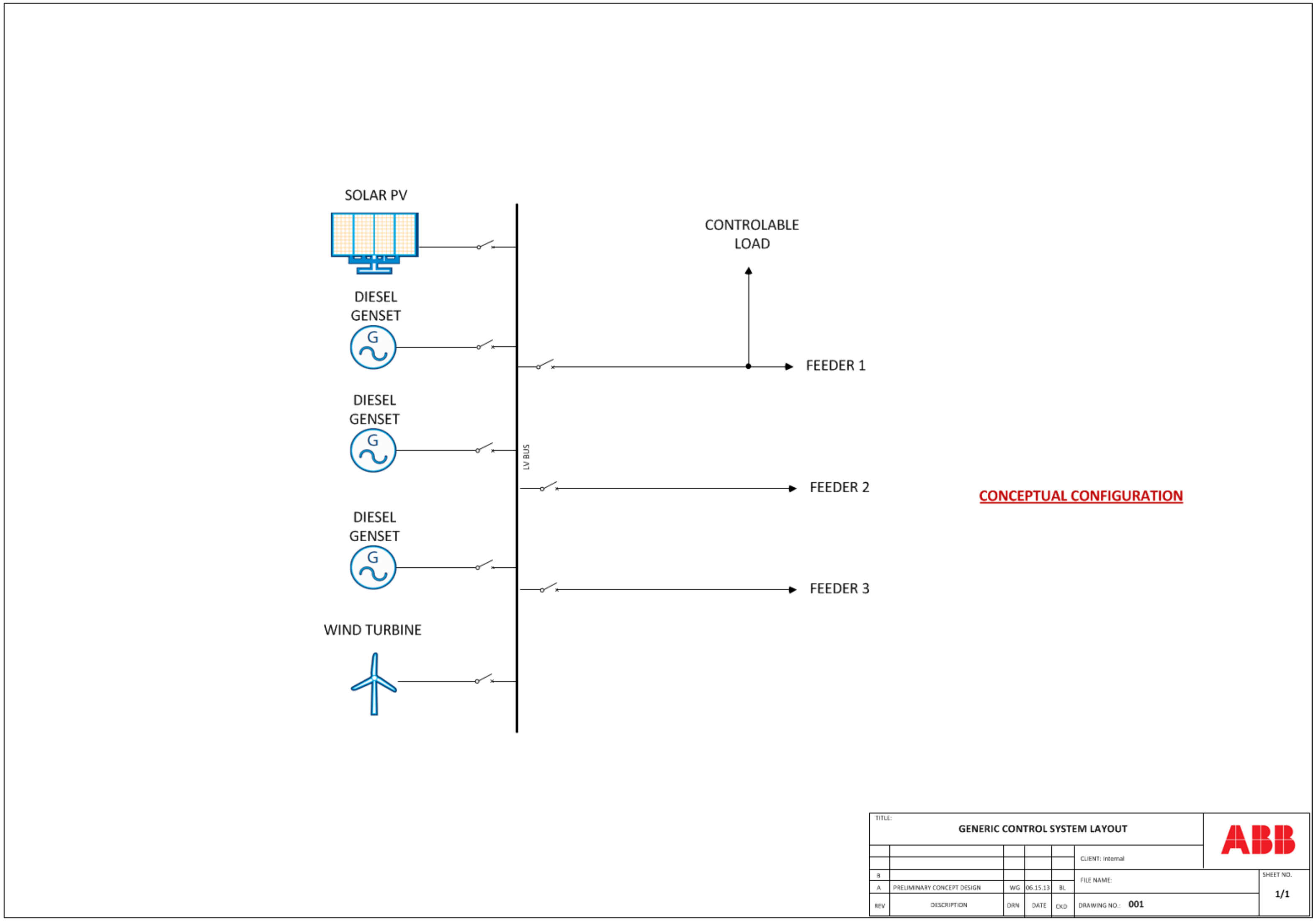
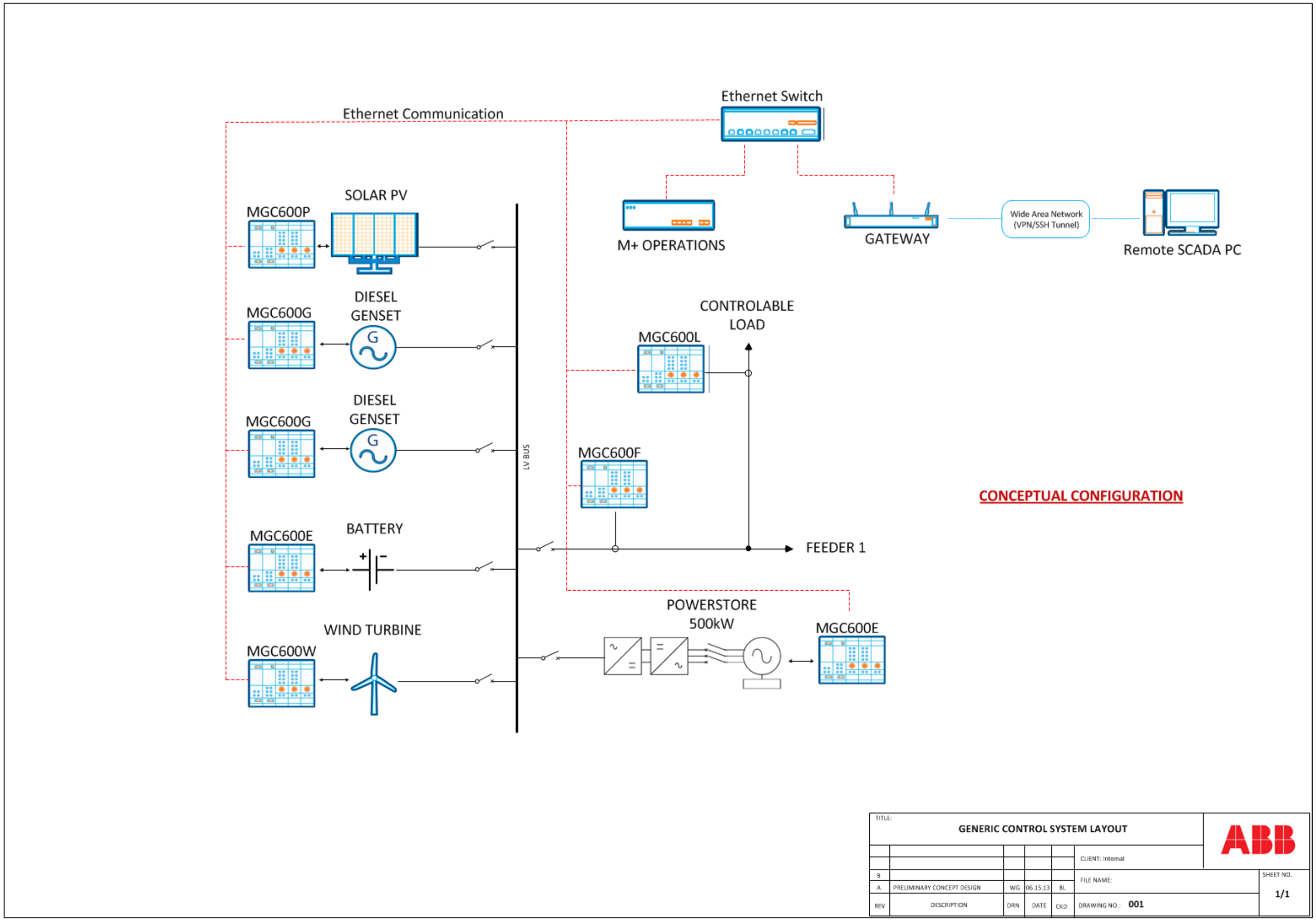


ABB Value Proposition – Remote Community

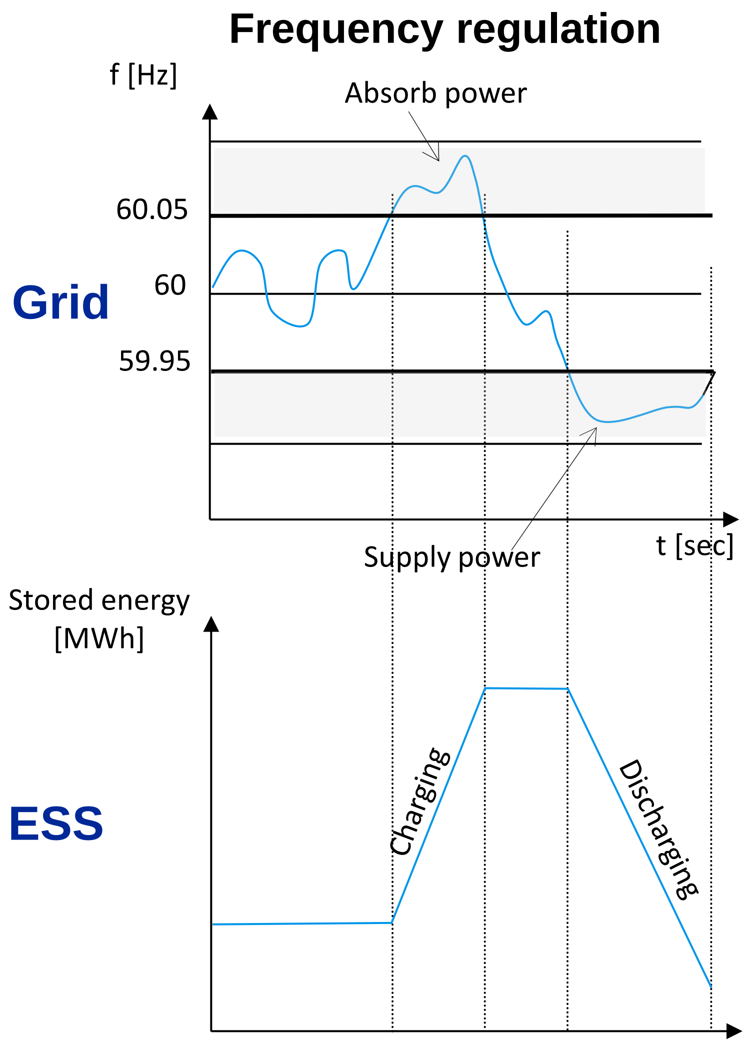


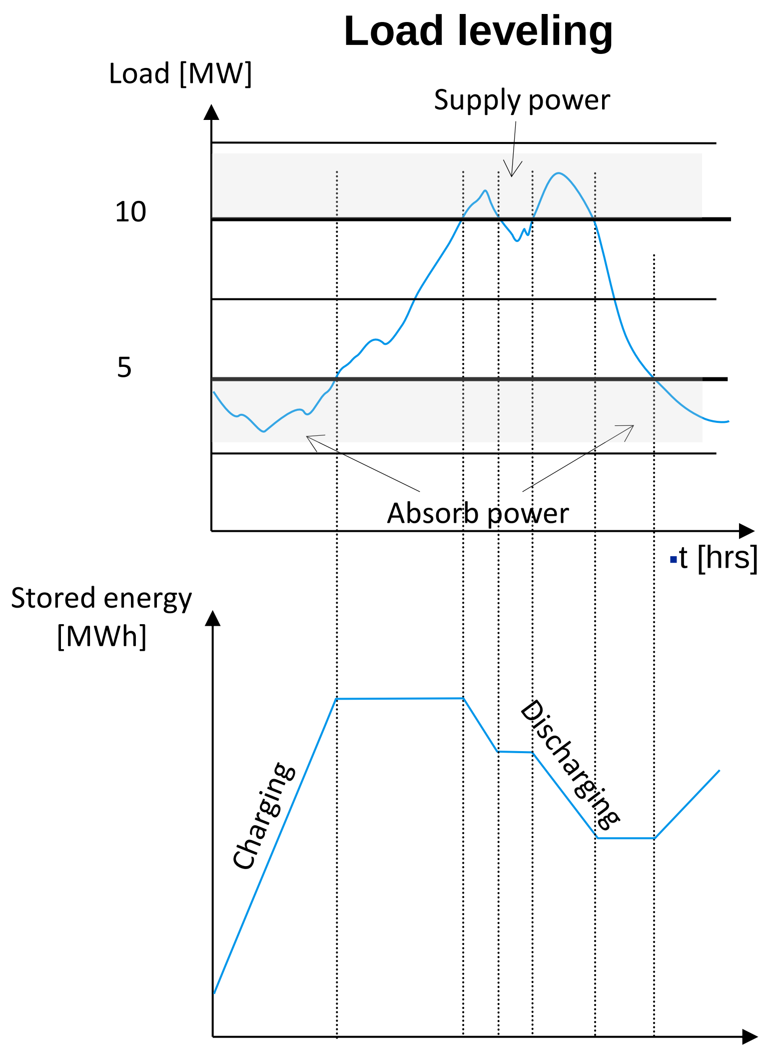
Solutions to integration
How do you determine the right solution?

Wind/Solar/Diesel Systems	Annual Average Contribution	Peak Penetration
No Integration	7%	20%
Automated Dispatch (MGC600)	10%	22%
Grid Stabilizing (PowerStore)	50%	100%
Automated Demand Response	60%	100%
Energy Storage	100%	100%

NOTE: General industry accepted figures. All systems are unique and dependent upon the generation mix, load profiles and renewable resource.

Microgrids key technologies
Energy storage - applications





Grid stabilizing: PowerStore-Flywheel System

Features:

High power; low energy

High Duty Cycle

Grid Stabilizing

Scalable & Modular

Frequency Control

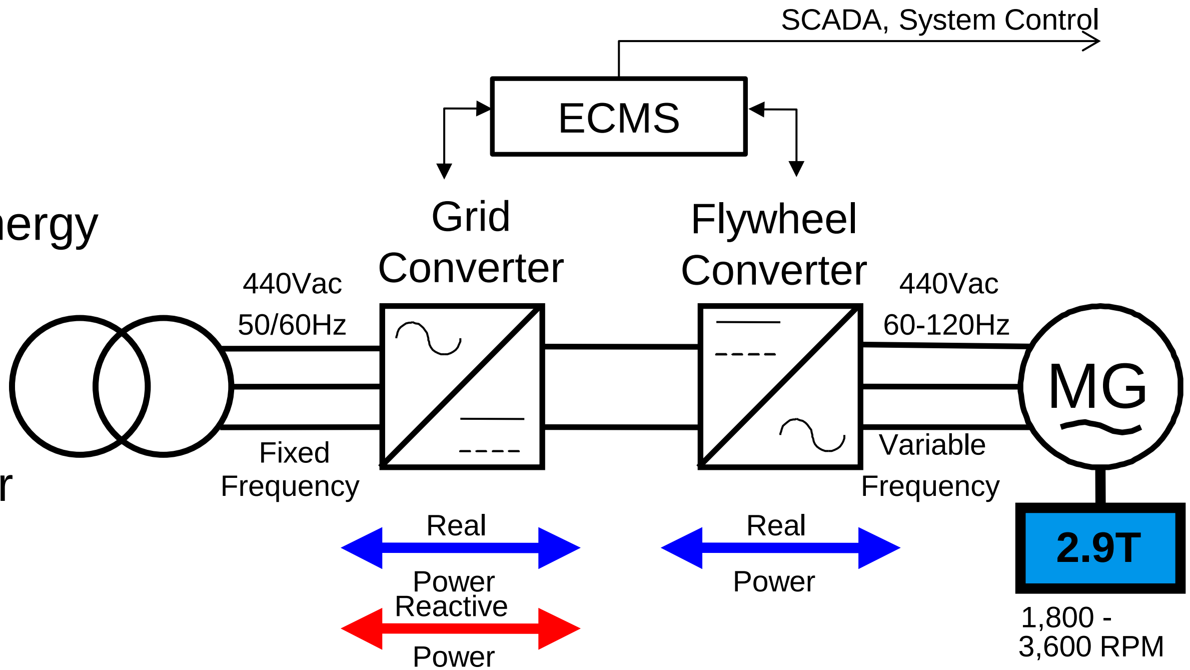
Voltage Control

Fault Ride Through

Spinning Reserve

Step Load Capabilities

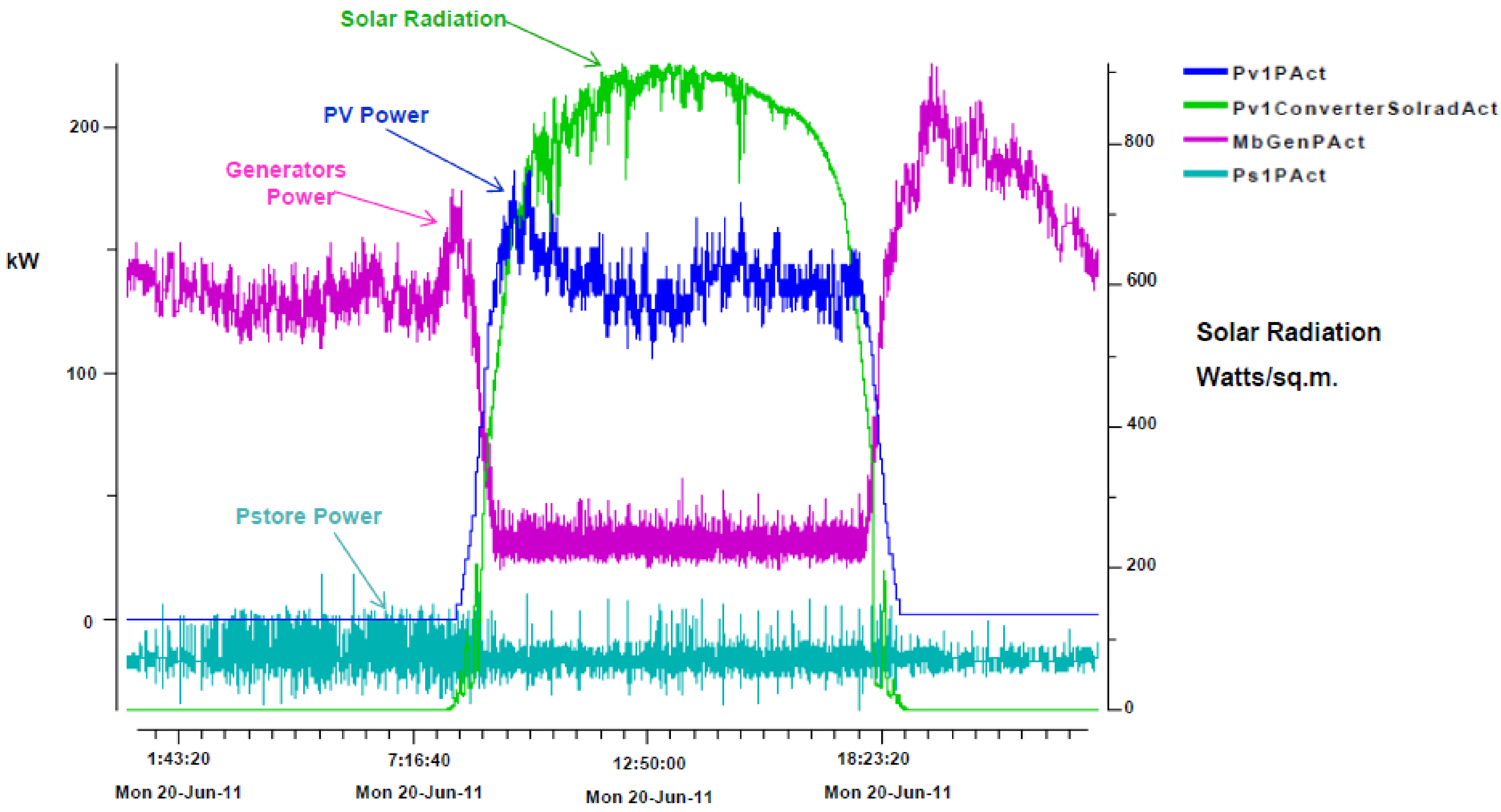
Voltage reference for
renewables only mode



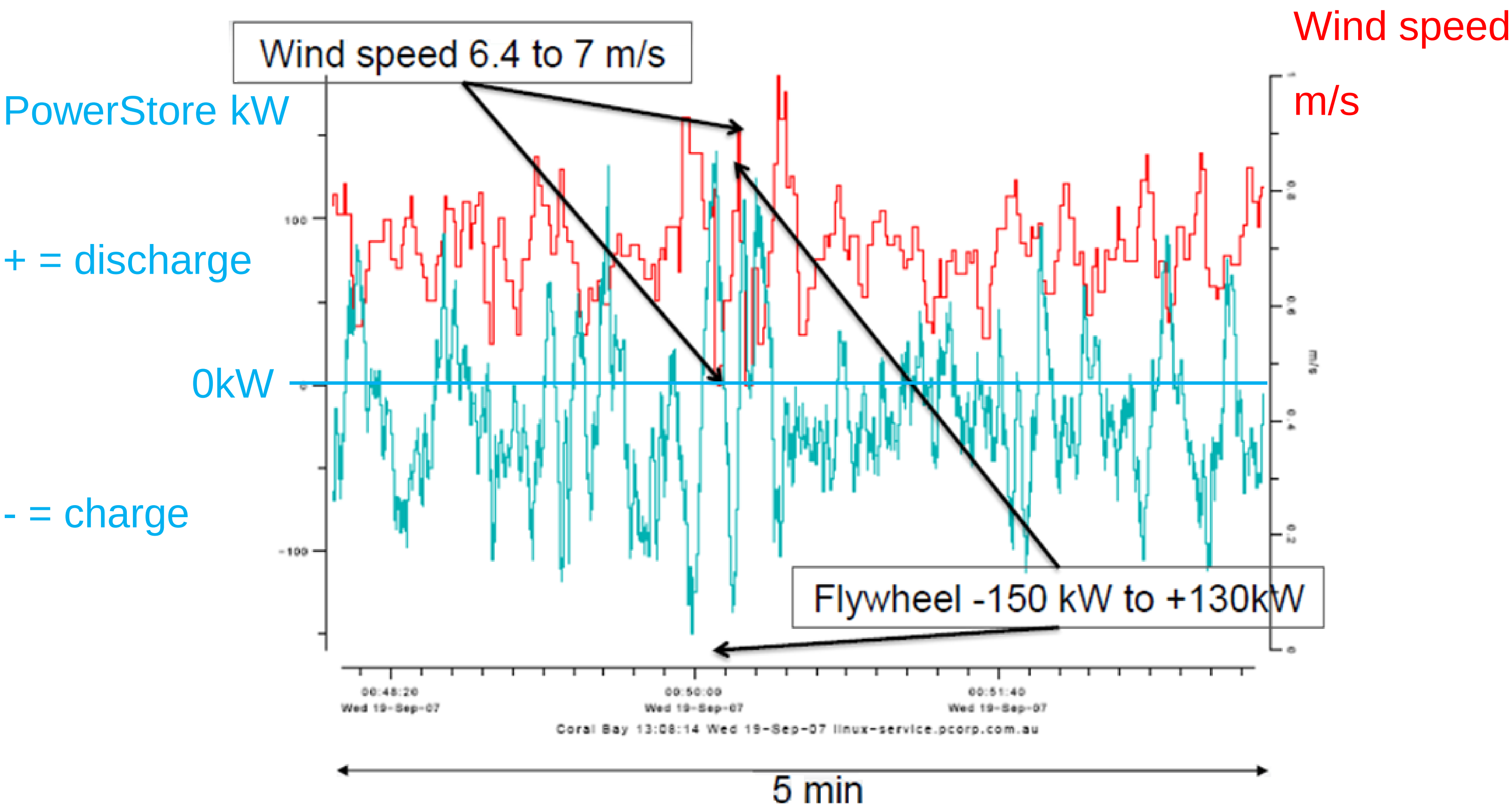
Inverters 500– 1,500 kVA

18 MWs Flywheel

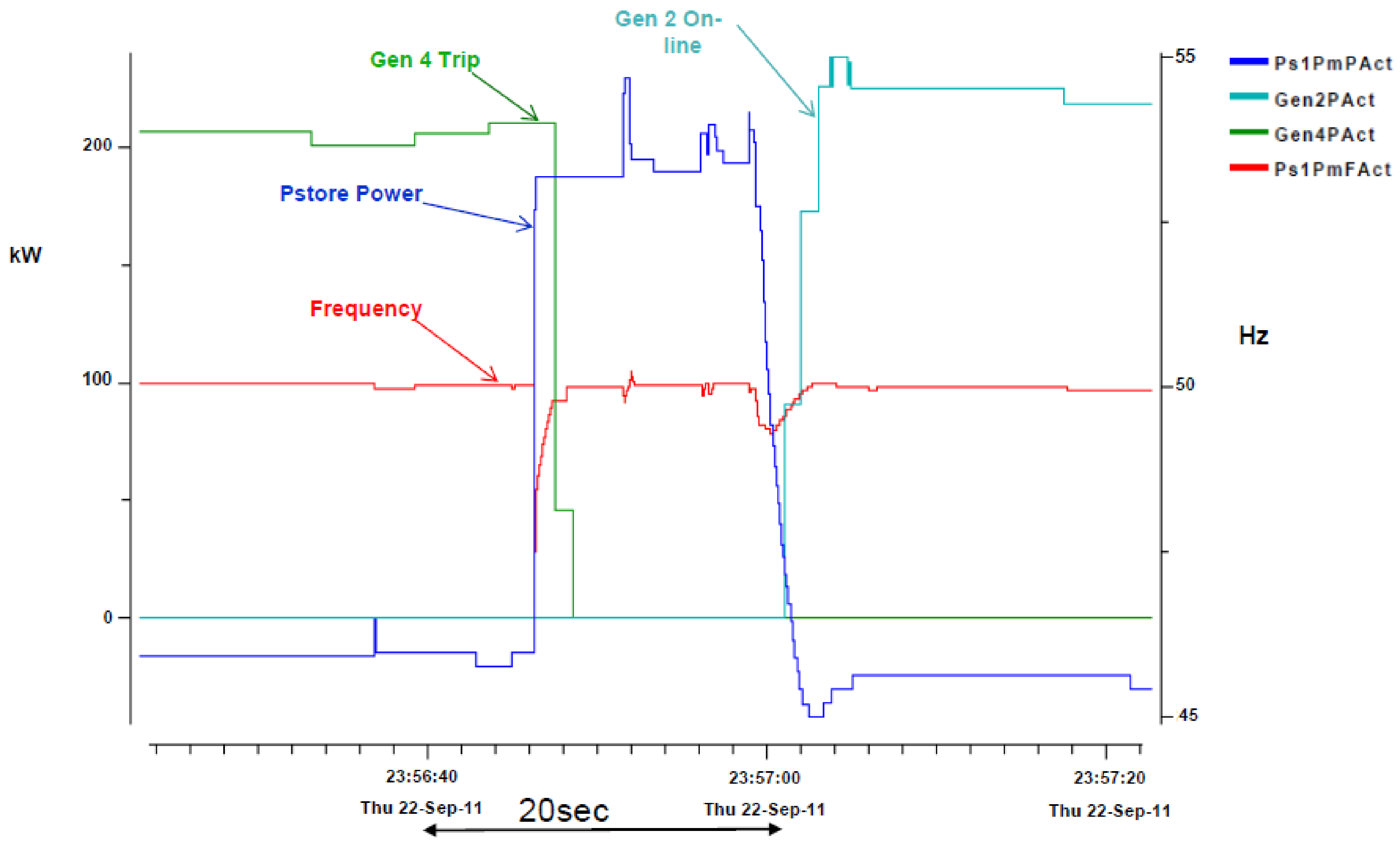
PowerStore Grid Stabilising Generator
Smooths PV output variations



PowerStore Grid Stabilising Generator
Mitigates variable wind power output



PowerStore Grid Stabilising Generator
Loss of diesel genset – Spinning Reserve / Step Load



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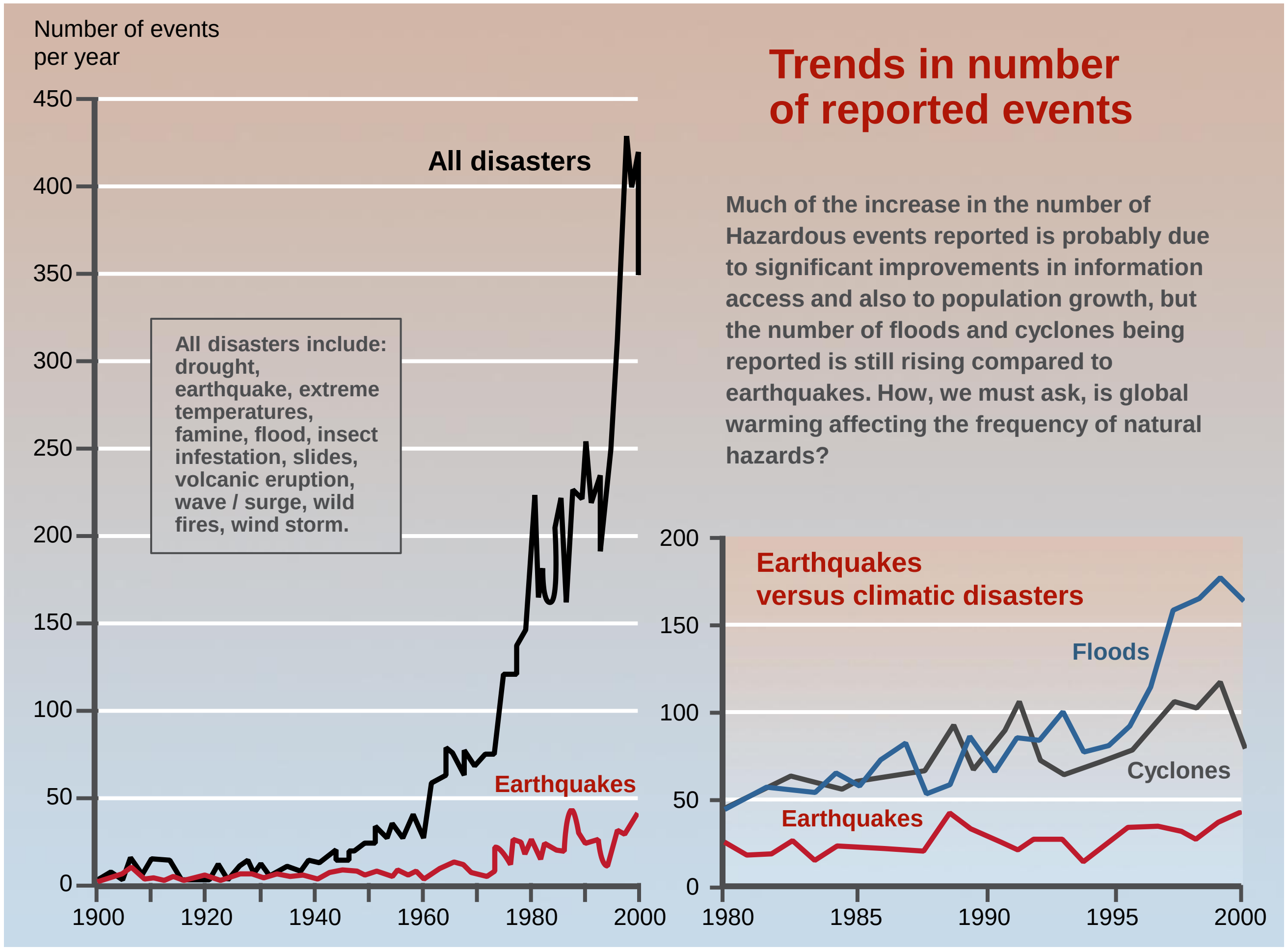
Why are we worried about Power Reliability?

Figure 2.13 ***Increased Frequency of Natural Disasters***



(Source: Center for Research on Environmental Decisions)

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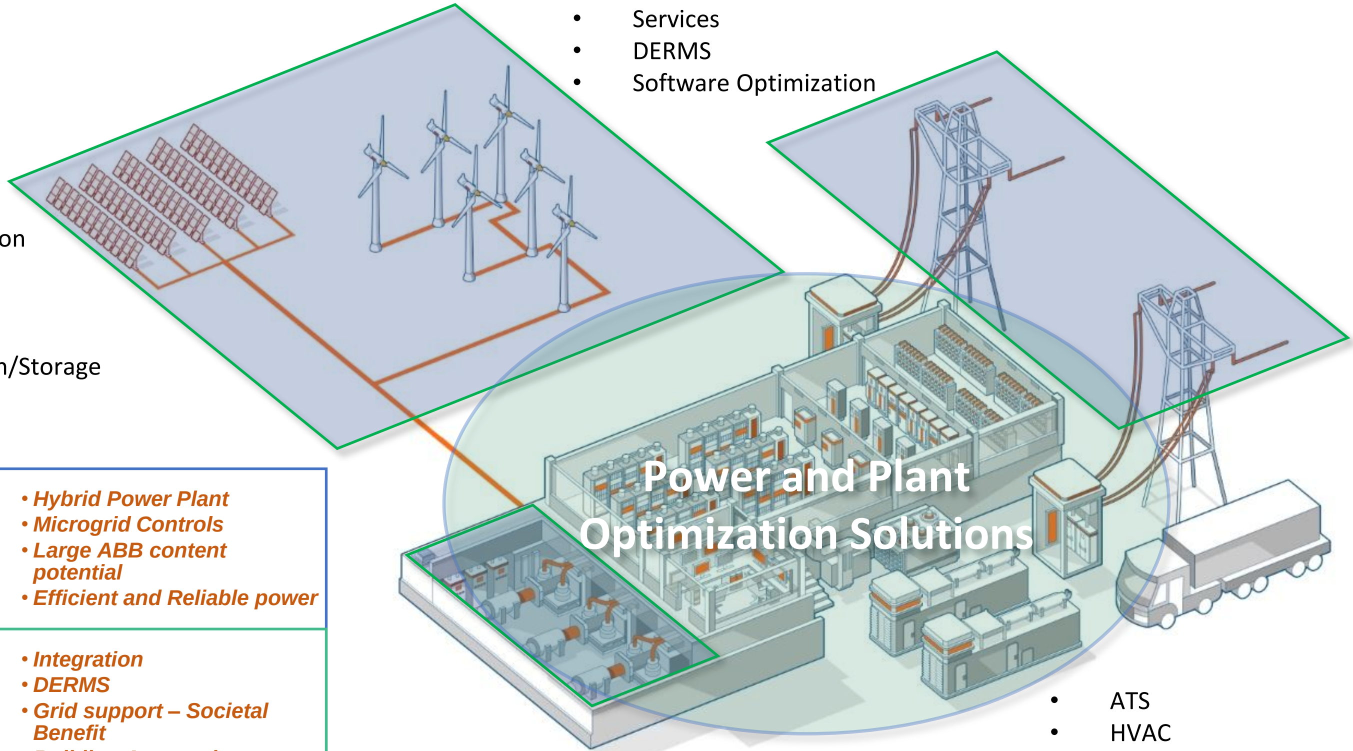
ABB Critical Power
Power and Automation

- Building Automation
- Services
- DERMS
- Software Optimization

- Energy Generation
- DCS
- UPS
- Renewables
- Grid Stabilization/Storage



- Transformers
- MV Switchgear
- LV Switchgear
- PDU

- ATS
- HVAC
- VFD
- Motors

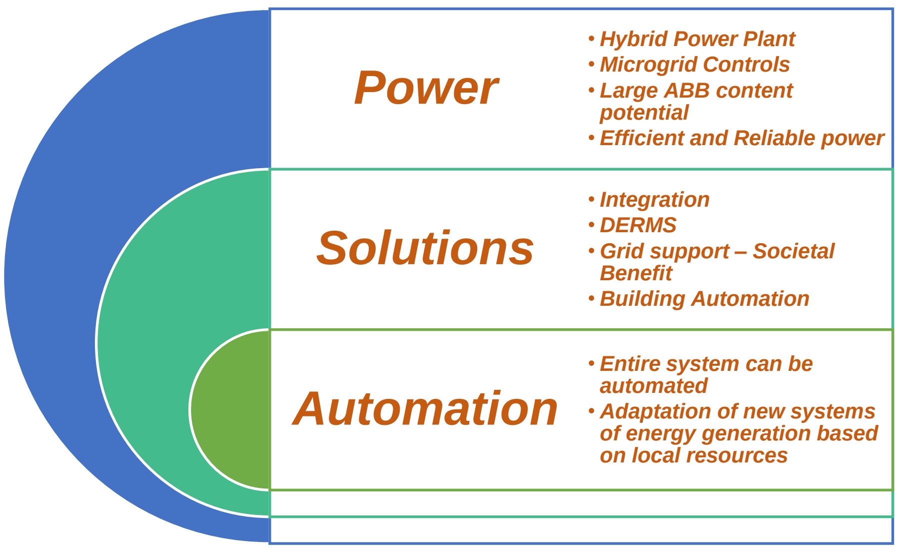


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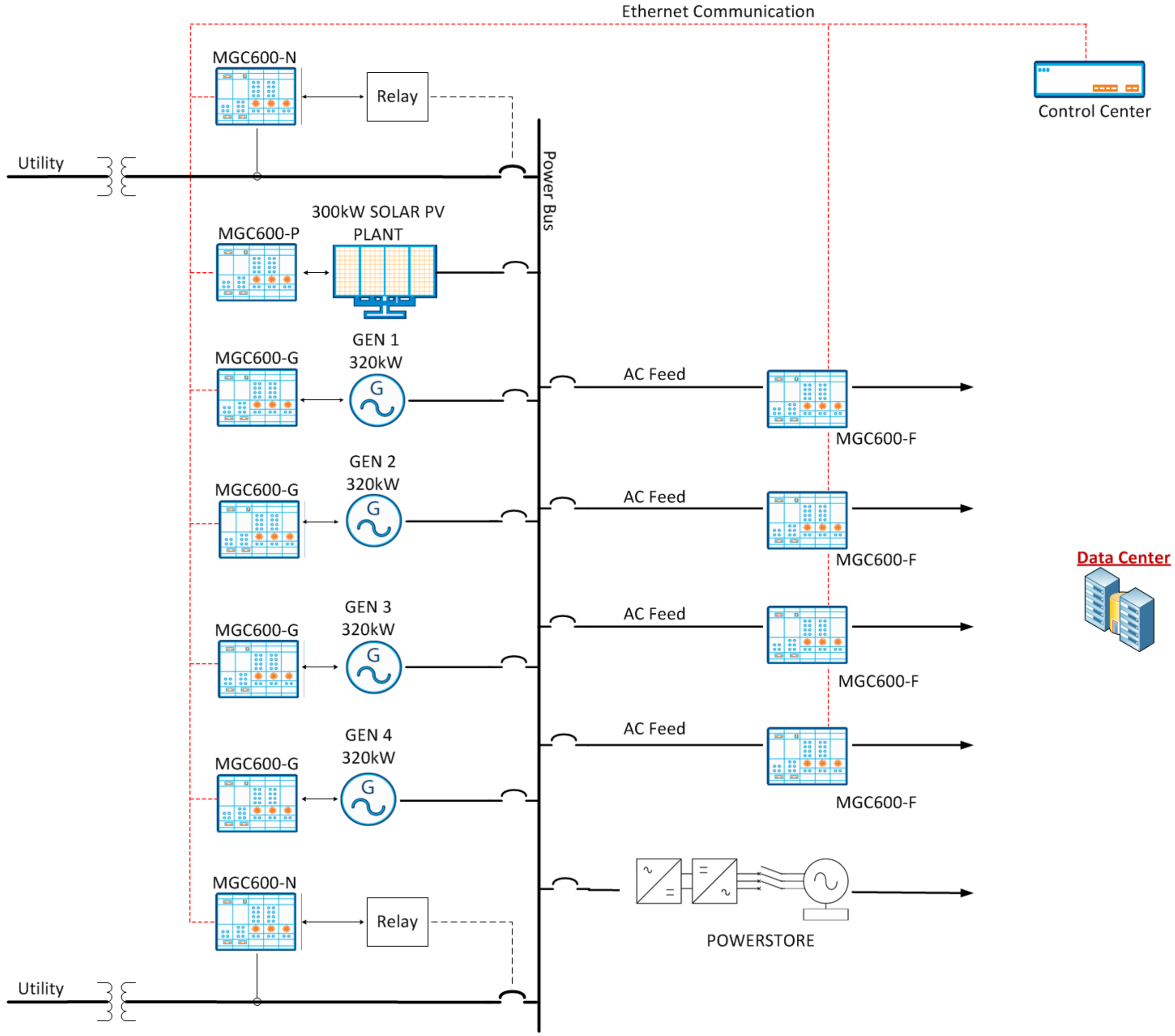
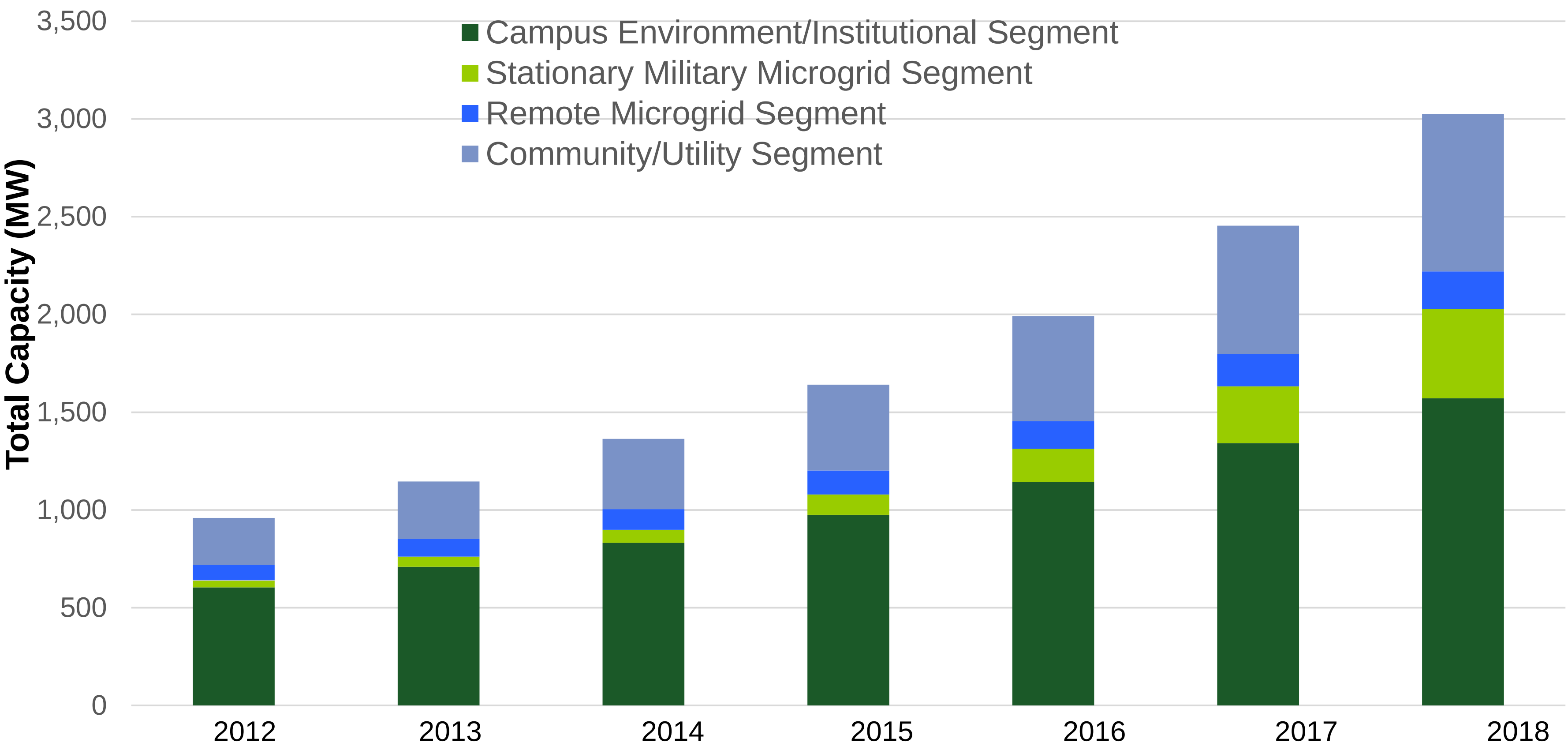
ABB Microgrid Plus™ System

Example Data Center Microgrid Design



Market Size: Growth Trends for Microgrid Market

Grid-tied microgrids market ~$1.5BUSD, growing to $9BUSD



Campus deployments dominate North American MG current landscape, with utility-owned MGs on the rise in coming decade.

Source: Pike Report

Microgrid Value Proposition: End User Ownership

Verticals likely to use MG services regardless of ownership

	Data Centers	Universities	Military	Government	Hospitals
Core MG Benefits to End Customer	• Reliability • Sustainability	• Reliability • Sustainability • Power Quality	• Reliability • Security • Sustainability	• Reliability • Security • Sustainability	• Reliability • Power Quality • Control
Value Case	While technology companies tend to site data centers in areas of high reliability and low power costs, value-at-risk can sometimes be high enough to necessitate MGs	Universities use MGs to protect equipment, but also as academic research and teaching tools. Much campus MG infrastructure funded via research grants	Army and Air Force Bases, often sited more remotely than Navy bases, may not enjoy reliable power. Sensitive missions require MG reliability regardless of local grid uptime.	Critical government facilities that serve health and public safety functions require the extremely high uptime that MGs can provide.	Especially after Hurricane Sandy, hospitals are aware of the operational and PR risk of sub-optimal reliability. MGs also enable DR and demand charge reduction.

Grid-tied microgrids deployments to date mostly pilots to prove the technology is possible. The primary and most critical customer to ABB is Mission Critical markets like Data Centers, Hospitals and Heavy Industry.

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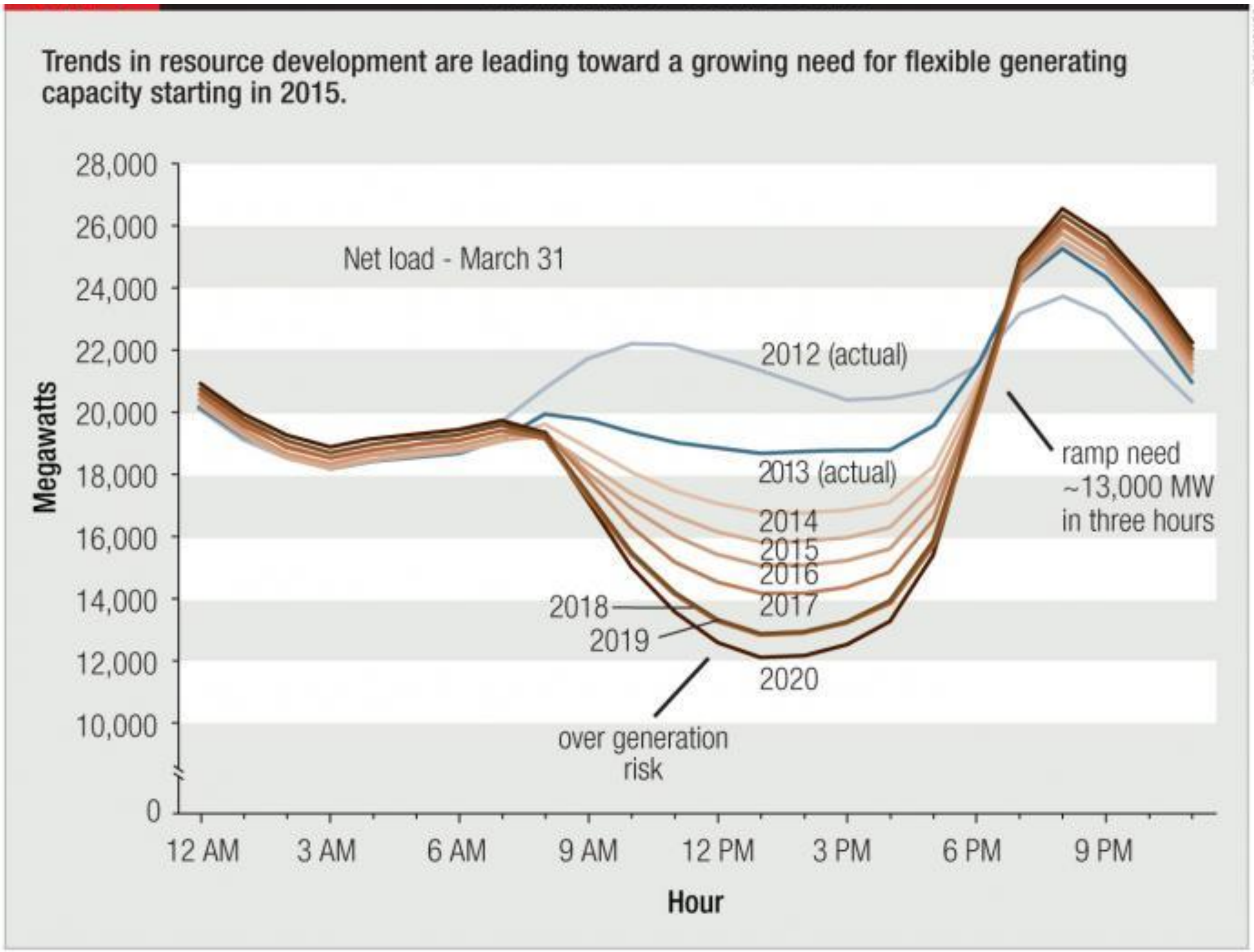
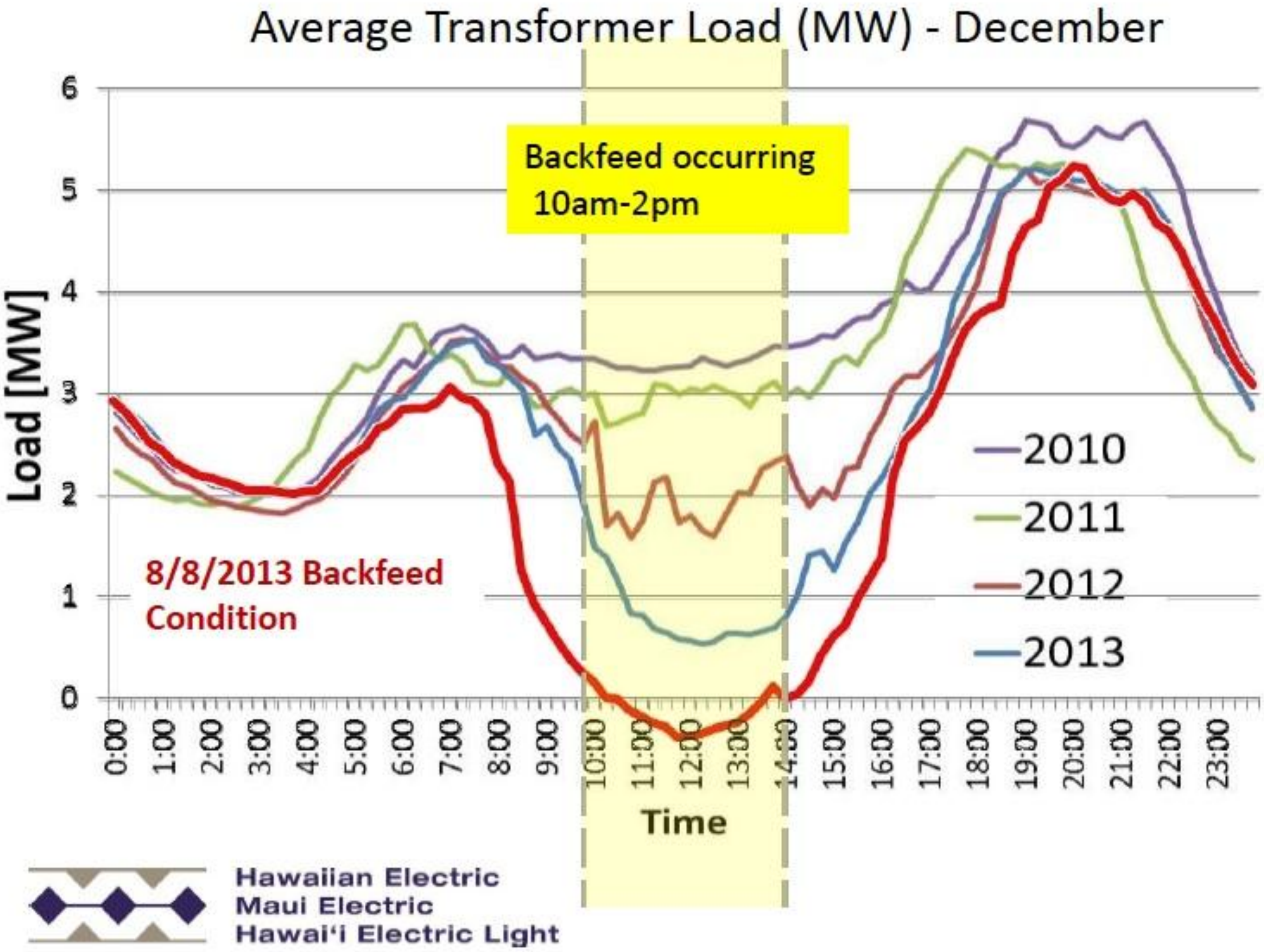
CA ISO duck curve



Source -- California ISO

Hawaii – tracking changes at the 46-kV level



MG Challenges: Regulation and Utility Business Models

Slow-moving PUCs and state legislatures reduce potential

	Summary	Description
1 **Regulatory Uncertainty**	**Most states lack formal definition of "microgrid"**	• Within certain deregulated wholesale markets, uncertainty regarding whether utility can own generation assets. • In regulated retail markets, difficult-to-impossible to include microgrid in rate base beyond pilot projects without demonstrating a clear benefit– "prudent investment"
2 **Utility Business Model**	**Existing utility business model designs do not incentivize MGs**	• Bundled, volumetric pricing defers utility investment in options that reduce consumption. • Unbilled fixed costs within rate tiers could result in a cross-subsidy of MGs by those receiving less reliability and power quality improvements. • Difficulty of providing preferred service in regulated markets violates the premise of the utility monopoly
3 **Environmental, Technical & Labor**	**Many other hurdles beyond regulation and business models**	• Local air quality regulations prohibit extensive use of diesel gen sets except in emergency use. • Standards for interconnection and islanding not yet defined, including IEEE 1547.4. • Labor laws change for utilities when behind the meter vs. in front, presenting challenges to utilities constructing and/or managing MGs
4 **Existence of Other Options**	**Relationship issues and other reliability options pose barriers**	• Few customers that need five "9s" of reliability limits overall utility interest. • Of those that do, many don't trust their utility to meet their reliability/power quality needs they should already be getting. • Most utilities don't consider MGs part of their core knowledge or within their "toolbox" and are thus more comfortable with existing tools

Various state and federal regulations and different utility business models across all 50 states and between countries inhibit a one-size-fits-all approach.

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