PRESCOUTER

Renewable energy’s dirty little secret

The hidden woes of curtailment, equipment damage, and the carbon footprint

Even as renewable energies grow, their inconsistency is a serious problem. It can harm the stability and power quality of the grid, and paradoxically, even lead to higher carbon emissions due to wasted energy. Despite their green promise, renewables are inadvertently highlighting the continued need for traditional fossil fuels in our power systems.

Renewable energy adoption will increase, but so will challenges with power quality and stability.

Over the past decade, renewable energy sources have made significant strides, contributing 10-20% of electricity generation in major economies. Despite this progress, challenges persist in the form of power quality issues, curtailment, imbalances, stability concerns, and the need to update existing infrastructure.

9.6%

Growth in renewable capacity during 2022

Executive Summary | Our 2-minute rundown of the space

Curtailment is contributing to carbon emissions. Poor power quality or "dirty energy" is damaging equipment.

THE CURTAILMENT DILEMMA

Curtailment occurs when generators are instructed to reduce their electricity output, while imbalances arise when non-renewable sources compensate for the unavailability of renewables. These challenges underscore the continued relevance of the fossil fuel industry in electricity generation, as traditional generators provide essential frequency response capabilities that renewable sources lack. The negative impact of power quality issues is evident in equipment damage, which affects utility customers.

THE DIRTY ENERGY DILEMMA

The integration of renewable energy sources into the grid can cause power quality issues, leading to equipment damage. This degradation is not only leading to financial losses due to equipment repair and replacement but also impacting the user experience of end consumers. For a sustainable transition to renewables, it is critical to improve power quality in grids that handle a high volume of renewable energy.

Achieving low-carbon energy generation requires energy storage, grid integration and demand-side management.

MODERNIZING INFRASTRUCTURE

To achieve goals of low-carbon energy generation, improving power quality is crucial. However, insufficient infrastructure exacerbates curtailment issues, impeding the transition to renewable energy. For utility companies to effectively reduce their carbon footprint while maintaining service, modernizing infrastructure becomes imperative.

STORING CURTAILED ENERGY

Renewable generation has experienced impressive growth in regions like China and Canada. Nevertheless, curtailments ranging from 4-20% are occurring worldwide. The dispatching or storage of curtailed generation would lead to significant reductions in carbon emissions. Examples from California and New York highlight the substantial curtailment of solar and wind energy, emphasizing the urgent need for energy storage, grid integration, and demand-side management.

Executive Summary | Our 2-minute rundown of the space

DIVE DEEPER: In this Intelligence brief, we highlight the challenges and strategies that can help to implement efficient approaches. Thus, the electricity grid can strive to achieve the intermediate target of net-zero emissions.

The Hidden Woes of Renewables

The past decade has seen the penetration of renewable energy in different forms - wind, solar, biomass, and other sources - emerging as one of the greatest success stories of the 2010s.

The renewable energy sector has surpassed expectations by successfully integrating with conventional generators and contributing to 10-20% of electricity generation in major economies.

In countries such as Norway, this share can even reach up to 90%. Notably, the substantial penetration observed in non-OECD countries is primarily attributed to hydro and biomass projects.

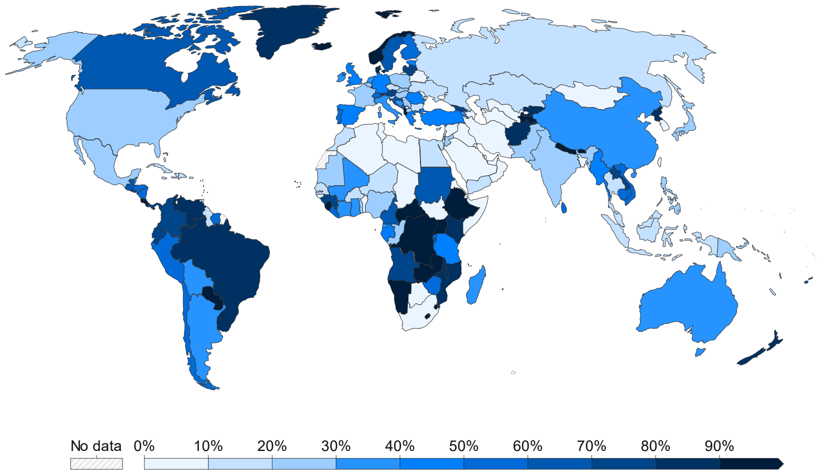


Figure. Distribution of electricity production from renewable sources in 2022. The renewable energy category encompasses hydropower, solar, wind, biomass and waste, geothermal, wave, and tidal sources. Source: Our World in Data.

While renewable energy sources have experienced significant growth in recent years, several pain points are still associated with their penetration.

Power quality issues causing equipment damage and loss of arbitrage.

Curtailment and imbalances due to excess or reduced renewable generation owing to weather conditions.

Equipment used at the moment may not be conducive to renewable penetration, for example, grid-following inverters.

Stability and reliability issues due to the intermittent nature of renewable generation.

Installation of new equipment to replace existing infrastructure without disrupting existing power generation, transmission and distribution.

These pain points pose challenges in ensuring stability and managing excess energy generation in the grid infrastructure.

Imbalances impact grid stability

Imbalances occur when the grid operator requests a non-renewable generator to increase its generation due to the unavailability of a renewable generator or to reduce generation during periods of low demand.

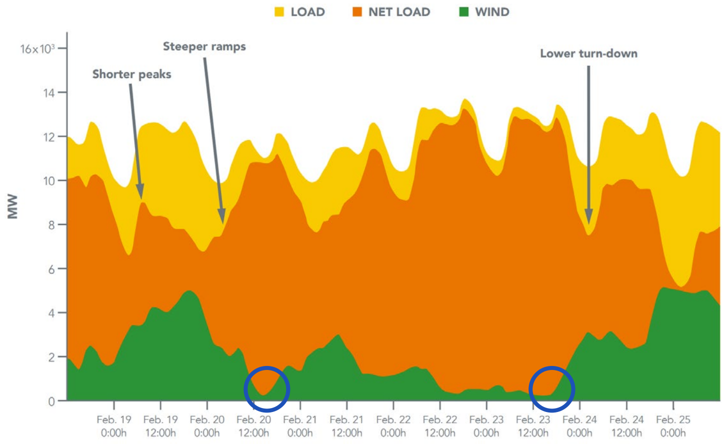


Figure. Impact of variability on power system operations and introduction to net load concept. The figure show the imbalances (highlighted as blue circles) due to unavailability of wind. Source: NREL.

Curtailment impacts power quality

Curtailment occurs when the grid operator requests the generator to reduce their electricity generation due to reasons such as excess generation, negative pricing, or self-scheduled cuts. Hence energy generation is scaled back.

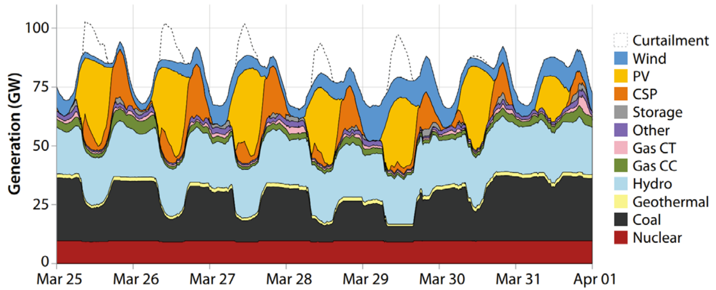


Figure. Results of a dispatch stack for a one-week period in the high-solar scenario, where 33% of the Western Interconnection generation is derived from wind and solar energy. Curtailment is showed at the highest peaks (gray). Source: NREL.

Energy grids around the globe are feeling the pain.

Extreme pricing due to the lack of wind power in the United Kingdom.

Poland declares threat to electricity supply due to too much renewable energy.

A Czech energy company has been forced to unplug hundreds of solar panels after they generated more power than the grid could handle.

Solar ‘tripping’ is a grid threat for renewables causing damage in Texas.

Chile posts record levels of solar curtailment in the first five months of 2023. 735 GWh could not be integrated into the grid, up 86% from the same period in 2022.

Traditional generators rely on inertia (rotational momentum from generators) to provide frequency response in power systems, whereas renewable energy sources do not naturally provide the same frequency response and can be less stable in terms of maintaining a constant frequency.

Some renewable generators have inertia, but the load fluctuates and hence would still require power electronics to correct the frequency response to the grid.

While hydropower provides an excellent source of inertia, it is solar and wind that has driven the greatest uptick in renewable energy generation. Photovoltaic solar energy and wind energy generation typically use inverters that are incapable of providing inertia to the grid.

Power electronics use controllers of a different kind to match the load from the grid. Today's inverters are generally of the grid-following kind. Consequently, renewable energy sources still need to be the best fit for load-balancing purposes. The operator's option is to curtail generation and use an inertia-based load to balance.

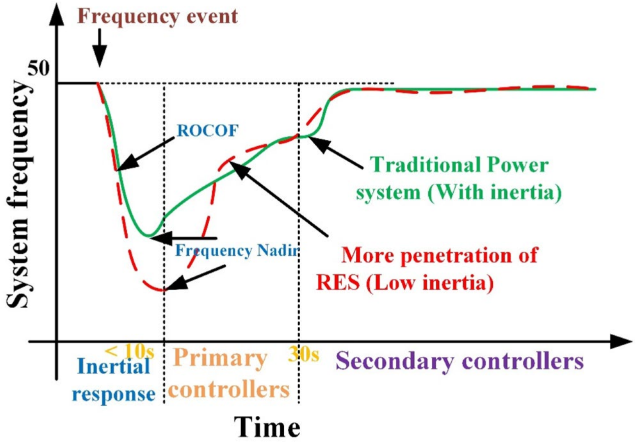


Figure. The various time frames for frequency control of the power system. It is clearly shown that the frequency dip is less when the power generation is only from synchronous generators. It is high if the penetration of renewable energy source (RES) is more in the power system. Source: Sarojini *et al*, 2022.

The Financial and Environmental Impact

Equipment damage is already being caused due to poor power quality from increased renewable energy penetration. This is having a negative impact on utility customers.

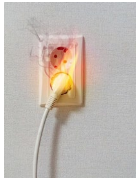
The US and EU are increasingly promoting for greater electrification for energy usage, aiming for a shift towards low-carbon energy generation. However, to achieve this goal, it is crucial to improve power quality.

It is important to fully utilize power generated from renewable sources to reap its benefits. Wasting renewable electricity results in higher carbon emissions from the power grid.

Hence, any equipment failure contributes to lower utilization of renewable energy and increase carbon emissions.

Evoenergy to pay compensation for damage to household appliances in Farrer power surge

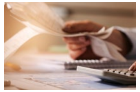
Evoenergy will pay compensation to customers in Canberra's south after a power surge caused hundreds of thousands of dollars of damage to home appliances.



Duke Energy customers seeking compensation after destructive power surge

Neighbors in Indian Land said hundreds and thousands dollars worth of appliances were fried by the voltage.

PG&E power surge leaves Lincoln residents with damaged appliances.



Electricity customers in Montenegro to get EUR 20-200 for poor supplier, system operator service.

Case Study

Industrial equipment manufacturer losing millions of dollars in damaged equipment. Reason unknown.

Poor energy quality was never on our radar. We would still be going around in circles and carrying a heavy financial loss if it weren't for PreScouter.

The problem

A leading industrial manufacturer was incurring a hefty financial bill with on-site equipment repairs for their clients. Previously reliable equipment began to fail at an alarming rate. Warranty repairs increased by an order of magnitude over a three year period.

Looking for much needed answers, the client consulted with one of the "big three". But, again, no apparent reason was found.

Baffled for answers, the client who was already working with PreScouter on other projects, expressed their frustration. And the PreScouter team, as always, was ready to help.

PreScouter's digital transformation team visited sites where the client's equipment was being used and damage was being reported. Over 100 power quality sensors were set up to monitor the local grid.

The culprit

Local solar arrays selling energy back to the grid were introducing significant total harmonic distortion into the electricity supply.

Our solution

The solution was quite simple. PreScouter installed a series of filters on affected equipment.

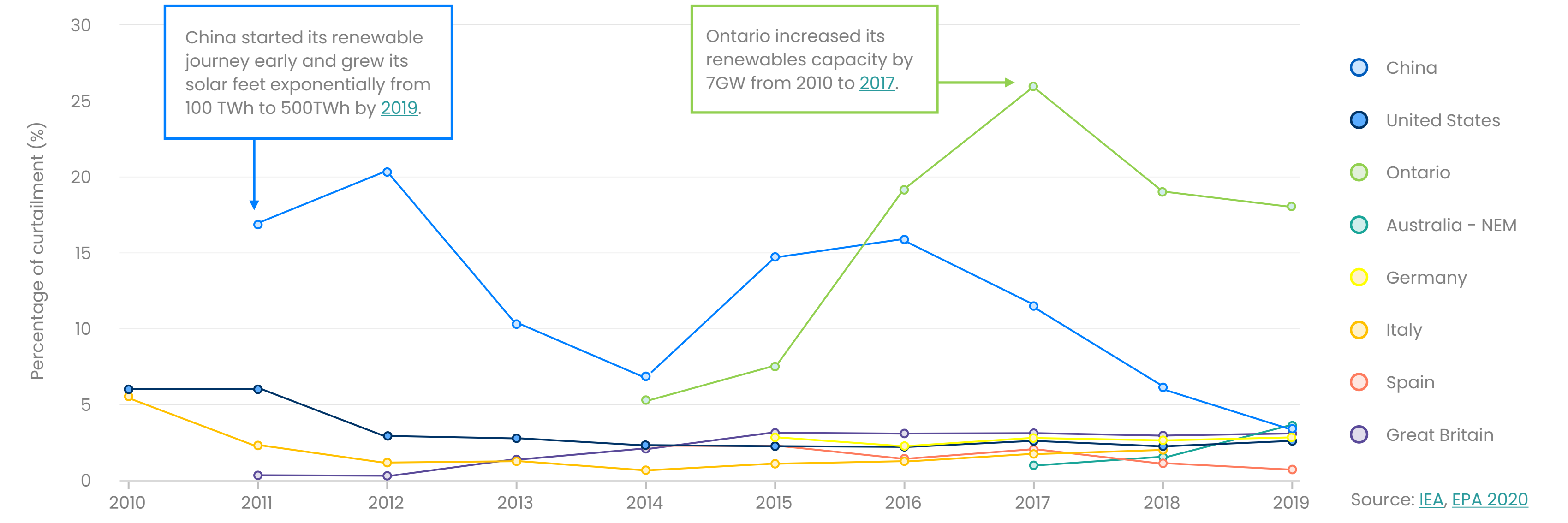
Expert Insights

"There are areas in the grid where the local generation is way higher than the consumption. This essentially means transmission back from the distribution network to the transmission network. But the grid is built to protect from such transmissions, hence causing problems due to excess generation and causing harm to these protection systems.

Power systems expert with 15 years of experience in research and utilities presently working in grid transformation activities for a grid operator.

Insufficient infrastructure leads to increased renewable energy curtailment as renewable penetration grows.

As renewable generation expands globally, there is an inherent learning curve associated with its integration. This curve demonstrates that as renewable generation increases, there is a likelihood of curtailment, where renewable power goes unused due to insufficient storage capacity or the absence of power quality correction equipment. Such curtailment poses challenges, leading to a slower transition to renewable energy and consequently higher carbon emissions.



Source: IEA, EPA 2020

Pressure is increasing on countries to lower their carbon footprint by reducing curtailments.

Curtailments between 4-20% are happening worldwide in mature economies. Most economies that are transitioning will see a peaking of curtailments. On the other hand, mature economies are adding renewable assets at speed.

Curtailments lead to wasted energy, increasing the carbon footprint of the usable energy produced.

In key markets such as China and Germany, the absolute amount of dispatched-down wind and PV electricity rose 20-fold from 2010 to 2017, with most of the increase coming from China. Had it been possible for this generation to be dispatched or stored for later use, emissions of 180 Mt CO21 could have been avoided, which is 3% of total US CO_2-equivalent emissions in 2018.

In 2020, 1.5 million MWh of solar energy was curtailed in California alone, which amounts to 0.65 Mt of CO_2 from fossil usage instead.

New York relies on wind and solar for 4% and 2.5% of its renewable energy, respectively. The New York Independent System Operator (NYISO) reported a curtailment of nearly 84 GWh specifically for wind energy in 2021. NY must develop at least 95 GW of new generation to reach zero emissions by 2040, which is unlikely due to state permitting and grid interconnection delays.

PRESCOUTER

By addressing the challenges of energy storage, grid integration, and demand-side management, the full potential of renewable energy can be harnessed.

On its own, solar power can generate enough electricity to meet the demands of the entire world.

But energy needs to be stored and dispatched when the sun is not shining.

It needs to be delivered on existing infrastructure.

Or we need to find ways in which the demand itself can be reduced or made more efficient.

Maintaining the quality of power is the primary responsibility of a grid operator, but so is keeping carbon emissions to a minimum.

Utility companies worldwide are increasingly considering modernizing their infrastructure to reduce their carbon footprint. They face a dual challenge: improving their future operations without sacrificing their current service.

With this dual challenge in mind, four approaches can help different parts of the electricity grid be more efficient and achieve the intermediate target of net zero in 2050 earlier than later.

4 Steps for Enhanced Renewable Supply

Replacing grid-following inverters with grid-forming inverters

Implementing the use of digital tools like digital substations and cyber-physical systems like merging units

Implementing demand-side response mechanisms - including energy management systems and saving sessions

Using hybrid energy systems where excess renewable generation is stored and sold at a higher price

Aggregators are enablers for residents to participate in the market. You could reduce the temperature by a degree, and no one would notice. And if a million homes are participating, it's a lot of units saved in aggregation.

Power systems expert with 15 years of experience in research and utilities presently working in grid transformation activities for a grid operator.

PRESCOUTER IS HELPING CLIENTS FORTIFY THEIR POWER STRATEGY

Prescouter has enabled clients to face reliability and resilience issues due to old tech, grid expansion, and renewables by providing innovative solutions.

- New innovations in inverters for various application areas.
- Use of graphene-based capacitors for grid resilience and hybrid energy solutions.
- Carbon market assessment for utility companies.
- Landscaping of the smart metering space to provide a bird's eye view of what is available in the market.
- Vehicle-to-grid pilot program assessments using subject matter experts.

Solving the Challenges of Dirty Energy and Curtailment

The following 4 strategies could help save millions in equipment damage and wasted energy.

Grid-forming inverters

Inverter technology facilitates renewable energy integration by regulating voltage, supplying active power, and enhancing renewable energy delivery to the grid.

Hybrid generation

Hybrid generation combines renewables, storage solutions, and smart software to optimize electricity storage and enable the selling of excess energy back to the grid.

Demand-side response

Smart software systems use smart meters and online apps to incentivize users with fees for reducing electricity consumption during peak or unusual grid loads.

Digital substations

To enable modern systems like virtual power plants and digital twins, analog signals from substations' equipment in the grid infrastructure need to be converted to digital signals.

Grid-forming inverters

Grid-forming inverters allow for enhanced grid stability and reliable power supply capacity.

Power conversion to AC requires equipment called rectifiers in conjunction with inverters. Traditionally the inverters have been grid following, i.e., react to the signals from the grid.

Grid-forming inverters have feedback loops that can control voltage, provide active power, and quickly respond to fluctuations induced in the grid due to an out-of-phase renewable energy generator.

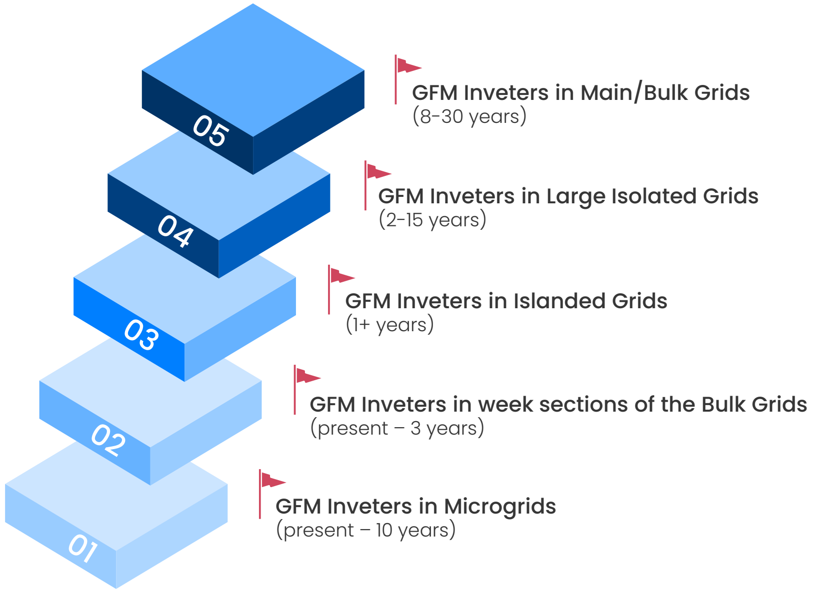


Figure. The evolution and implementation steps of Grid-Forming (GFM) inverters in power electronic interfaced Renewable Energy Sources(RES). As RES gradually replace Synchronous Generators (SG), the system experiences changes in structure and operation, leading to a decrease in system inertia and an increase in intermittent power generation. Source: Antilla *et al.* 2022

Consider the case that 90% of energy is renewable and 10% is from traditional synchronous generators. The frequency would be so volatile that there's nothing to follow. But that's not sustainable. Grid followings are not sustainable because they all need a reference from the grid and that reference would not be reliable very soon. So, the new approach is to have the grid-forming inverters.

Power systems expert with 15 years of experience in research and utilities presently working in grid transformation activities for a grid operator.

SMA

AT A GLANCE

TECHNOLOGY

Grid-forming Inverters

CUSTOMERS

Australian Energy Market Operator, Edify Energy, Versorgungsbetriebe Bordesholm GmbH

TRL

9

STRATEGIES:

SMA grid-forming inverters help stabilize the system while renewables and fluctuating loads are at work. This system enables asset owners to integrate their renewable assets into the grid.

SMA Grid-forming technology claims to play a crucial role in enhancing power quality and grid stability, offering several potential benefits, including improved inertia, enhanced system strength, reduced short-circuit levels, and better system restoration.

SMA solution is composed of Battery inverter (1), Battery (2), Digital monitoring software (4), and central device manager (3).

It is available at all levels (Transmission, Distribution systems, and isolated microgrids)

The essential functions include Energy Arbitrage, Frequency control, and stability services. They provide stable grids with 100 % clean energy.

Solutions sizes can vary from 0.03 MW to 250 MW.

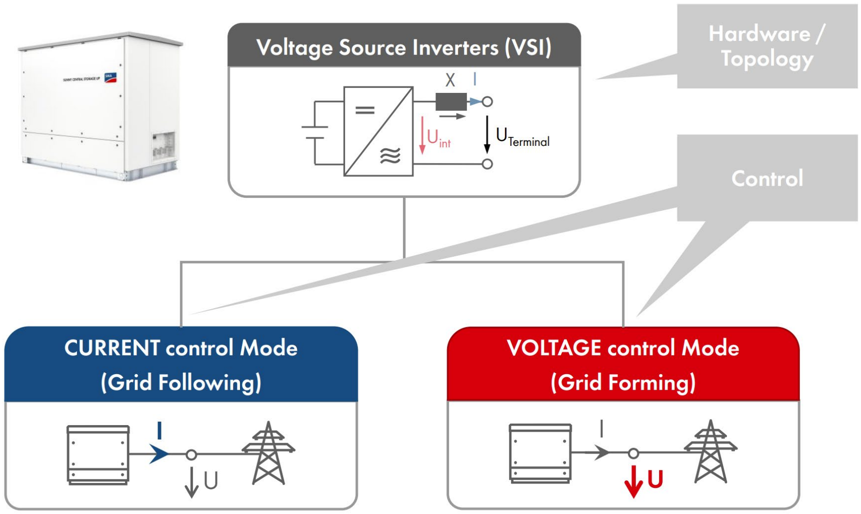


Figure. The grid-forming inverters provided by SMA with two modes of operation - Current Control Mode and the Voltage Control Mode. Source: SMA

PRESCOUTER

SMA

Improving Grid Stability using Grid-forming Inverters

KEY ADVANTAGES

- Actively reacts to the demands of the grid as and when there is a load fluctuation.
- Response times are in seconds with no significant effect on grid stability.
- A Digital Monitoring system is part of the package to monitor and manage load fluctuations.

KEY LIMITATION

- It may need a high energy source during restart.

CASE STUDIES

Grid-forming Project: Bordesholm, Germany 2019 (15 MW)

Battery Storage Application, Frequency Containment Reserve, Emergency islanding operation for 8,000 inhabitants

Grid Connected Battery Storage Stability Grid-forming Project: Australia 2023 (250 MW)

World's largest grid-forming storage project, Primary Reserve / Stability Services, Prepared to improve system strength by applying grid-forming control.

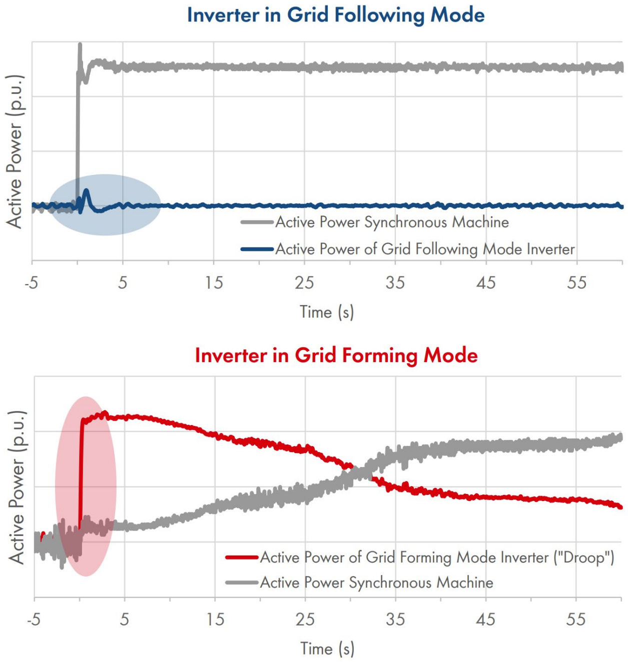


Figure. Change in active power when working in different modes. Source: SMA

PRESCOUTER

GE Renewable Energy

AT A GLANCE

TECHNOLOGY

Grid-forming Inverters

CUSTOMERS

Kalyon Yeka Project

TRL

9

STRATEGIES:

The GE’s FLEXINVERTER provides a complete solar and energy storage power conversion solution.

In a 20ft ISO high-cube container, GE's FLEXINVERTER Power Station contains an inverter, medium voltage power transformer, optional MV Ring Main Unit (RMU), auxiliary transformer, and AC & DC coupling configuration option.

The GE’s FLEXINVERTER also includes a high-efficiency Plug & play with Night-time/Idle-time Disconnect option, Outdoor UL / IEC installation options, BESS system configurations up to 20 MVA+, FLEXIQ enabled

Solutions sizes can vary from 0.03 MW to 250 MW.

Figure. GE Battery Inverters. Source: GE

PRESCOUTER

GE Renewable Energy

KEY ADVANTAGES

- Can deploy reactive power resources at any point of the day.
- FLEXIQ Enabled, which is GE which is GE’s in-house plant control and monitoring software.

KEY LIMITATION

- It may need a high energy source during restart.

CASE STUDIES

Kalyon has selected GE Renewable Energy to deliver FLEXINVERTER solar power stations for the Karapinar phase II-A and phase II-B solar power plants.

The project in the Turkish region of Konya Karapinar was to begin commercial operations in December 2022.

GE Renewable Energy has previously commissioned phase I of the 267 MW ***Karapinar solar facility***.

Figure. FLEXINVERTER Energy Storage Power Station. Source: GE

Grid-forming inverters are essential to keep the electric grid reliable and resilient as renewable penetration increases.

Dhiraj Krishna Kumar

Project Architect, PreScouter

Hybrid generation

Hybrid storage solutions with asset management and market bidding platforms optimize renewable energy integration and storage.

The Duck Curve (shown on the right) illustrates the rising penetration of Solar Energy in California, highlighting its universal relevance. While solar penetration does help in reducing daytime loads, addressing evening peak demands is crucial.

Energy storage emerges as the key solution for storing excess solar energy. The buying and selling of electricity thus need to be more dynamic with software boosted by Artificial Intelligence.

This approach will give rise to companies that will play a role as energy aggregators and that utilize software to manage assets, including residential units, and optimize grid load.

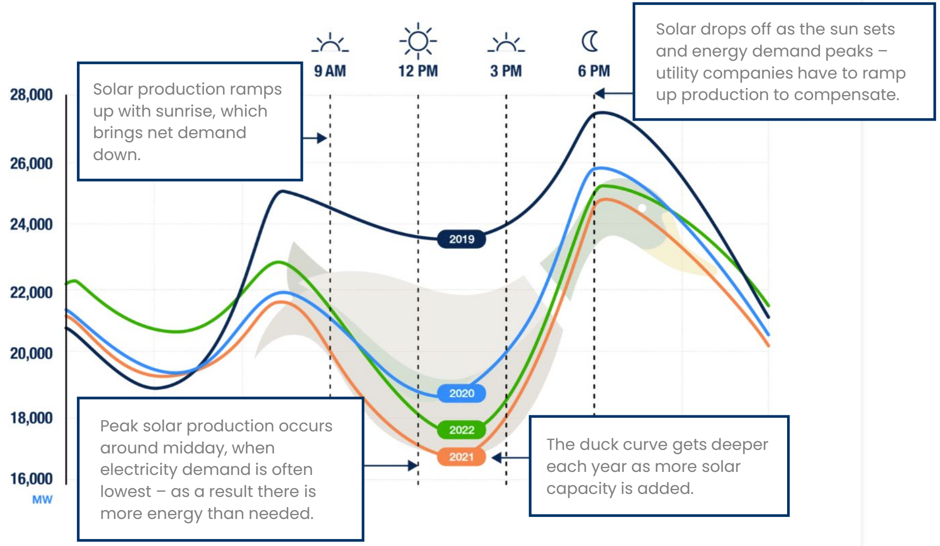


Figure. Duck Curve showing the penetration of solar energy in the California grid from 2019 - 22. Source: Pacific Green

Fluence

AT A GLANCE

TECHNOLOGY

Hybrid Storage Solution

CUSTOMERS

Siemens and AES

TRL

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STRATEGIES:

The Fluence modular cubes use LFP or NMC batteries (depending on the customer's needs) to store energy.

Fluences uses two software solutions for market bidding, asset management, and performance optimization. The systems are Fluence IQ (a digital platform composed of Mosaic and Nispera software) and a Fluence Operating System that allows the control of the generation and storage systems.

Mosaic software uses artificial intelligence (AI)/machine learning (ML) to monitor and calculate optimal bids across all markets by monitoring system loads, transmission headroom, generator activity, and weather and analyzing price forecasts, operational constraints, and business objectives.

Nispera is an AI-based software designed to optimize renewable asset performance with real-time monitoring, automated reporting, and AI-powered analytics. The platform integrates asset data with ML models and visualization tools aiming to uncover hidden performance issues and identify failure patterns.

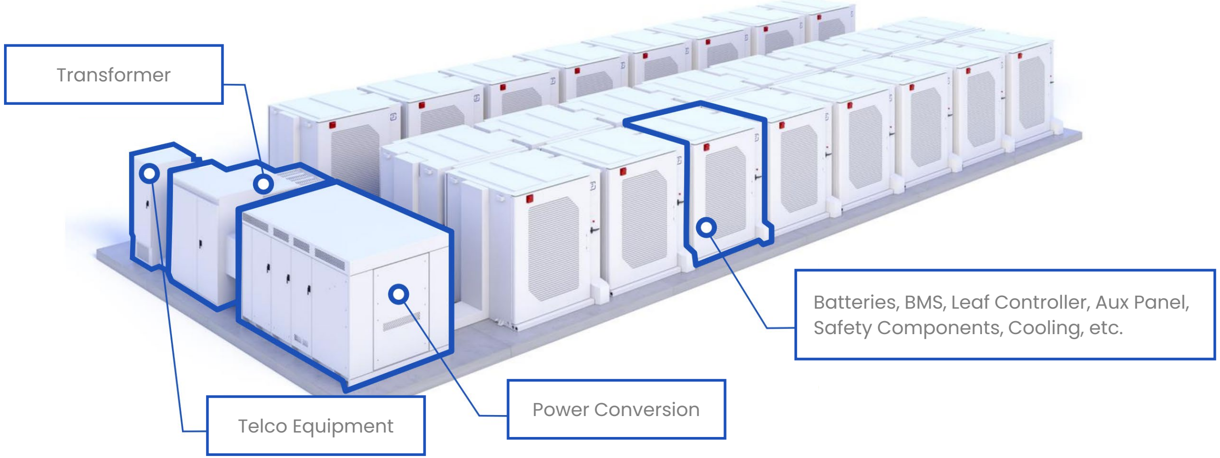

Figure. System configuration using the Fluence Cube. Source: Siemens

Fluence

Improves revenues, resilience and flexibility

KEY ADVANTAGES

- Easily configurable and highly scalable;
- Simple system design and engineering;
- Support a wide range of temperature operation (-30°C to 45°C); and,
- Enables solar facilities to sell up to 50% more solar energy per site.

KEY LIMITATION

- Future contracts with Fluence will have a product price based on raw material indexed pricing, which may be subject to fluctuations and result in variations in the energy price [19]; and
- The high weight of the blocks (around 8,000 kgs) may require a reinforced base structure, which can make the project more expensive.

CASE STUDIES

High Desert Solar Plus Battery Energy Storage Facility

The project located in Victorville, California linked to a solar facility of 108 MW

The High Desert facility of 208 MWh with a 50 MW power rating. The facility uses Fluence OS and Fluence IQ products.

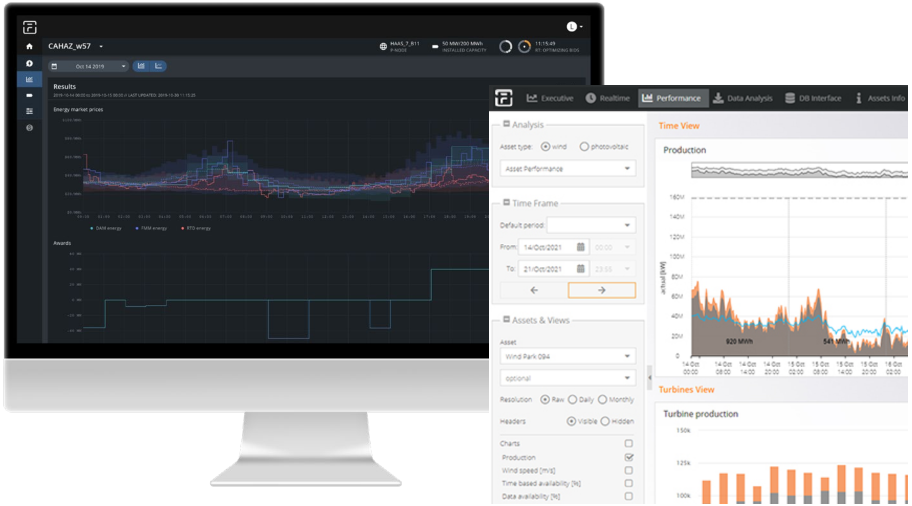

Figure. Interface of the Fluence digital platforms for optimal bids prediction and performance optimization. Source: Fluence

Demand-side response

Demand-side response strategies enable utilities to balance electricity supply and demand

Utilities typically engage in forecasting the expected electricity demand and strive to generate an amount of electricity that matches the predicted demand. They also maintain reserves to accommodate potential decreases in demand. Grid code obligations would require operators to pay generators on standby or to cut down.

Another response would be to ask significant power consumers to reduce consumption at peak hours, reducing the load on the grid. Consumers who choose to participate are adequately compensated.

All it would take is to connect online and switch the lights off during peak hours as instructed by the operator or provide access to power-consuming devices, e.g.: reduce the temperature by 1 degree Celsius.

Figure. Smart Meters go a long way in helping distributors in assessing the demand data and proposing new energy saving schemes to consumers. Source: Octopus Energy

EnelX

AT A GLANCE

TECHNOLOGY

Demand Side Management Software

CUSTOMERS

UMass

TRL

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STRATEGIES:

EnelX provides e-city, e-industry, e-home, and financial service solutions, primarily energy-related solutions.

EnelX makes use of digital technology solutions for public agencies. Two examples of their solutions are Demand Charge Management and Energy Arbitrage.

Demand Charge Management involves using commercial energy storage to reduce a facility's peak electrical grid demand. By doing so, customers can potentially lower their fees associated with peak demand periods.

Energy Arbitrage involves consuming energy from a storage system during low-cost periods and avoiding energy consumption from the electricity grid during high-cost energy periods.

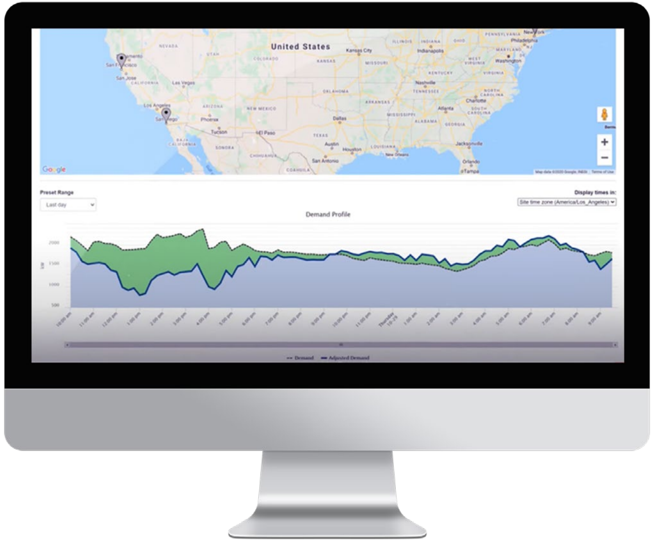

Figure. Onsite Demand Profiles created by EnelX software. Source: Youtube

EnelX

Improving Grid Stability using Grid-forming Inverters

KEY ADVANTAGES

- Easy to enroll in the program.
- Provide customer-specific demand response consultation to clients using its software.

KEY LIMITATION

- It inherently depends on customer participation, i.e., customers can drop out at the last minute.

CASE STUDIES

Demand Response programs with PJM (grid operator): PJM Synchronized Reserve Market, PJM Emergency Load Response Program, PJM Economic Demand Response, PECO Act 129 Demand Response, Energy Supply Mgmt., Demand Mgmt.

As of Q1 2018, Temple University's (Philadelphia, Pennsylvania) demand response participation has generated about $4.1M in gross revenue, $1.5M in cost savings through strategic energy supply management, and over $9M in avoided capacity charges.

In addition to financial gains, the Temple University team has enhanced campus efficiency by maintaining a 300,000 MWh electric load despite a rise in student population and new facilities.

ANCILLARY SERVICES PROGRAMS
Participants respond in real-time or have the capacity to influence the frequency response using specific hardware.

CAPACITY RESPONSE PROGRAMS
Energy users are paid upon the capacity to reduce their energy consumption as per demand on the grid on request.

ENERGY MARKET PROGRAMS
Customers are paid to reduce demand on the grid in times of high electricity prices.

Figure. Three types of Demand Response Programs offered.

Reliability of the grid can also be maintained with demand-side management tools and digital solutions.

Hasan Gunduz

Analyst, PreScouter

Digital substation

Digital substations are revolutionizing the power grid with advanced technology and improved functionality

Grids all over the world are going through significant transformations in terms of both generation and distribution equipment. This transformation would mean the need to convert analog equipment into digital systems. The primary port of call is the substation.

Present-day equipment still uses analogous signals, which need to be converted to digital to enable the input to digital twins. The data collected can be used with AI ML software to optimize the power quality on the grid.

IEC View

A fully automated distribution system can make the power grid much more reliable. The IEC 61850 standard can help to achieve reliability by overcoming the critical interoperability hurdle.

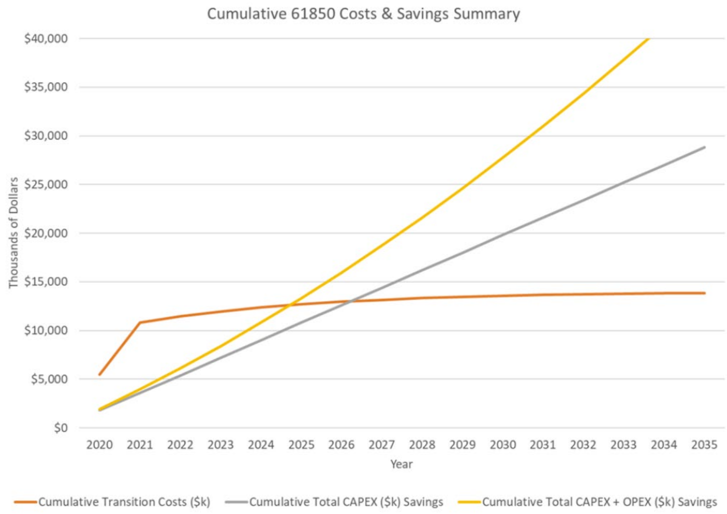

Figure. Cost Benefit Analysis of implementing IEC 61850 suggestions. Source: PAC World Conference

Toshiba

AT A GLANCE

TECHNOLOGY

Process Bus Technology for Merging Units

CUSTOMERS

Digital Substations

TRL

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STRATEGIES:

Toshiba provides a merging unit technology that converts a traditional substation using analog signals and copper wires into a digital substation. The process bus technology enables the reading of output values from transformers and digitizing the values as input to secondary systems.

The system supports many functions, including the metering of voltages, currents, power, frequency, and power factors. In addition, it also records events and faults and has direct communication with the substation automation systems.

The system supports time synchronization with external systems, trip circuit supervision, high-speed tripping, digital inputs for switching, and features that can enhance the cybersecurity of the substation on the whole.

The systems are compact and hence have a lower footprint than traditional ones. The digital system also helps mitigate the dangers of high voltage as the connections are digital.

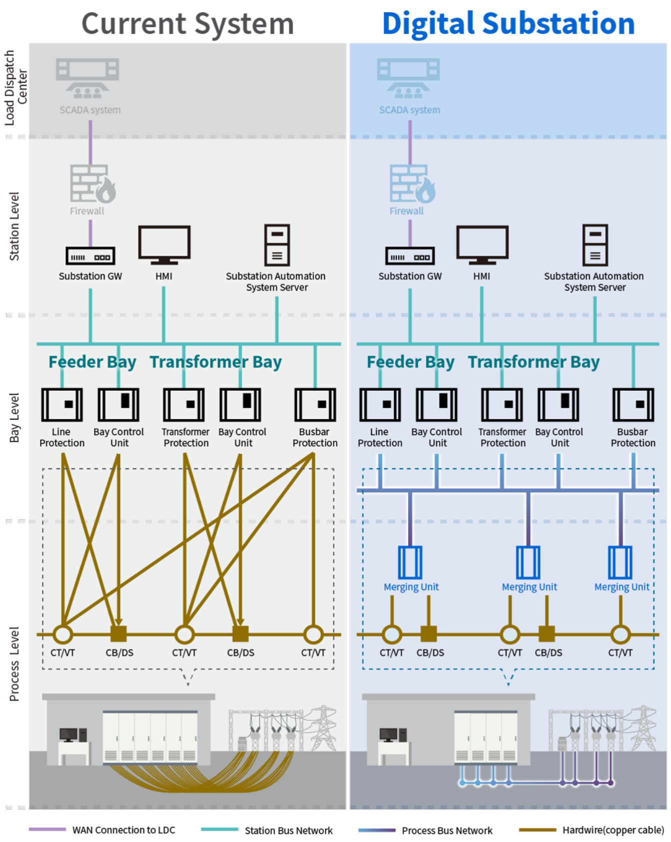

Figure. Current System vs a Digital Substation. Source: Toshiba

Toshiba

Process Bus Solutions to build a Digital Substation

KEY ADVANTAGES

- It has a lower carbon footprint and is safer than a traditional system.
- A digital system makes the metering accurate and provides a precise picture of grid connections.
- Improves the visibility of faults and power quality at each node of the grid where implemented.

KEY LIMITATION

- The entire grid will need to be digitized to harness the actual potential of a digital substation.

Figure. Toshiba Merging Unit - GMU200.
Source: Toshiba

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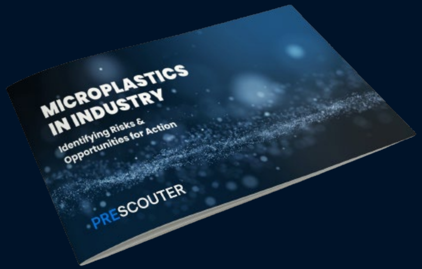

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