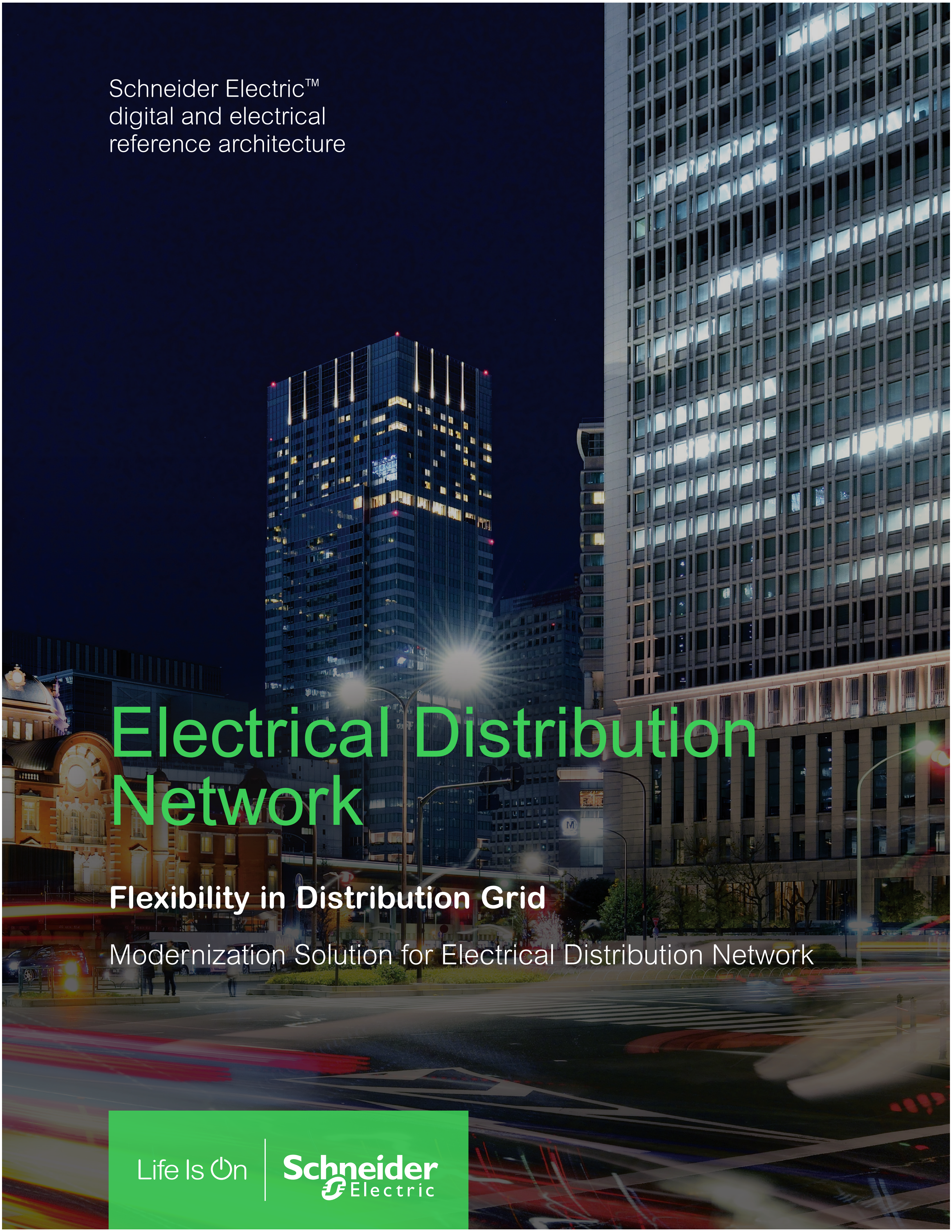


Schneider Electric™
digital and electrical
reference architecture

Electrical Distribution Network

Flexibility in Distribution Grid

Modernization Solution for Electrical Distribution Network

Life Is On | Schneider Electric

Contents

Context

The decision on **grid modernization is a strategic initiative** which is initiated at the highest level in the Electric Company organizations.

Grid modernization will bring more automation possibilities and intelligent management. It can **fundamentally** change the way utility operates the network and interacts with end-users. Managing these changes is difficult: most electrical companies take years to decide to move ahead.

Schneider Electric is a trusted partner to accompany electrical distribution companies to set up a direction guideline for the development of their network. It is important to “think ahead” in order to refine the goals and define the right solution to align with the expectations on performance and development of the network.

This document is a use-case illustration about the **Flexibility in Distribution Grid.**

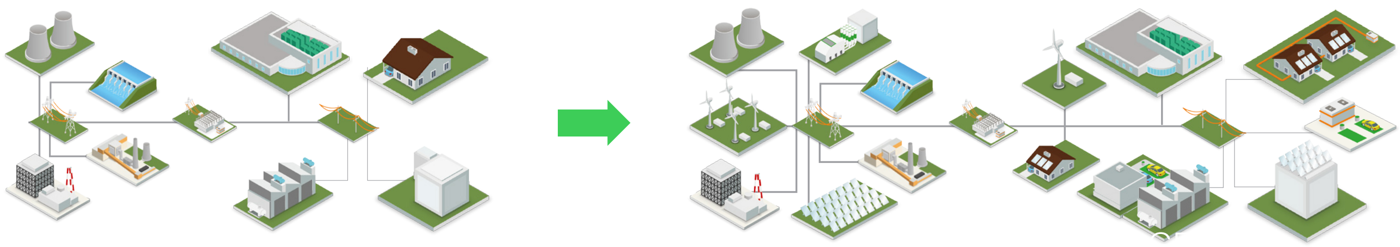
Problem to solve

Power systems had been built and configured for totally regulated and centralized control. In the new context with energy and climate crisis that are the drivers for Clean Energy Adoption and electrification in buildings, transportation and industries; the difficulty in managing uncertainty, dynamicity and accommodating new types of energy flows becomes more and more recurrent phenomena.

While an increasing number of stakeholders participate to plan, promote and provide services to address these changes, including stakeholders that are not traditionally involved in power system operation management such as retailers, market operators, etc., the impact is expected to be more severe for both suppliers and customers.

	Flexibility 1.0	**Flexibility 2.0**
Context	Totally Regulated and Centralized Control of Power System	Boosting Clean Energy Adoption and Environment Policies Renewable energy sources, Electrification of heat, transport, industries
Participants	Transmission and Distribution Operators	Energy Regulators, Transmission Utilities, Distribution Utilities, Prosumers, DER* producers, Retailers, Aggregators, Market Operators, …
Objective	System balancing, Constraint managements, Planning & Development, Optimization of Energy Portfolio, Economic KPI,…	
Main concepts	One-way power flow One Electricity Provider	Distributed « Two-way power flow » in harmony Multiple Stakeholders / Participants

* DER producers = Solar, Wind, CHP, Genset, …



Yesterday’s power systems — Today’s power systems

Figure 1

Today, not all regulatory frameworks are robust enough to drive this new environment in harmony. Each country takes their own path to better handling with this transition. As a point of convergence for all diversities, the flexibility management is seen as the key solution.

Flexibility Approach for Distribution Grids

What is Flexibility?

There are many interpretations and definitions that can be found and referenced for the concept of "Flexibility" in power system. We note here the one that seems covering most of the related regulatory, economic and technical aspects.

Flexibility is the **power adjustment** of an **energy resource** within a given timeframe in response to a signal in order to provide a **technical or economical service**

Power adjustment

Shift or change of expected generation, consumption or storage patterns.

Energy resource

- Generation *(conventional, PV, wind, genset, cogen, …)*
- Storage system
- Load (heating, cooling, EV, …)
- Aggregated resources *(Microgrid, Virtual Power Plant)*

Signal

- Price-based
- Incentive-based
- Sustainable goals (e.g., CO_2)

Services

- Grid services (Balancing, Network Constraint Management)
- Market participant Services (Capacity, Supply Arbitrage, …)
- Behind-the-meter Services: (Increase self-consumption & resilience, Energy bill optimization, …)

Figure 2

Some key elements should be discussed.

First of all, variability and uncertainty are not new to any power systems which are designed to balance supply and demand at all times. However, compared to the system dominated by several large generation centers that are supplying passive end-users, this balance is much harder to achieve for the system with many options for generation resources and engaged consumers.

High integration of renewable energy and new technologies applied for active and aggregated customer concepts like VPP (Virtual Power Plant), microgrid, prosumer…, is foreseen. They are more flexible and dynamic than conventional generation and also able to provide services to help power systems in operation management. Relevant services offered by these new resources or pools could be of grid supports, market participation or behind-the-meter services.

For better engaging with flexibility providers, these services are valued based on prices, incentive initiatives or sustainable goals, driven by regulation.

Why the Flexibility matters for distribution grids?

While there are gigawatt scale projects of wind, solar or storage that are built to be connected to HV network, majority of new energy resources is connected to MV or LV distribution networks. By 2030 it is expected that 70% of renewable capacity could be connected to distribution grids. Distribution grids were not designed for that and are facing many technical issues for maintaining the quality, reliability and resilience of the system while facing to the fast growth of demand.

Flexibility services are seen as the key Solution for mitigating constraint network management and network investment deferral.

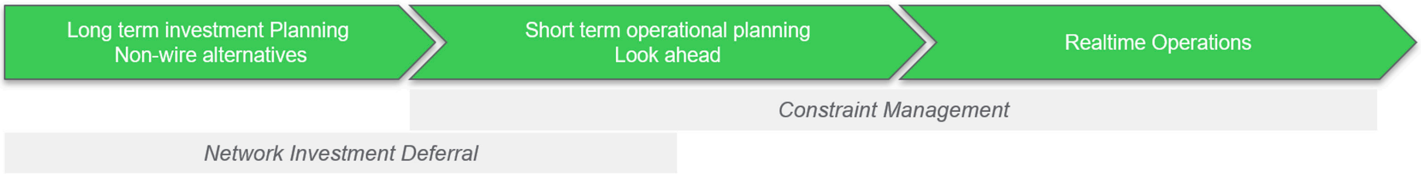


Figure 3

According to the rapport from SmartEN (Smart Energy Europe) about "Qualification of benefits of Demand-side Flexibility in EU", the €11.1 to €29.1 billion annually saved in distribution grid investment needs could be expected in EU between 2023 and 2030 through implementation of flexibility for distribution grid services.

How to implement flexibility for Distribution Grid?

The value of Flexibility can be clearly outlined. But the more difficult questions are: "How to implement flexibility" and "who should be involved"?

The answer is "it depends"!

Deploying power system flexibility requires a holistic approach. Because, although all stakeholders can drive different benefits from flexibility, they use the same resources. Therefore, a strategic alignment at institutional framework should be conducted at country level to define the roles and responsibilities for all relevant participants. This high-level regulatory setup is particularly important as it lays out the overall objectives of the power system development.

Then, the next framework is to define a set of economic and market rules to specify the interaction between stakeholders. By allocating costs and risk, each participant will find the way to efficiently shape his operations and business strategy.

The last framework, but not less important, concerns technical standards, which are fundamental to ensure the stability and reliability of power system operations.

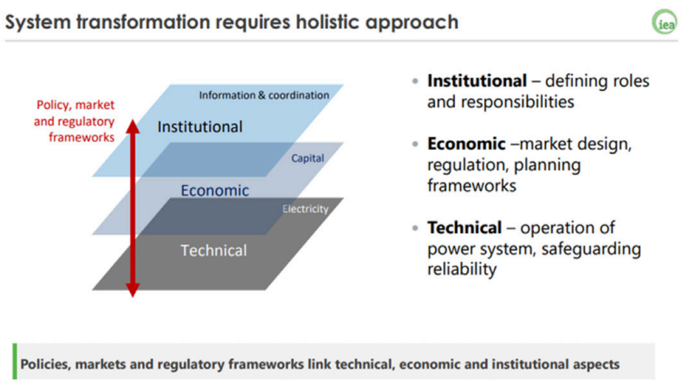


Figure 4

All of these aspects: institutional, economic and technical are very country-specific. They are experimented through demonstrations and small-scale pilot projects, with the need of fast scale-up. We will see some examples of deployment as follows.

Flexibility Model

Australia

The first example is about the Flexibility model deployed in Australia.

Australia has a highly deregulated power system with separate transmission, distribution and retail companies managed by a single ISO. To boost the adoption of clean energy and deployment of DERs, it has a specific regulation named "dynamic connection agreement" that encourage small-scale assets to provide services to distribution grids.

New Demand Response markets have also been created and DER Flexibility marketplace trials are on-going. The overall objective is that Distribution Utilities will be able to leverage DER flexibility to avoid predicted capacity constraints and defer grid reinforcement needs, especially in a context of high solar PV penetration while providing customers with maximum power of choice.

Institutional: Highly Deregulated

- Grid code requirements, with boosting "Clean Energy Adoption"
- Dynamic Connection Agreements for DER, especially small-scale assets (prosumers) with dynamic limits of import/export

Economic:

- New Demand Response markets have been created and 'DER Flexibility Marketplace' trials are ongoing
- Distribution Network Service Providers are experimenting with direct incentives for network support and dynamic network tariffs

Technical:

- Dynamic DER export and import limits considering grid constraints are being legislated for new DER connections in some states
- Integration with energy markets for dispatch of VPP assets is growing

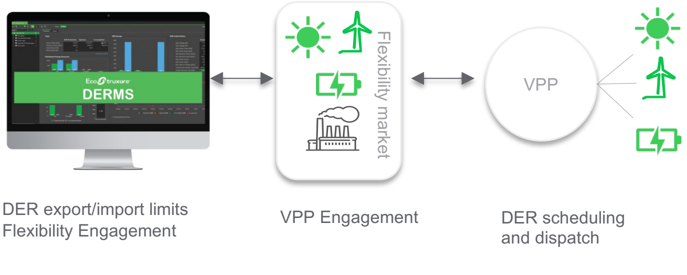
A promising approach has been deployed by Evoenergy under ARENA funding, as part of ARENA's Advancing Renewables program. The goal of the DER Integration and Automation project is to simulate the utilization and control of DER to ensure that the network is maintained 24x7 within technical limits (Dynamic Operating Envelopes). This allows for deferred grid augmentation investment and increases network capacity to host more DERs. To achieve this Evoenergy is leveraging the existing EcoStruxure ADMS along with EcoStruxure DERMS, integrated with Evoenergy IoT Hub and a Flexibility Marketplace. Dynamic Operating Envelopes planned for grid-wide deployment by multiple Australian utilities.

ARENA Report: https://arena.gov.au/assets/2021/08/der-integration-and-automation-project-report.pdf

evoenergy

ARENA
Australian Government
Australian Renewable Energy Agency

"Optimize Grid capacity with Dynamic Operating Envelopes"



European Union

The second example concerns the Flexibility model in EU countries.

Similar to Australia, EU power system is highly deregulated with a strong motivation for Clean Energy Adoption.

But, if flexibility deployment in Australia is still in exploration stage, the economic models for rewarding flexibility services are more mature in some EU countries such as in UK and Netherlands. Actually, many options mainly on price-based are available that allow flexibility providers to valorize their offers at market value.

Institutional: Highly Deregulated

- Grid code requirements, with boosting “Clean Energy Adoption”
- Constraint Management Services at distribution level

Economic:

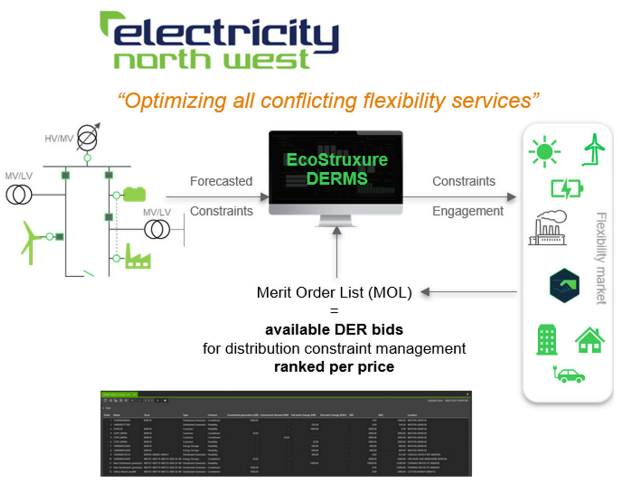
- Development of economic models is mature in some countries (UK, Netherlands)
- Many options for rewarding Flexibility Services provided by DER (real-time tariffs, time-of-use tariffs, service biddings, flexible connection, curtailment …)

Technical:

- Active Customers or Aggregators are paid in exchange for shifting or shaping their energy use to support grids via Flexibility Market

Let’s take the project with “Electricity Northwest” as illustrative case. With high penetration of renewable energy, the network operation is stressed to its limits with risk of over-loading and reverse injection. When a constraint is detected, all flexibility providers can propose their service through a flexibility marketplace (PICLO in this case) to mitigate the issue. Each participant comes in with his availability, capacity and price for the proposed services. Distributor has to choose, among these options, the best trade-off between technical-economic criteria to address the issue. This is valid for real-time operation as well as network development planning.

The EcoStruxure DERMS has been deployed to help “Electricity Northwest” utility to optimizing the use of competitive flexibility services for network constraints management.



USA

Another deployment model example can be found in USA.

With the same motivation towards the adoption of clean energy at institutional framework, in the implementation aspects, however, there are multiple models deployed in USA with different maturity levels.

The key concerns in USA power system is to mitigate peak constraints and network development to covers growing demand. Therefore, most flexibility services are proposed to address these issues.

Institutional: Highly Deregulated

- FERC* (Federal level): Revised wholesale market rules to implement aggressive clean energy & environment policies
- PUC** (State Level):
  - *- Some utilities operate and manage vertically services at distribution level*
  - *- Some utilities operate and manage distribution grid as one part of the vertically integrated services they provide*

Economic:

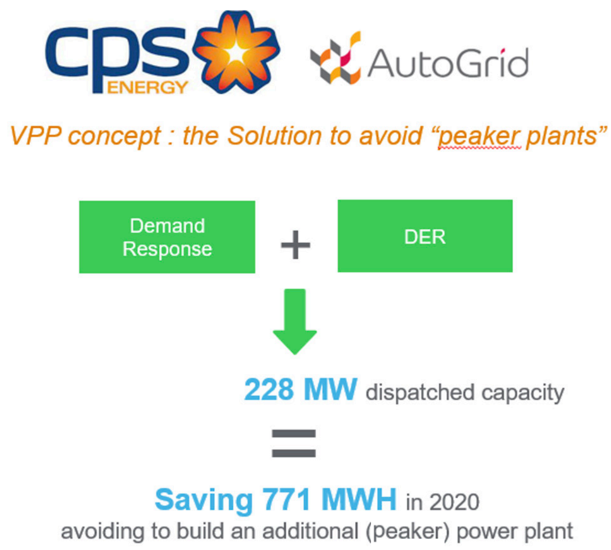
- Price-based DER dispatch & control, Bilateral Contracts, Utility Retail Program

Technical:

- Distributor fully integrates VPP concept for peak shaving
- Distributor relies on Demand Response Solution for network investment deferral

* FERC : Federal Energy Regulatory Commission, ** PUC : Public Uitlities Commission

Let's take the case of pilot project with CPS energy in Texas. In this project, the AutoGrid Flex solution has aggregated 228 MW dispatched capacity of DERs (including customer-sited solar power systems, EV chargers and energy storage systems), accurately monitor their activity in real-time to address the network constraints. Based on demand response and DER management, the project results in a significant energy saving and help CPS Energy to efficiently mitigate peak issues avoiding the building of an additional power plant.



Other countries

Flexibility can be also leveraged in the countries where power system is still in totally regulated regime.

Institutional: Totally Regulated

- Single Regulator with limited REN adoption capacity
- Grid code requirements
  - ➡ *to reject REN in case of congestions*

Economic:

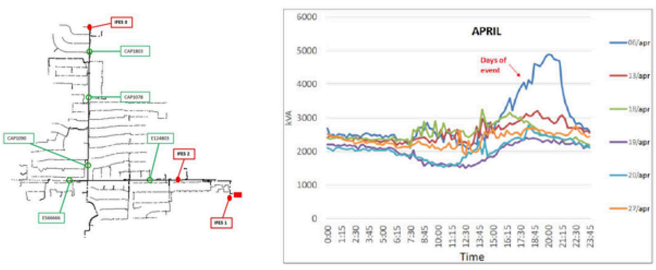
- Vertically integrated utilities :
  - ➡ *One energy provider = One energy retailer*

Technical:

- Utility uses its owned Flexibility Assets to mitigate network constraints
  - ➡ *overcurrent, reverse power flow, voltage unbalance …*
- Active Customers or Aggregators are enrolled in Demand Response Program and use Microgrid solutions to optimize their energy bills and get resilience

In such countries with limited REN adoption capacity, distribution utility uses its owned Flexibility Assets to mitigate network constraints. The project with Brazilian CEMIG utility is a typical example. In this project, the EcoStruxure DERMS solution has been proposed to accurately monitor the grid-scale battery storage system. This is the right solution to increase the capacity of the network to host renewables and EV users.

Increase renewables and EV hosting capacity



Grid-scale Battery Storage System as non-wire alternative solution

Generic flexibility value chain for Distribution Utilities

Throughout the previous examples, we can see the shape in operation of distribution grids. Going out of the basic "one-way power flow" model from transmission to distribution to end-users, a new environment where all stakeholders (producer, active consumer, aggregator, network operator, market operator…) should cooperate in a harmonious way to ensure an efficient network operation and sustainable development.

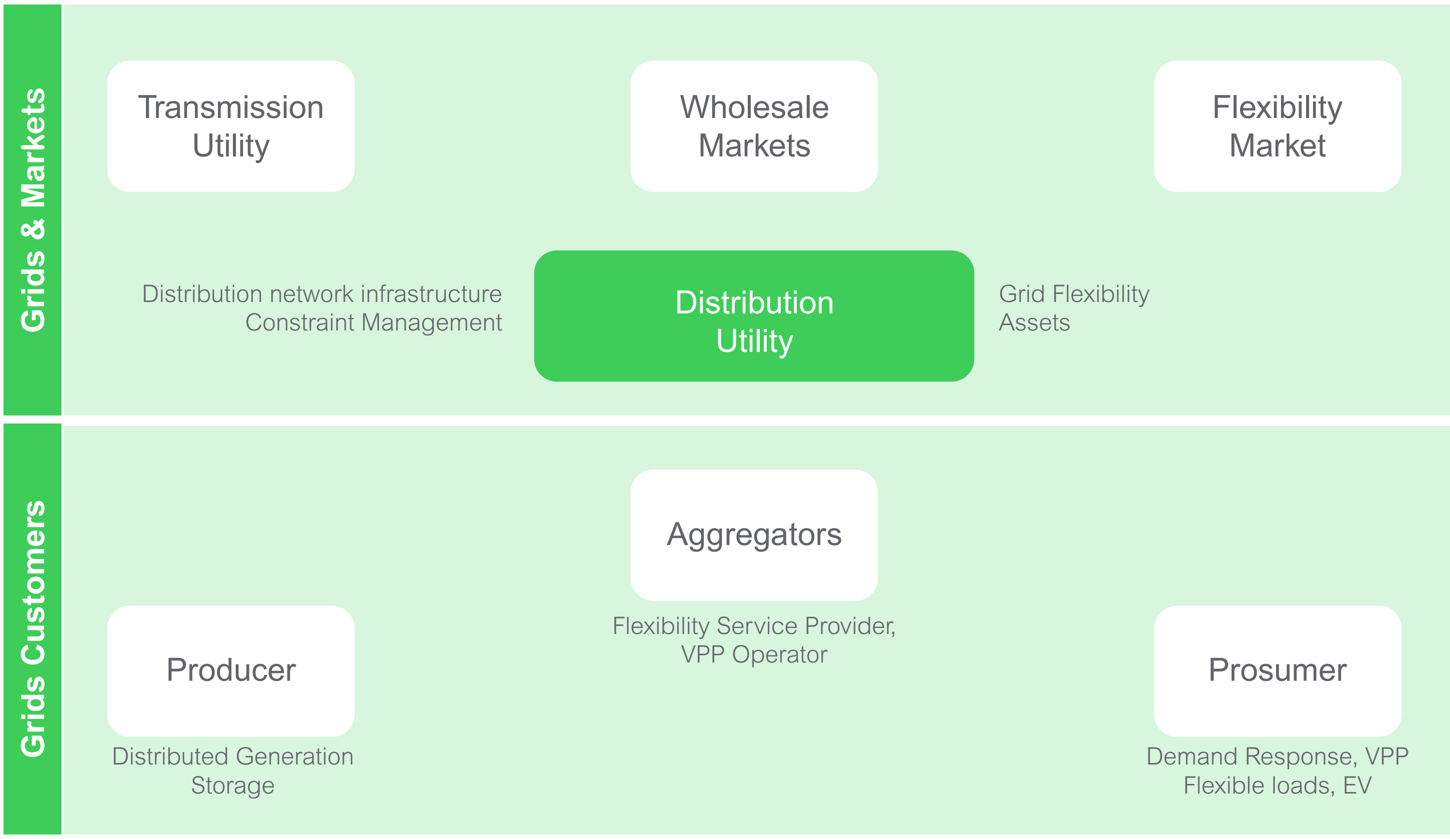


Figure 5

Schneider Electric technologies enabling flexibility for distribution utilities throughout complete DER lifecycle

At Schneider Electric, we are committed, based on EcoStruxure solutions, to address Flexibility in Distribution Grid integrating complete DER lifecycle. From getting DER engagement to operation monitoring, reporting and planning for development, adopting these new advanced technologies is one of the crucial steps in the transition of distribution utilities towards a more sustainable future.

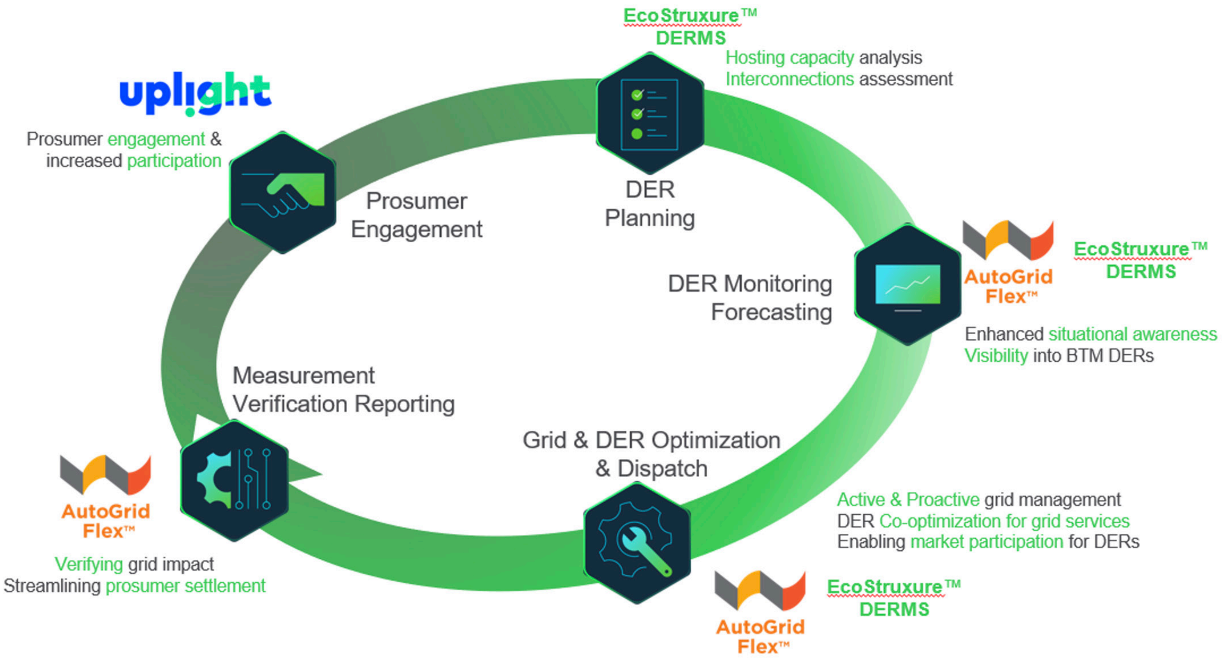


Figure 6

Typical digital architecture

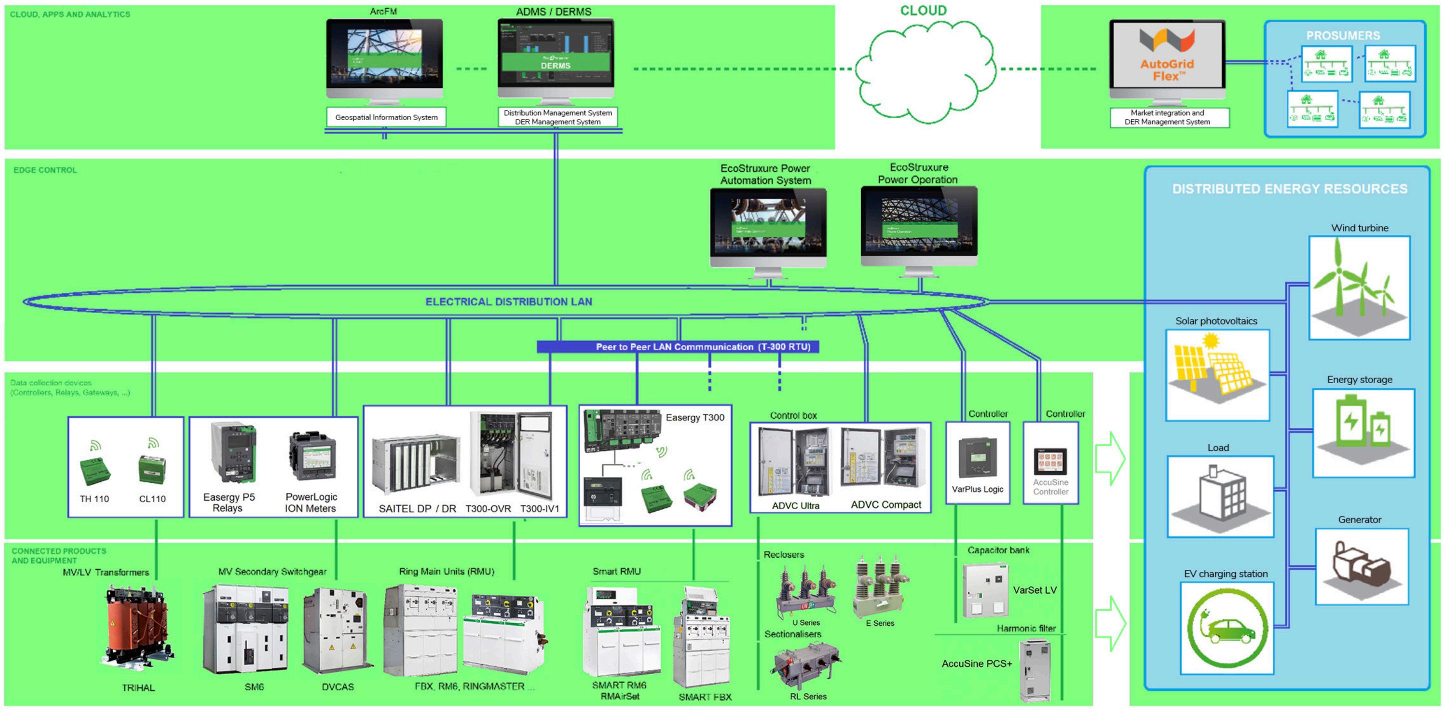
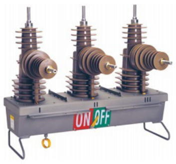
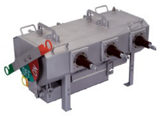


Figure 7

Schneider Electric products used in the Use Case

Network function	Product name	Main technical characteristics		Link to offer / spec
Grid DERMS	**EcoStruxure DERMS**	DER Monitoring, forecasting and control. Hosting capacity analysis, grid constraint management, usage of DER flexibility		learn more
Edge DERMS	**AutoGrid Flex**	Flexibility services: Economic constraint mgmt, Program management, Monitoring and forecasting, Measurement & verification, Value co-optimization, Virtual Power Plants	AutoGrid Flex™	learn more AutoGrid
SCADA	**EcoStruxure Power Automation System**	SCADA digital control system for Substation automation based on PACiS technology		learn more
SCADA	**EcoStruxure Power Operation**	Power SCADA for Electrical System		learn more
Protection Relay	**Easergy P5**	MV Protection relay from overcurrent to differential protection with arc flash protection, LPCTs, LPVTs, redundant Ethernet communication and IEC 61850		learn more
Power meter	**ION Range**	PowerLogic ION 9000 Advanced Power Quality Metering		learn more
Power meter	**PM Range**	Power Logic PM 8000 / PM7000 Compact, high performance Power meters		learn more
RMU	**"Smart" RM6**	Gas insulated switchgear up to 24kV With T-300 RTU. Short Time current rating up to 21kA, rated for Internal arc up to 20kA AFLR with options		learn more

Network function	Product name	Main technical characteristics		Link to offer / spec
RMU	**"Smart" FBX**	Gas insulated switchgear up to 24kV With T-300 RTU. Fully SF6-insulated RMU switchboard, available in compact or extensible installation footprints. Short Time current rating up to 25kA, rated for Internal arc up to 25kA AFL with options		learn more
RMU	**RM6**	Gas insulated switchgear up to 24kV. Short Time current rating up to 21kA, rated for Internal arc up to 20kA AFLR with options		learn more
RMU	**FBX**	Gas insulated switchgear up to 24kV. Fully SF6-insulated RMU switchboard, available in compact or extensible installation footprints. Short Time current rating up to 25kA, rated for Internal arc up to 25kA AFL with options		learn more
RMU	**Ringmaster**	Hi-reliable Gas Insulated Switchboard for underground secondary distribution. For indoor and outdoor applications, up to 13.8kV		learn more
RTU	**Easergy T-300**	Remote Terminal Unit made of: - HU250: head unit communication gateway - SC150: switch controller module - LV150: transformer and low voltage monitoring module - PS25/PS50: power supply module		learn more
RTU box	**Easergy T-300 IV1**	Remote Terminal Unit box for indoor installation, with T-300 RTU.		learn more
RTU box	**Easergy T-300 OVR**	Remote Terminal Unit box for outdoor installation, with T-300 RTU.		learn more
Recloser	**E-Series**	Light-weight reclosers up to 38kV and 170kV BIL.		learn more

Network function	Product name	Main technical characteristics		Link to offer / spec
Recloser	**U-Series**	Light-weight reclosers up to 27kV and 125kV BIL.		learn more
Recloser	**W-Series**	Single-phase reclosers up to 24kV		learn more
Sectionalizer	**RL-Series**	3-Phase load break switch / sectionalizer up to 38kV.		learn more
Auto recloser control box	**ADVC Compact**	304 grade stainless steel cabinet. ADVC monitors the CB and provides protection, measurement, control, and communication functions (connected via a control cable to the recloser).		learn more
Auto recloser control box	**ADVC Ultra**	316 grade stainless steel cabinet. ADVC monitors the CB and provides protection, measurement, control, and communication functions (connected via a control cable to the recloser).		learn more
LV Capacitor bank	**VarSet LV**	Smart LV Capacitor bank with VarPlus Logic controller		learn more
Harmonic filter	**AccuSine PCS+**	Active harmonic filter for harmonic mitigation, power factor correction and load balancing.		learn more
Transformer	**Trihal**	Efficient and connected "cast resin" type MV/LV Transformer. Optional On-Load Tap Changer (OLTC).		learn more

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