Session 7: DER Management and Prosumer Enablement

PART A: Distributed Energy Resources (DER) and its Impact on the Grid

Session Content

- Introduction, challenges, moving forward
- Planning & Operational Scenarios DER Impact on Grid
- Prosumer Growth on Utility's Technical & Financial Operations
- Key Takeaways/ Recommendations

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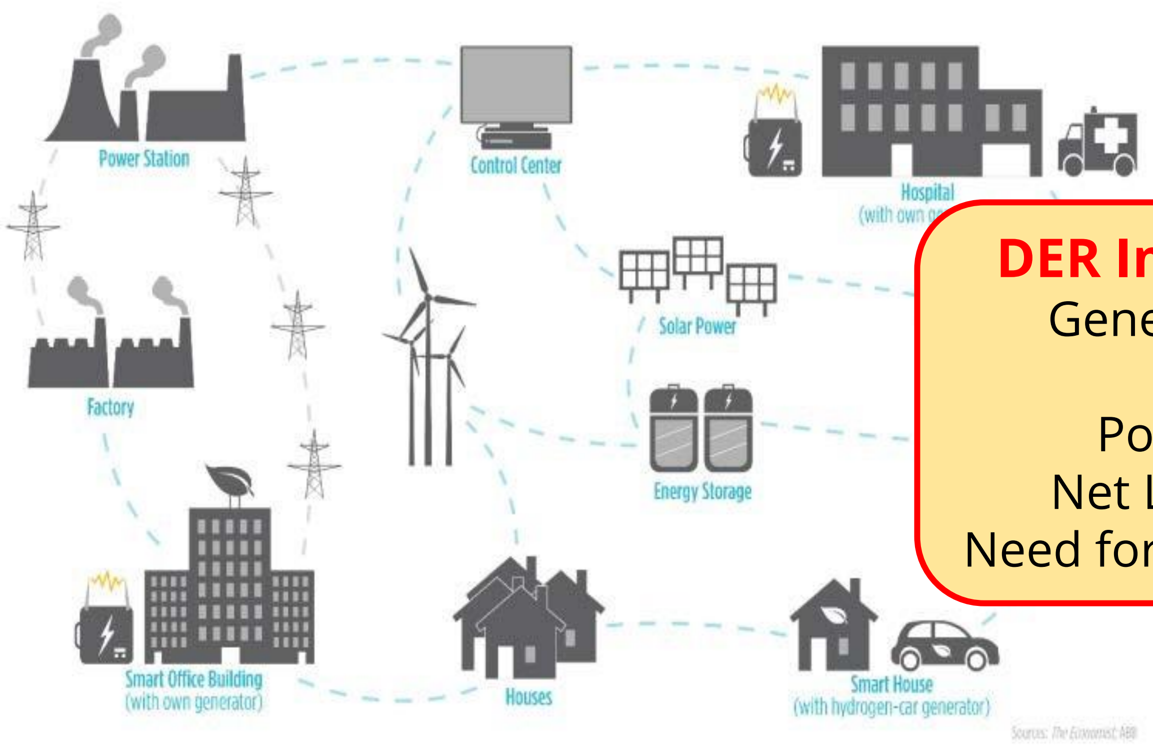
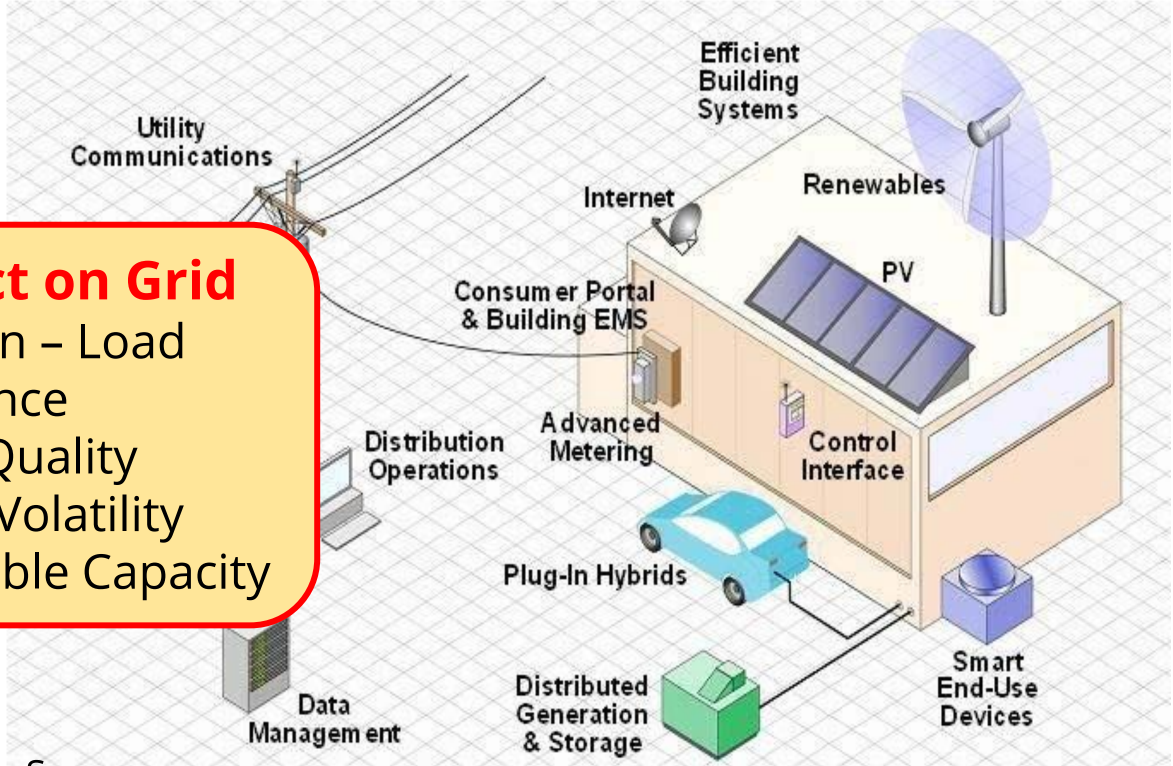
Introduction

Utility of the Future
Decarbonization – Decentralization - Digitalization

Technology Interactions With Grid Elements



DER Impact on Grid
Generation – Load Balance
Power Quality
Net Load Volatility
Need for Flexible Capacity



Source:
www.electricalacademia.com

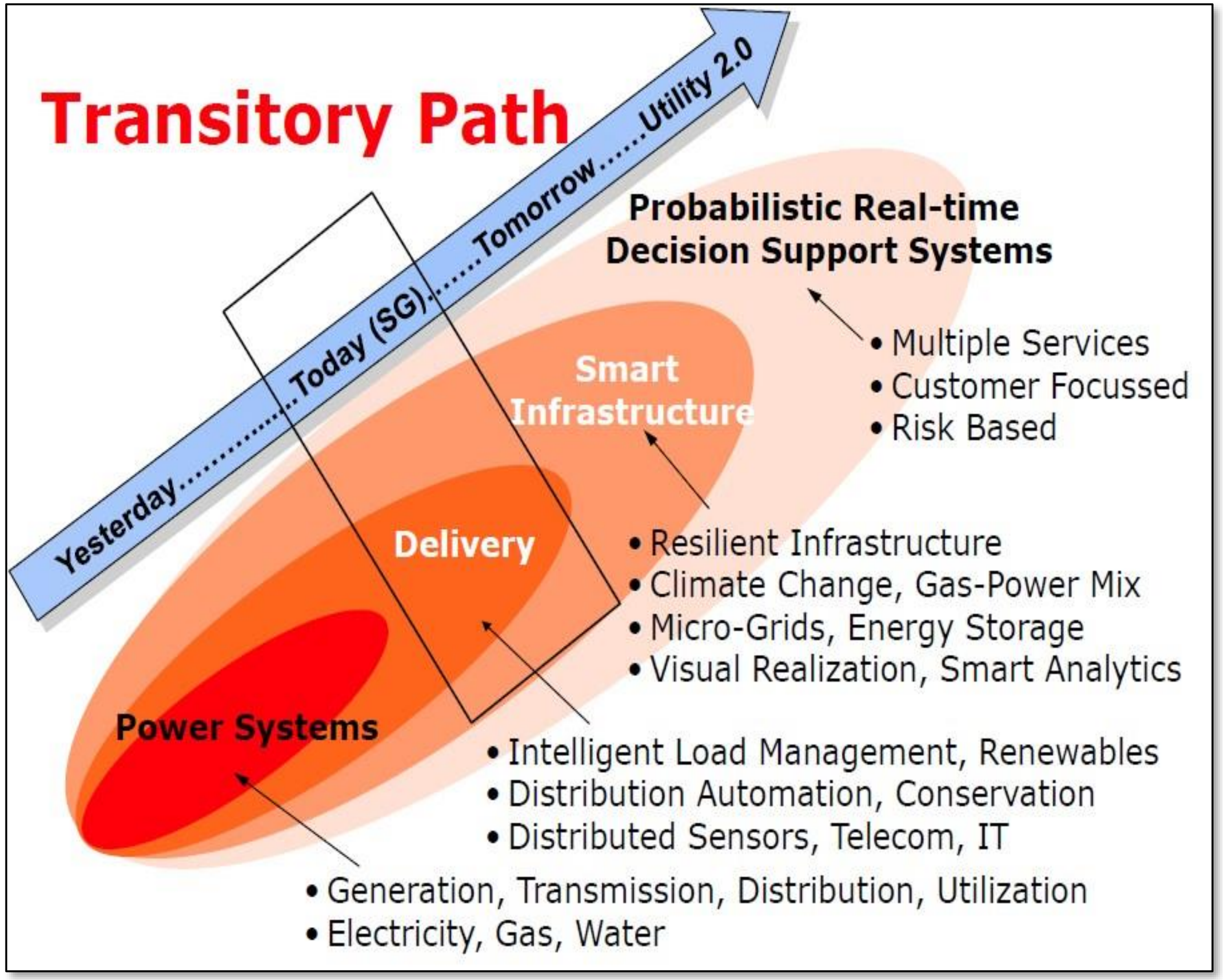
Maximum Asset Utilization
Reliability – Climate Resilience – Easy Restoration

Maximum Asset Interaction
Connectivity – Scalability – Automation

Challenges

Distribution Challenges

- **Radial system** – Dx not designed for multiple Gen
- **Rural Feeders** – "Long, weak, light" (Volt-Var issues)
- **Technical Limits** – Protections, capacity, reverse flow
- **Planning Tools** - : Load Flow / Dynamic / Transient
- **Tx Constraints** – Dx Back-feed, R.E not dispatched
- **Tx/Dx Code Overlap** : How does this work?
- **Solutions**
  - Technical limits
  - P&C - Impedance relays, anti-islanding, wireless T/Trip
  - VAR enhancements; Bi-directional Line-Regulators
  - Smart Grid solutions to further facilitate R.E

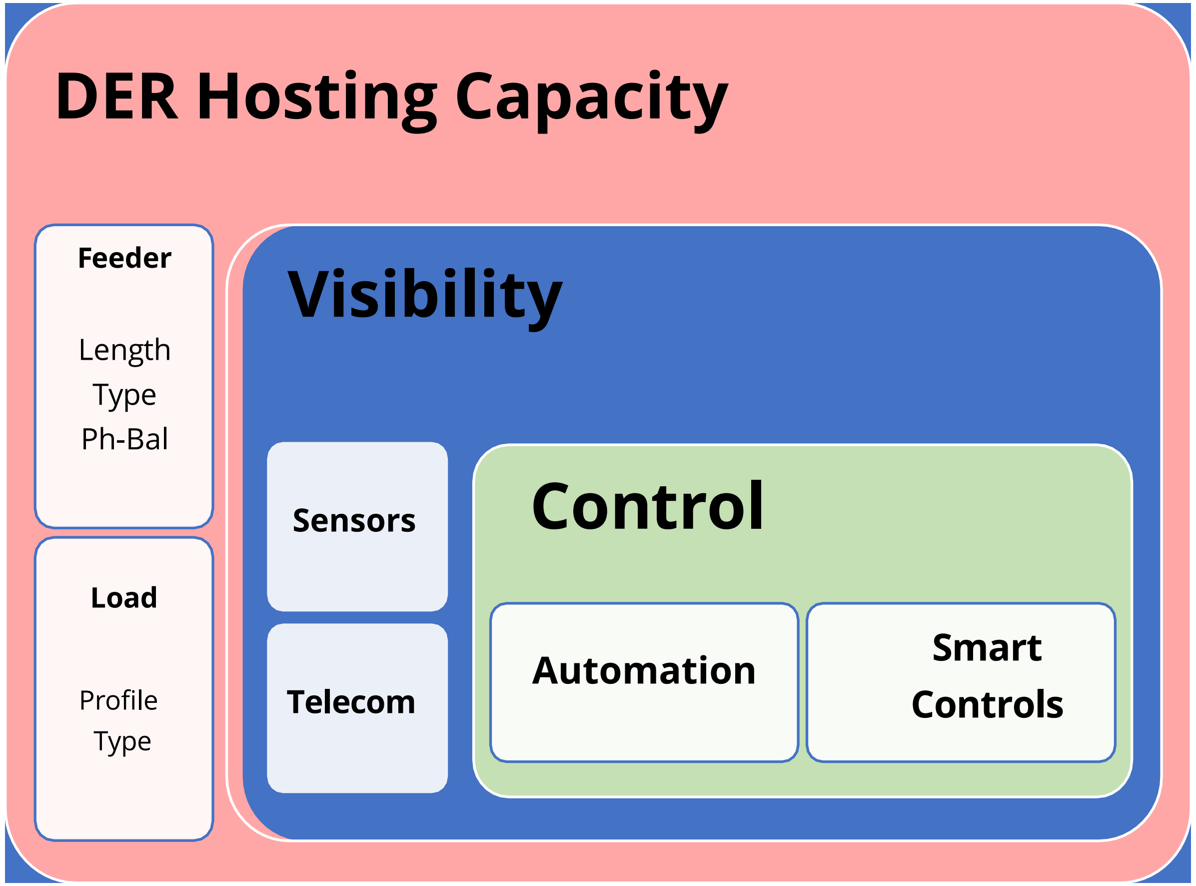


Moving Forward

Feature	Today's Dx Grid	Smart Grid
Components	Electromechanical	Digital
Power Flow	One-way	Two-way
Billing	Single Tariff	Multi Tariff, Time of Use
Generation	Centralized	Distributed
Network Topology	Hierarchical	Peer-Peer, Adhoc
Sensors	Few	Everywhere
Visibility	Blind (Dx)	Self Monitoring
Restoration	Manual	Self-healing
Reliability	Forced Outages	Adaptive, Islanding
Maintenance	Reactive	Pre-emptive
Testing	Manual / Local	Self-check / Remote
Load Management	Over-Provisioned	Demand Response
Control	Centralized	Distributed / Localized
Customer Relations	Broadcast	Peer-Peer, Portals

Planning & Operational Scenarios
DER Impact on Grid

1. DER Hosting Capacity Not Uniform across Feeders

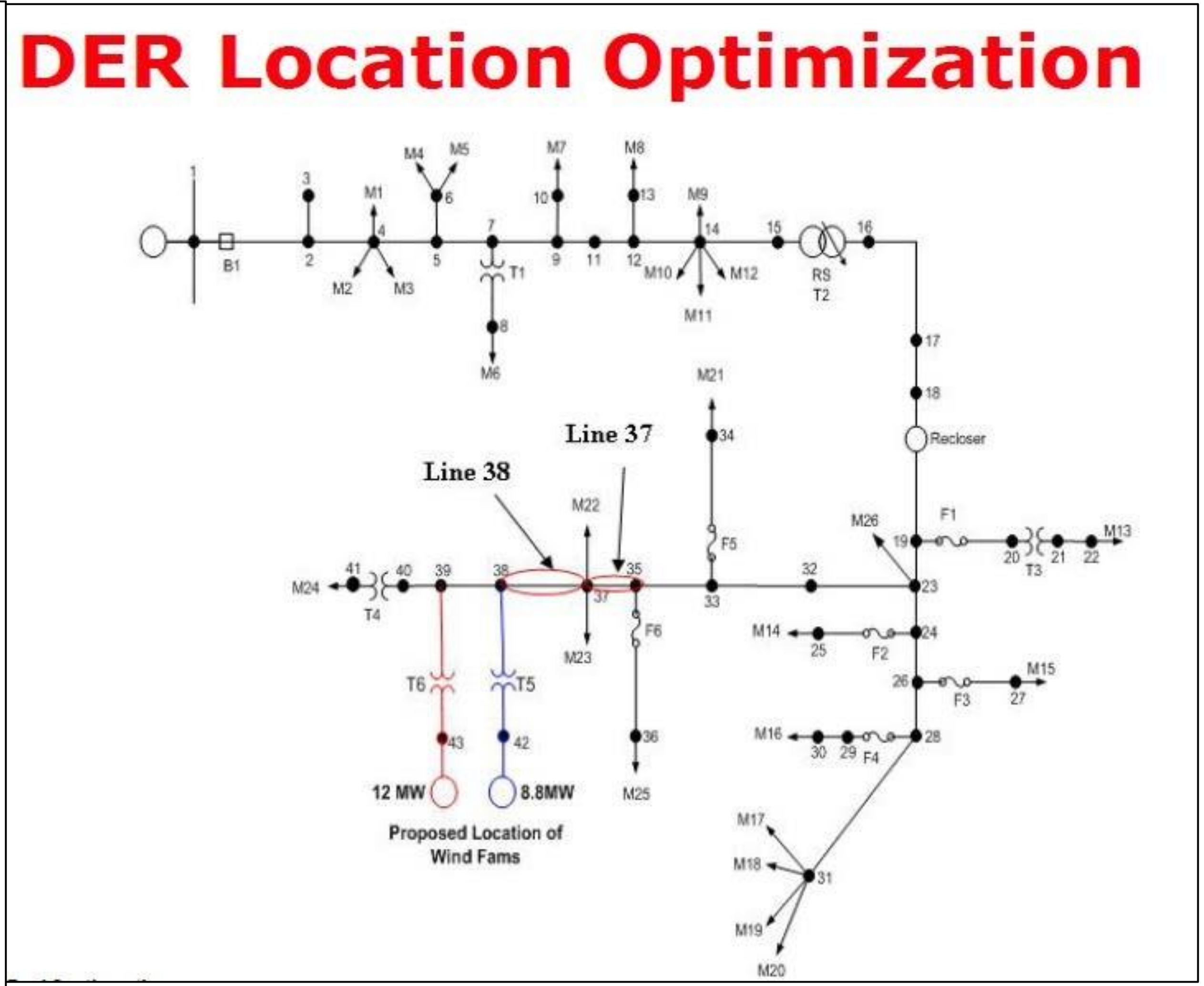


Strict Penetration Limit (Before and After)							
Feeder	Base Case			Max. Penetration w/ Upgrades			
	PV (%)	PV (MW)	Cost (k$)	PV(%)	PV(MW)	Cost(k$)	
1	29.7	1.0	0.0	167.9	5.9	60.2	
2	29.7	1.5	0.0	197.1	10.4	32.5	
3	53.6	2.2	67.9	264.7	10.9	149.3	
4	34.9	1.2	0.0	134.5	4.8	22.0	
5	43.7	2.0	67.3	193.7	8.7	96.8	
6	38.9	2.6	0.0	219.6	14.5	78.5	
7	36.9	1.9	0.0	92.7	4.7	131.4	
8	23.8	1.4	0.0	129.2	7.6	2.0	
9	1.9	0.1	0.0	161.3	8.1	21.0	
10	12.8	0.3	0.0	62.9	1.6	27.5	
11	39.0	2.0	37.2	61.0	3.1	178.3	
12	8.0	0.7	37.2	11.9	1.0	118.7	
13	2.9	0.2	0.0	104.9	5.8	150.2	
14	15.9	1.5	0.0	18.0	1.7	33.0	← Minimum
15	20.0	1.6	0.0	76.0	6.2	21.5	
16	5.9	0.5	59.7	63.9	5.2	167.1	
17	17.0	2.0	0.0	104.9	12.1	31.0	
18	42.9	2.8	0.0	336.7	22.2	25.0	← Maximum
19	25.9	1.6	74.0	67.8	4.1	80.0	
20	44.9	2.7	0.0	184.6	11.0	2.5	
AVERAGE	**26.4**	**1.5**	**17.2**	**132.7**	**7.5**	**71.4**	

Notes:
- The above does not include battery deployment
- The above feeders represent different voltage levels

2. Not All DER Locations Optimal for Grid

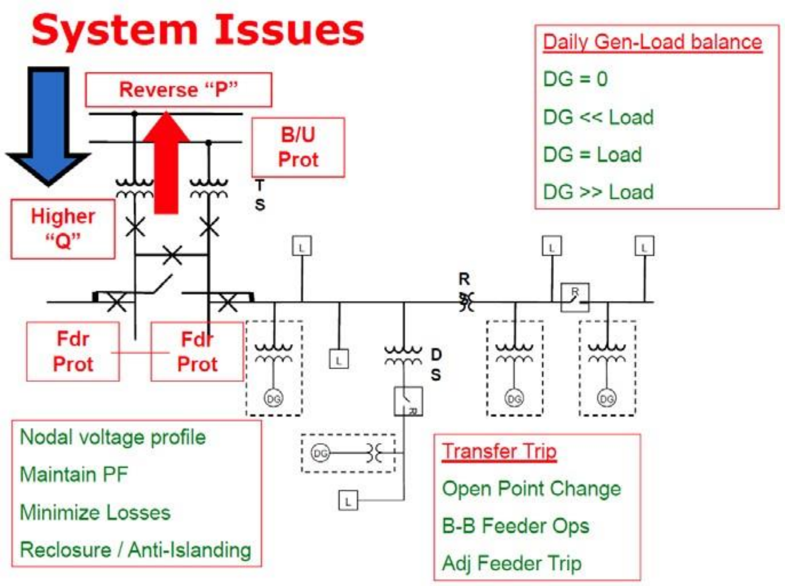
- Create potential power congestion
- Increase line losses due to back feed
- Create voltage management issues
- Rob additional potential DER capacity
- Require additional grid investments

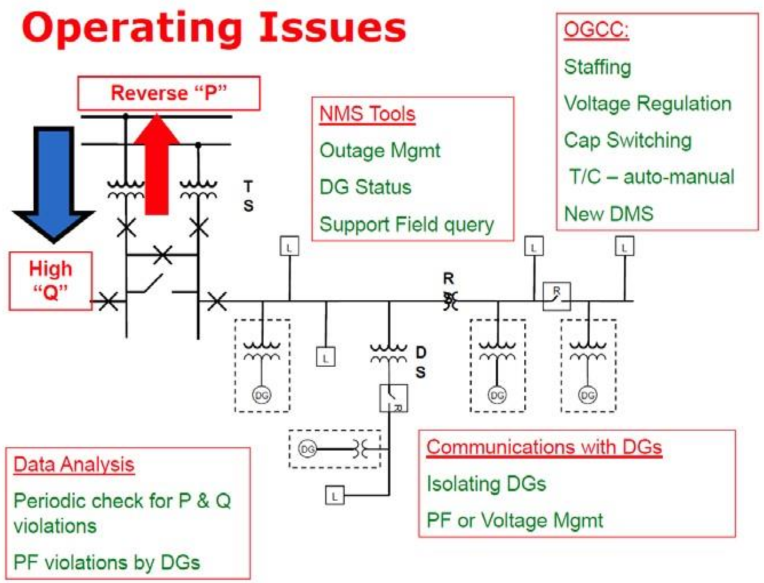


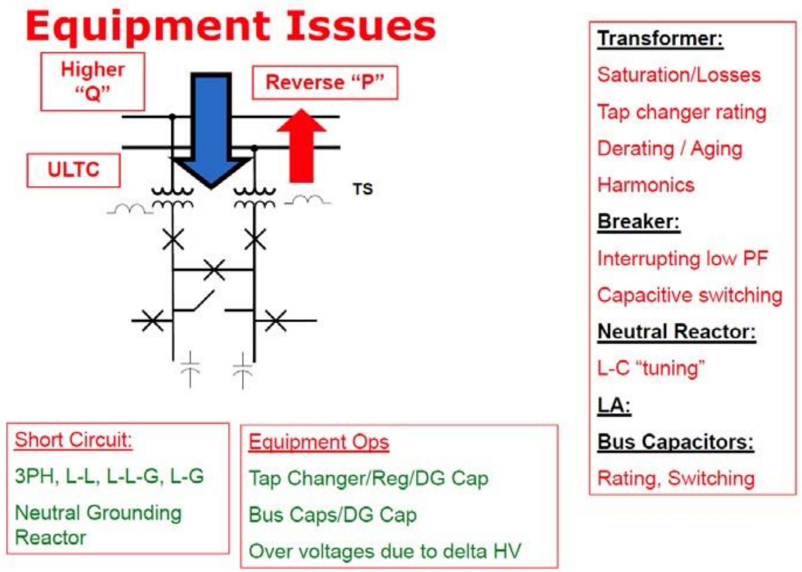
3. Managing Bidirectional Real and Reactive Power

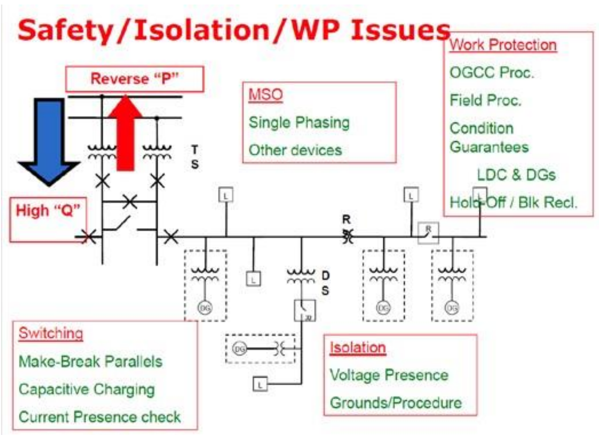
Real Power

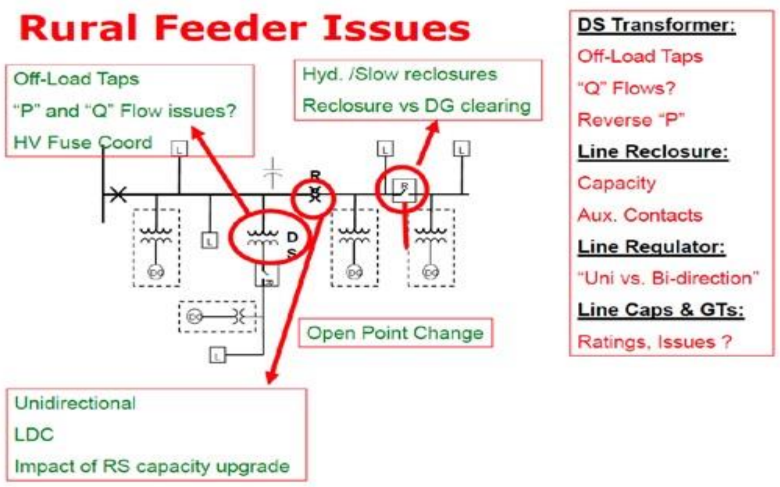
Reactive Power





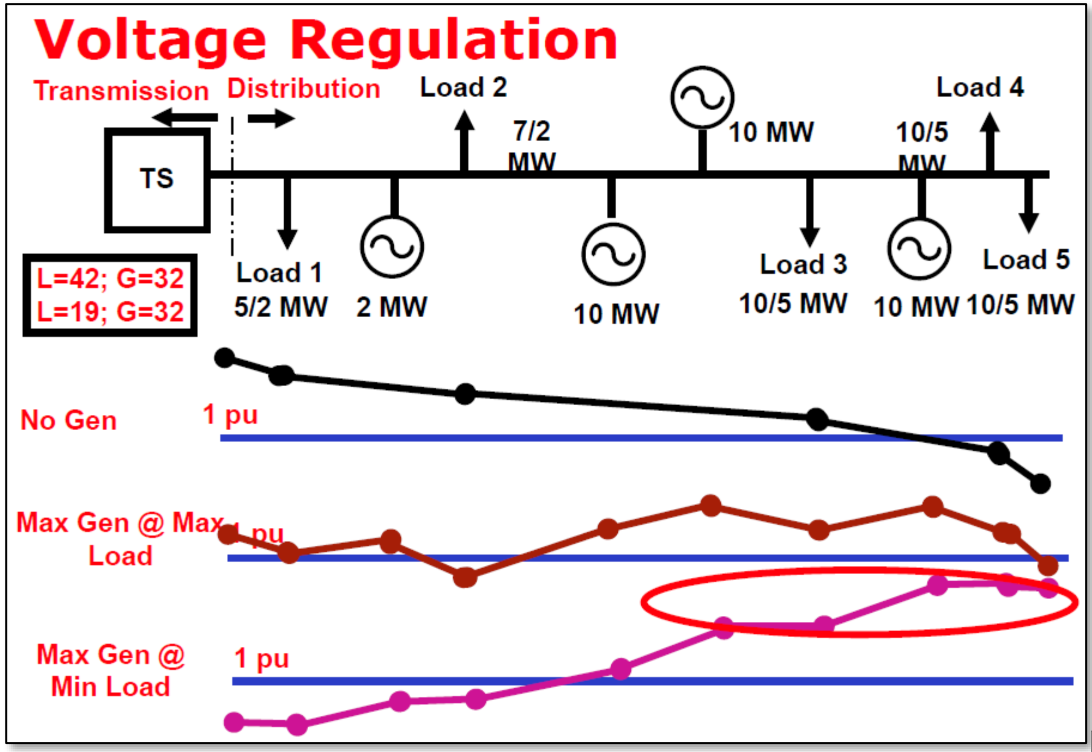


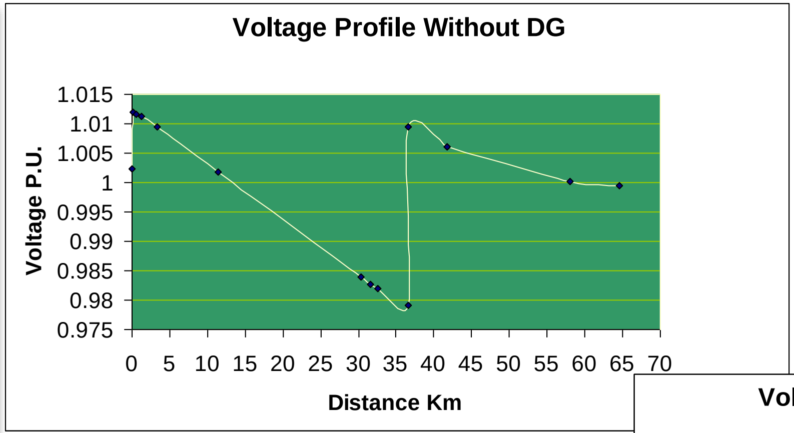


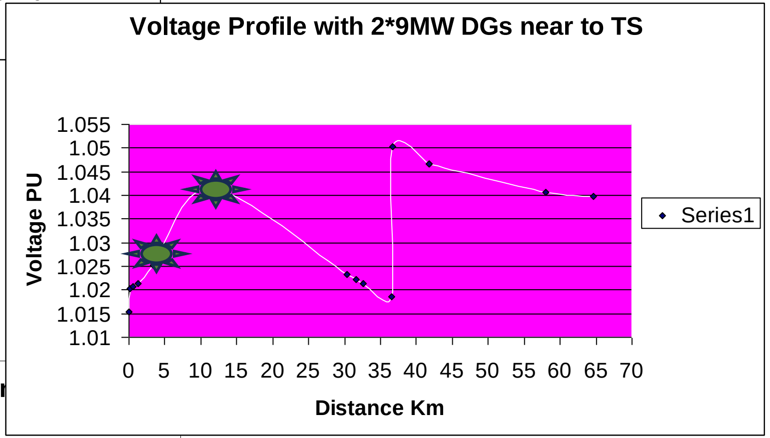


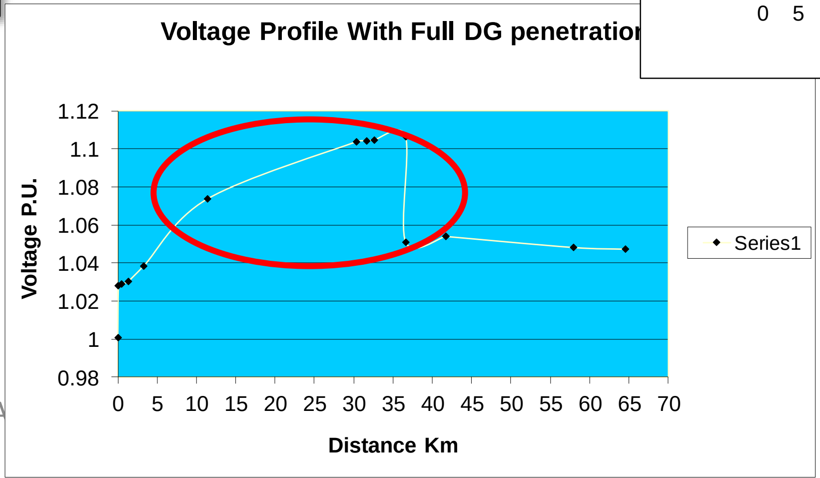
Bidirectional P & Q flows due to DER output and Load

4. Managing Voltage Regulation Due to VRE Generation



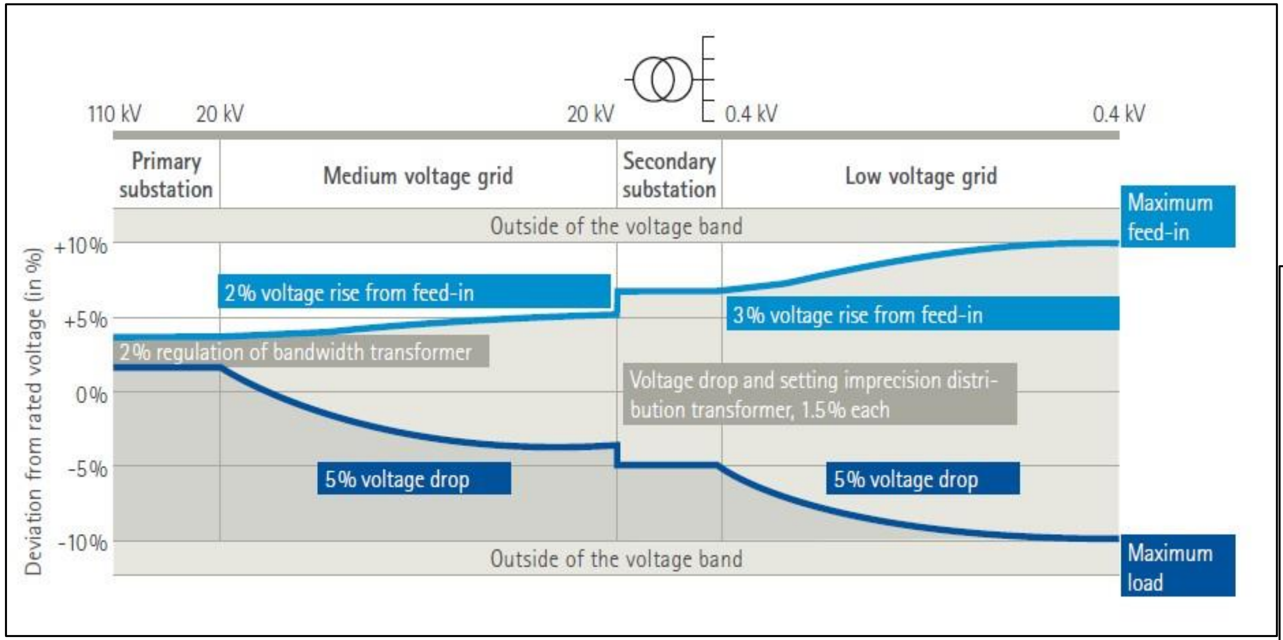


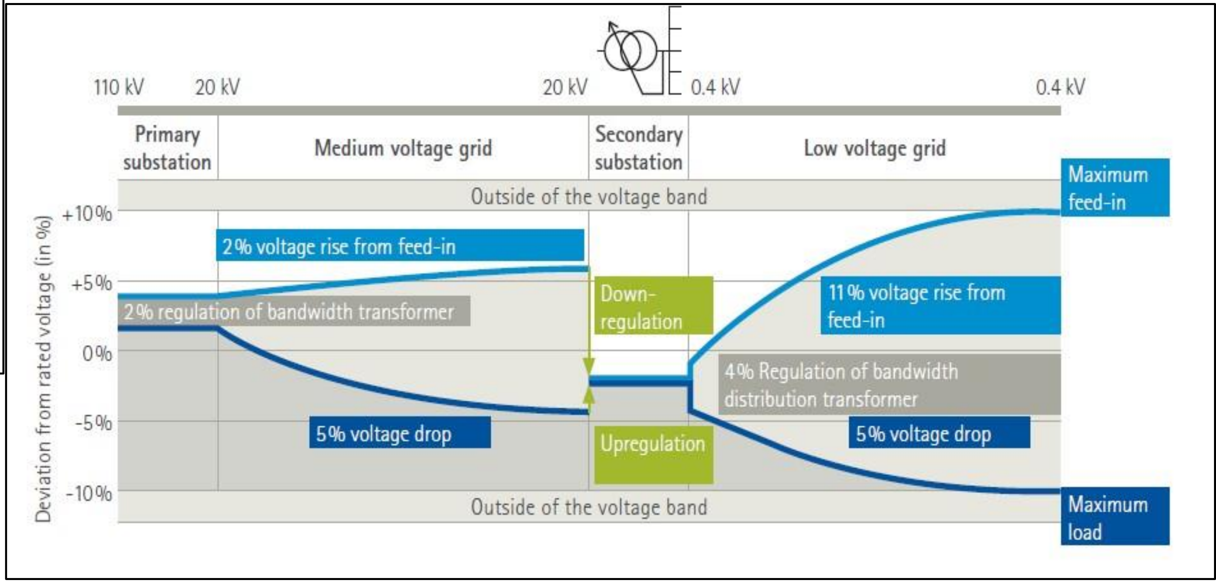




DER location, its power output and load points are all interactive on nodal voltages

5. Automatic Tap Changer on MV and LV Transformers to Control Voltage

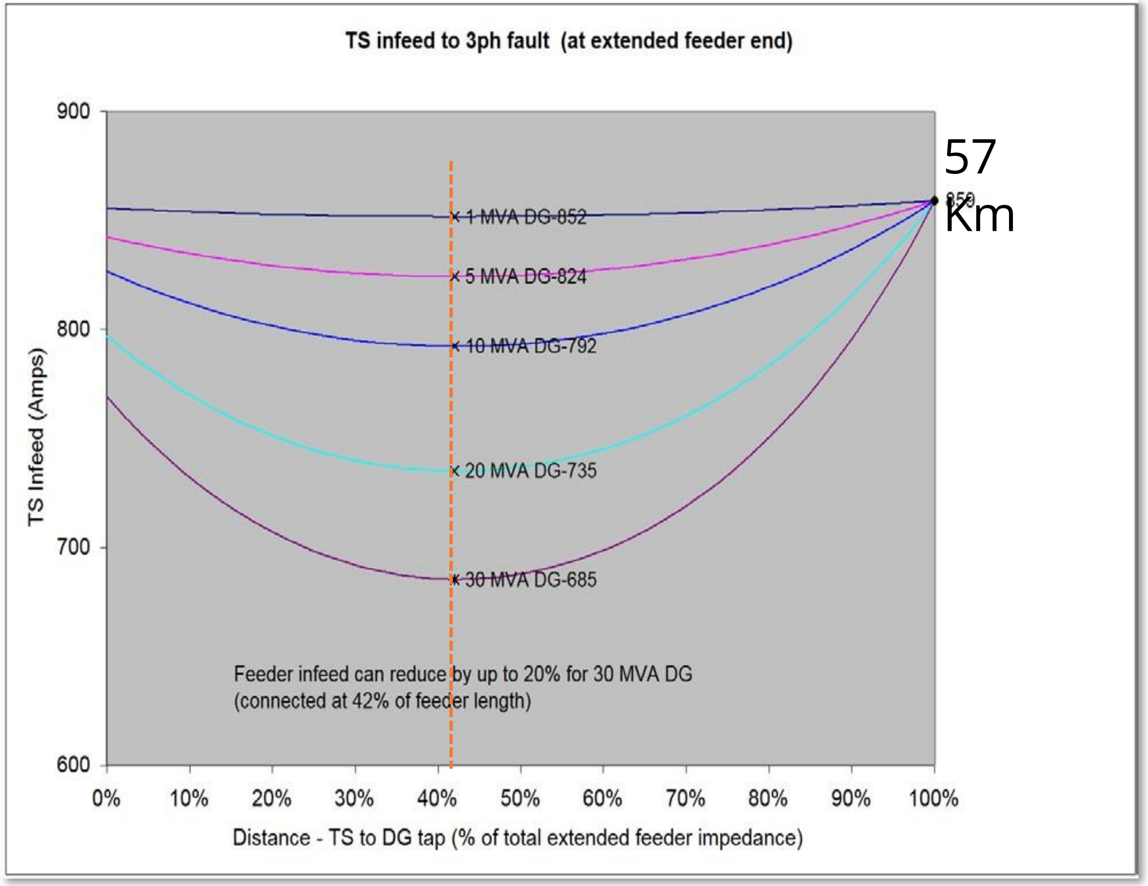




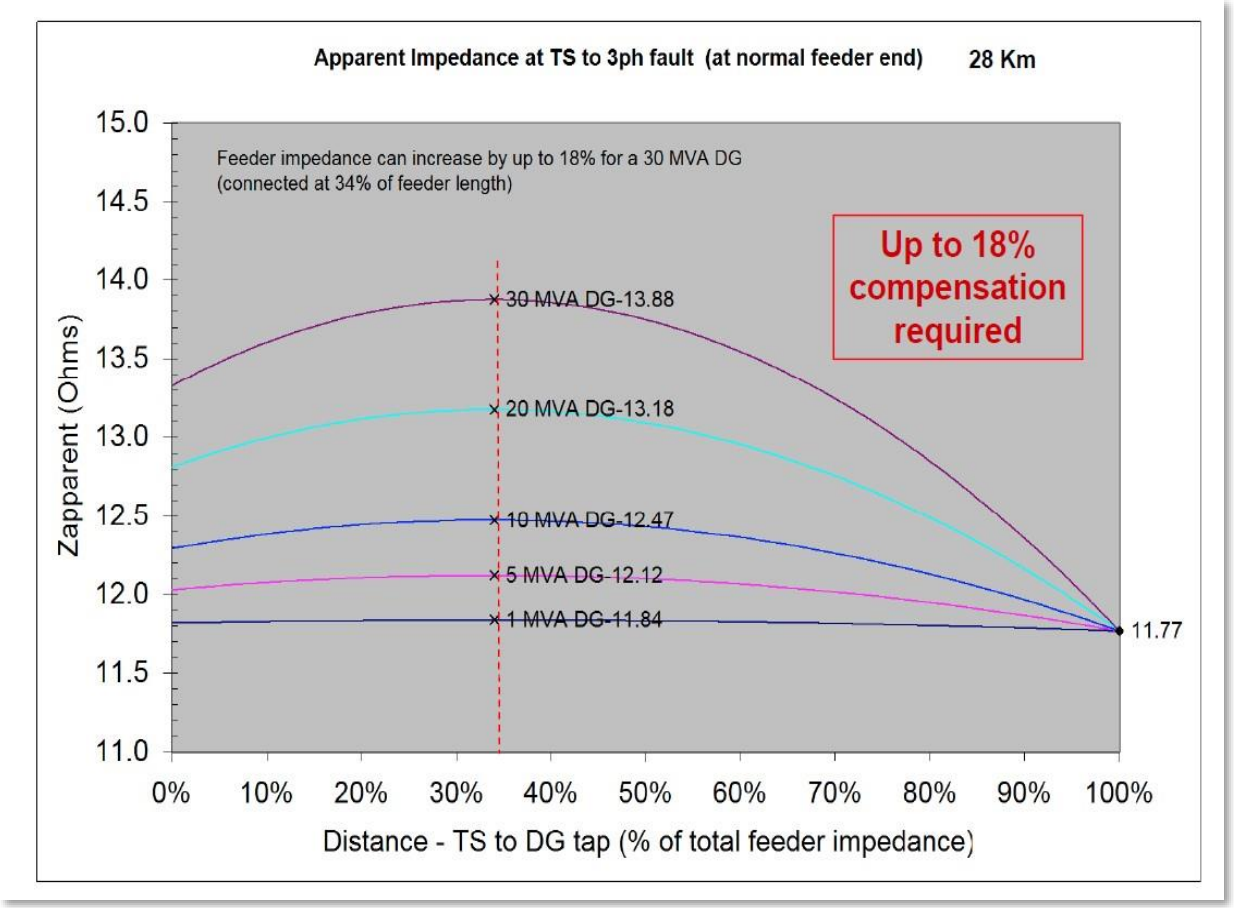
- Many Dx transformers
- Increased investment on upgrades
- Increased tap-changer operations
- Tap changer wear and tear

6. Impedance Feeder Protections Enable More DER

Feeder Protection – Short Circuit In-Feed



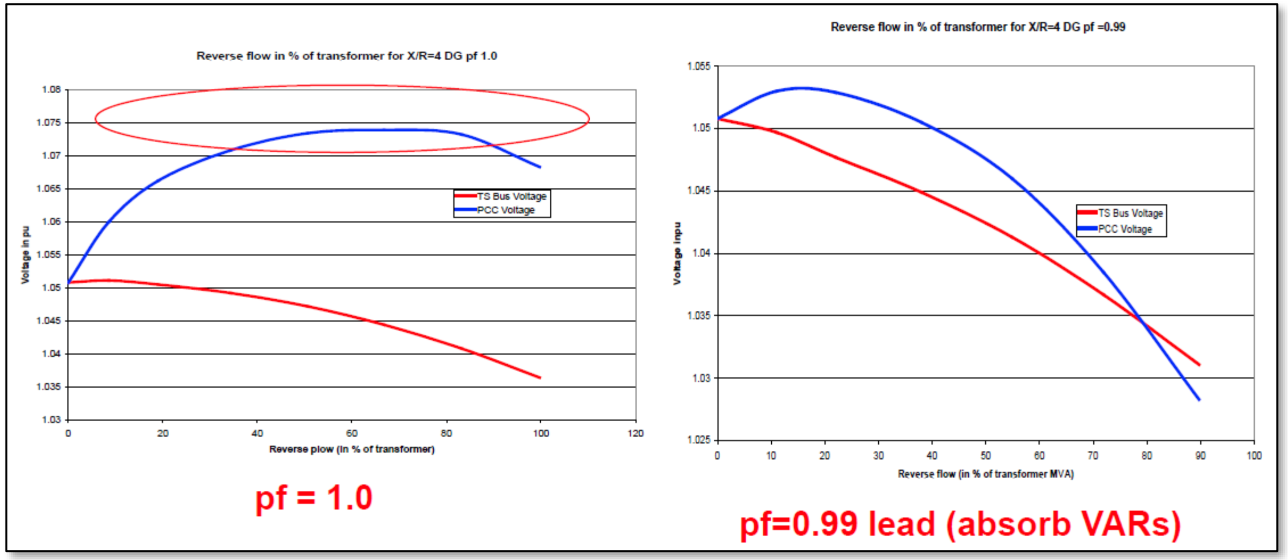
Feeder Protection – Apparent Impedance



- **Overcurrent protection not suitable for some DER locations.**
- **Even impedance relays need compensation due to DER short-circuit infeed**

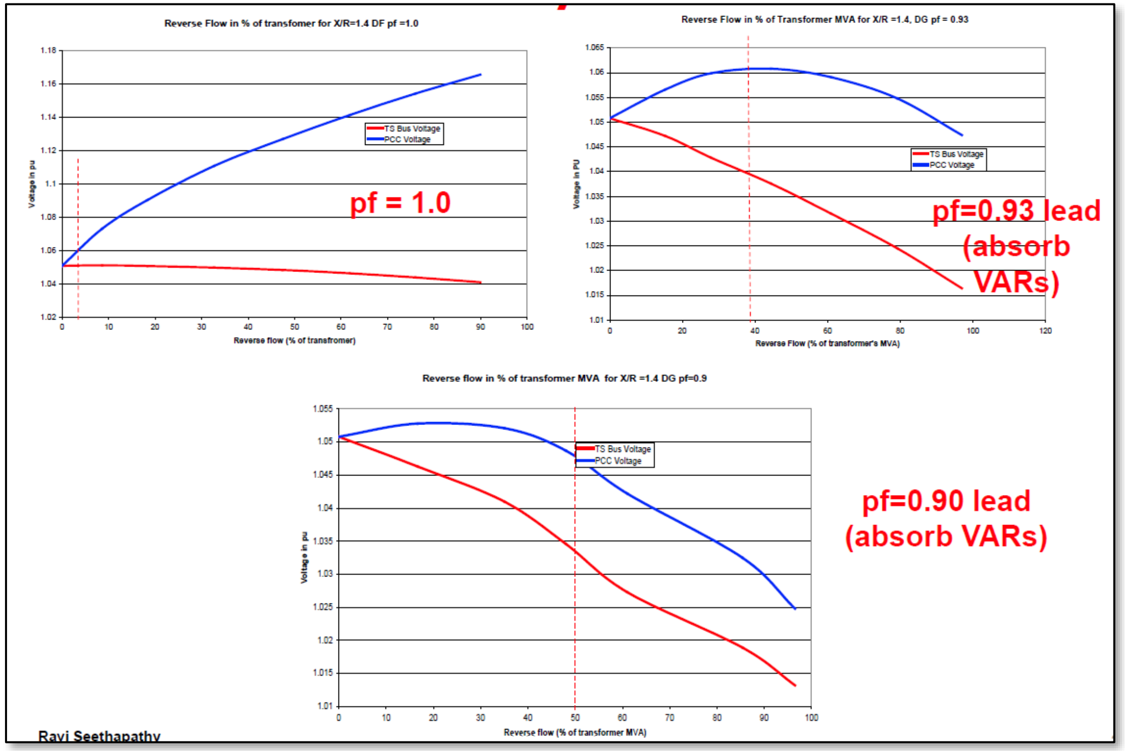
7. Power Factor Control Essential for Feeder (X/R)

Reverse Power Flow – X/R = 4.0 (Strong Feeder)



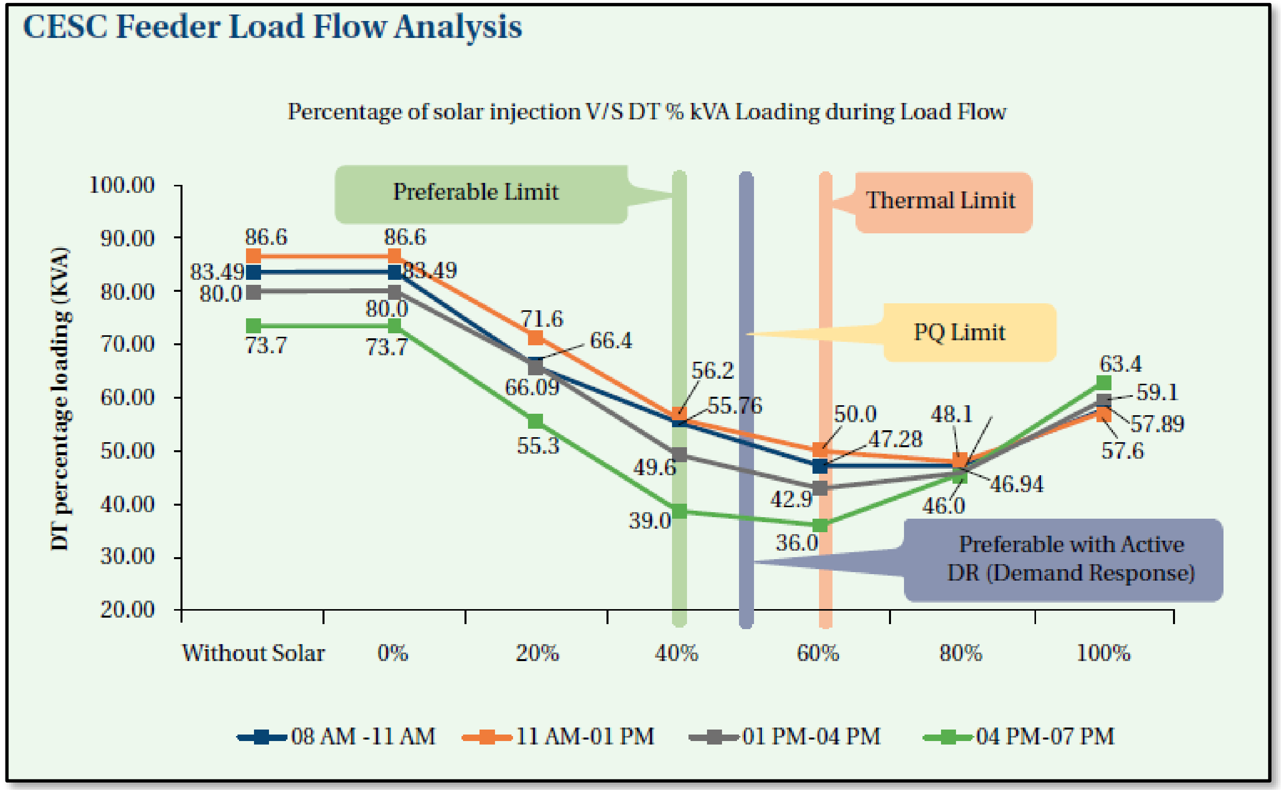
Very Sensitive to Power Factor Variation
Voltage will bounce around

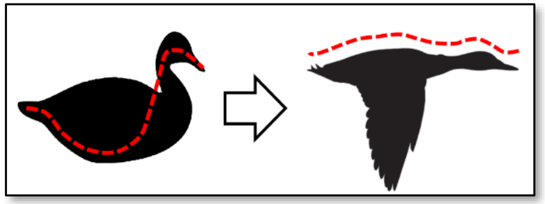
Reverse Power Flow – X/R = 1.4 (Weak Feeder)

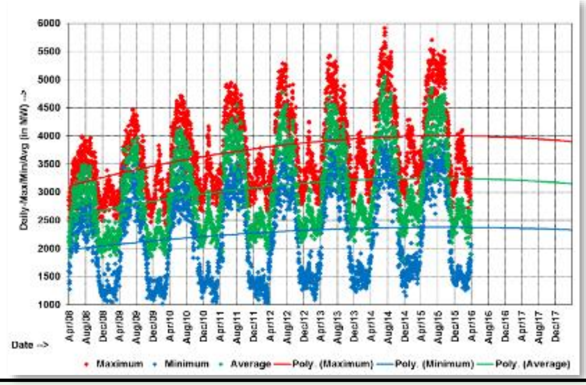


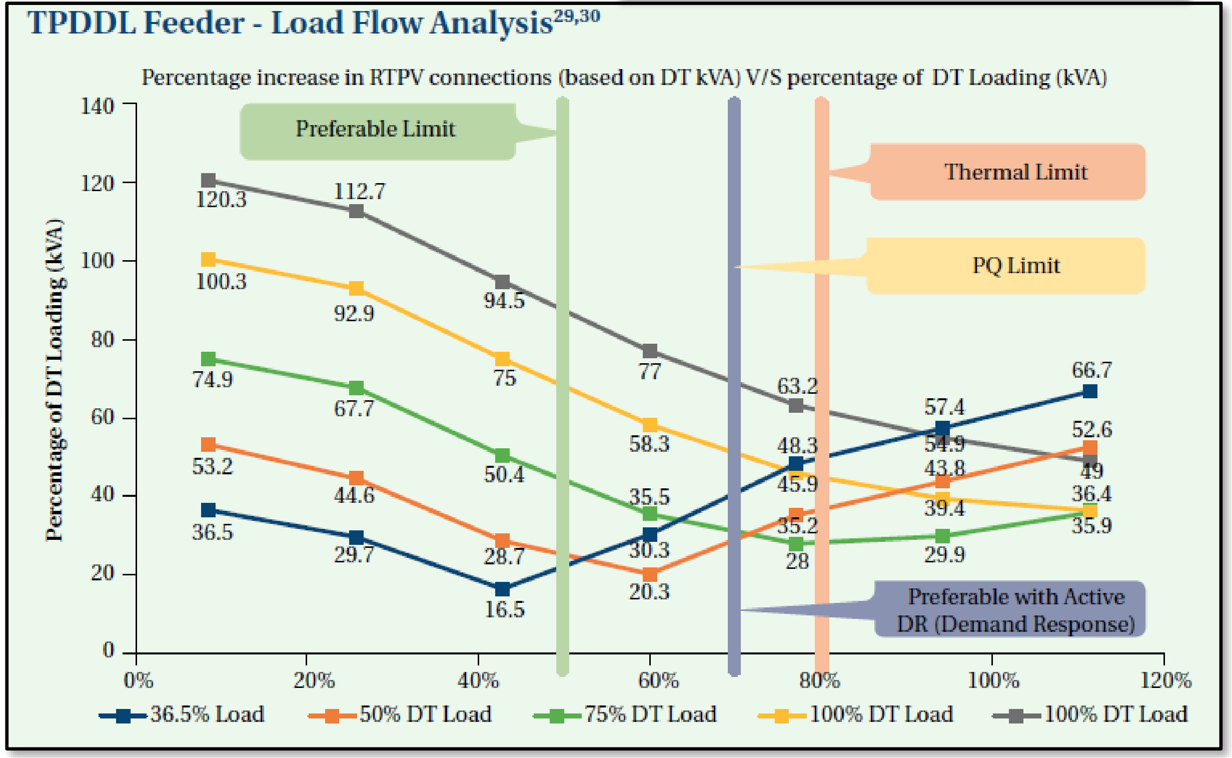
Higher DER Penetration requires wide Power Factor Control

8a. LT Solar PV Limits – Heavy Urban Load



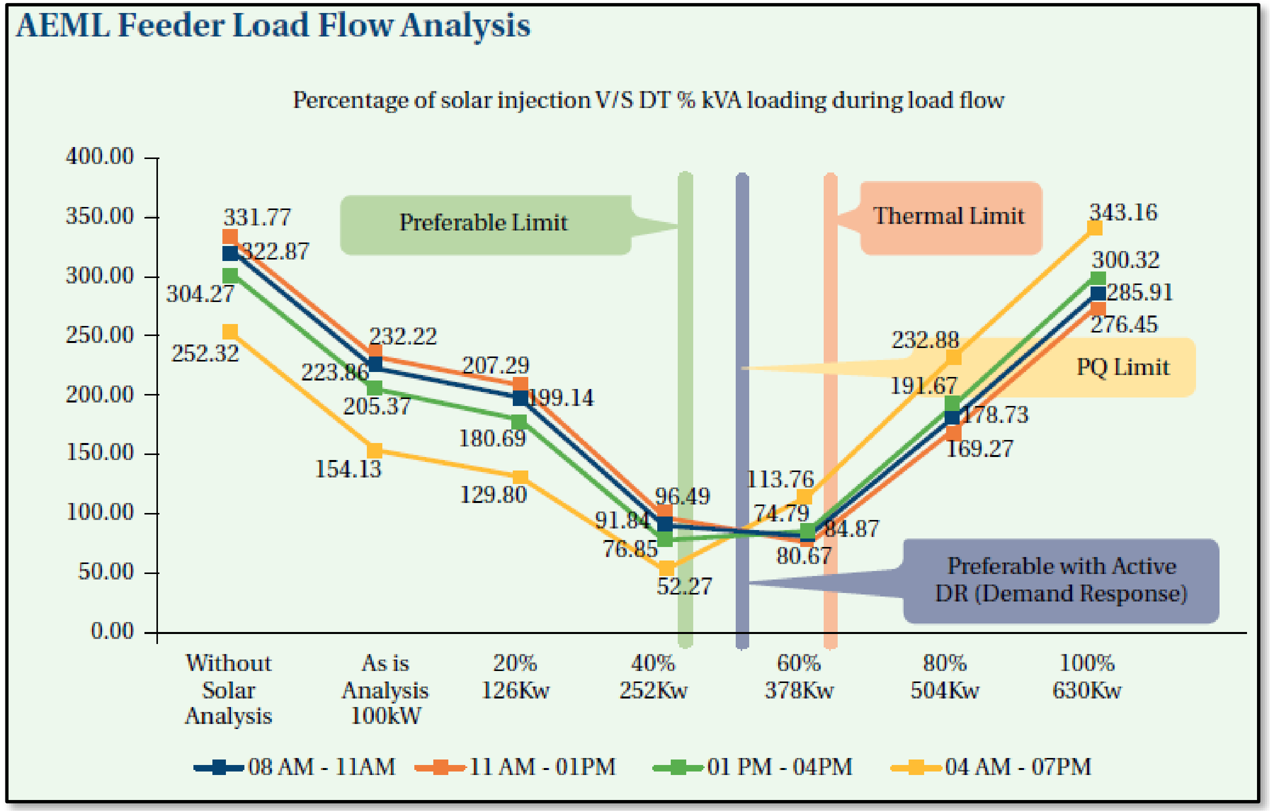


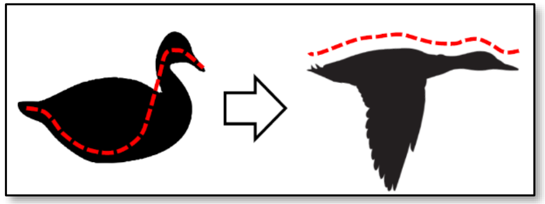


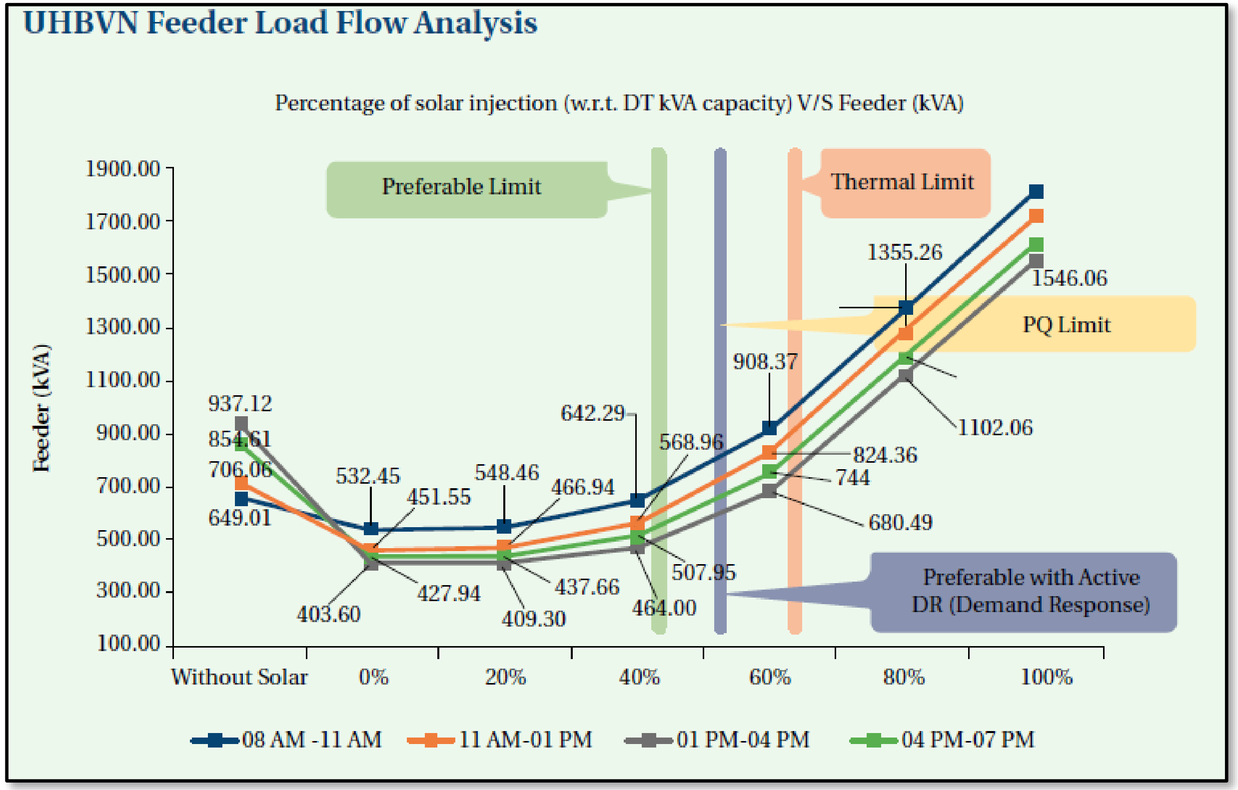


- **Duck Curve Needs Flattening**
- **High seasonal variation difficult to manage**
- **Solar PV limit 40-50% of DT → 70% with active DR**
- **Solar PV back feed should be limited to 60% of DT**

8b. LT Solar PV Limits – Light Rural Load

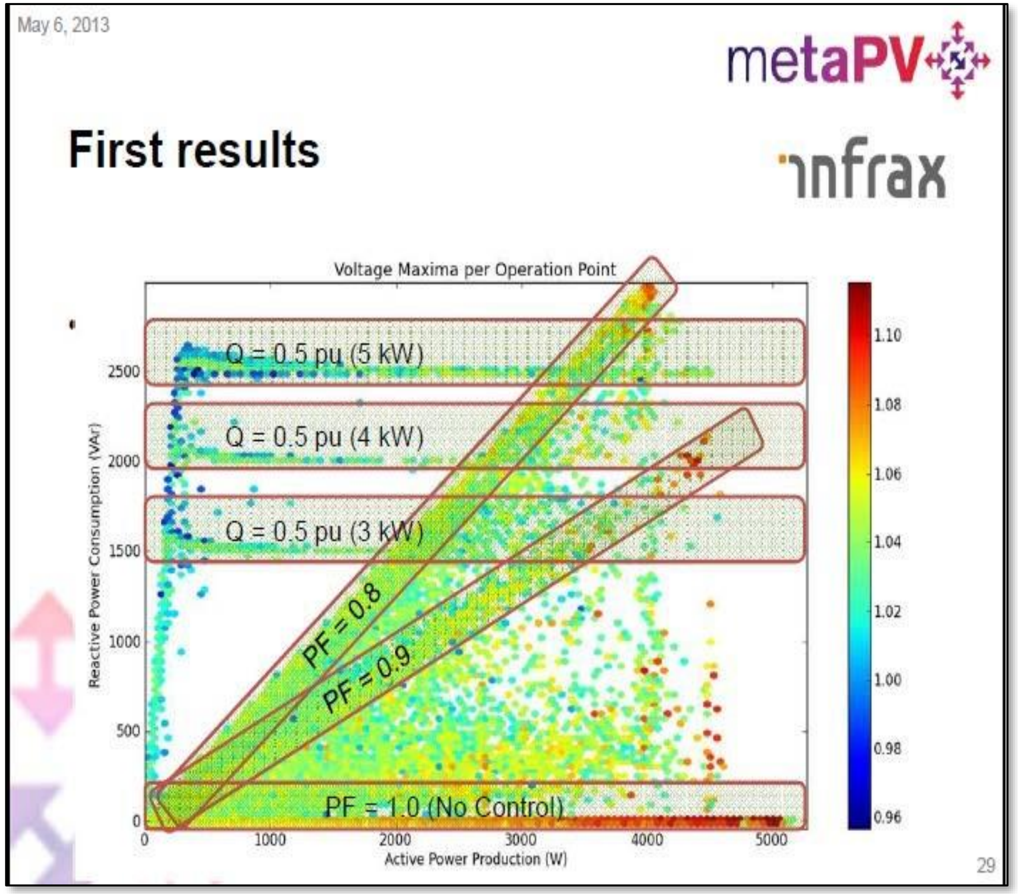


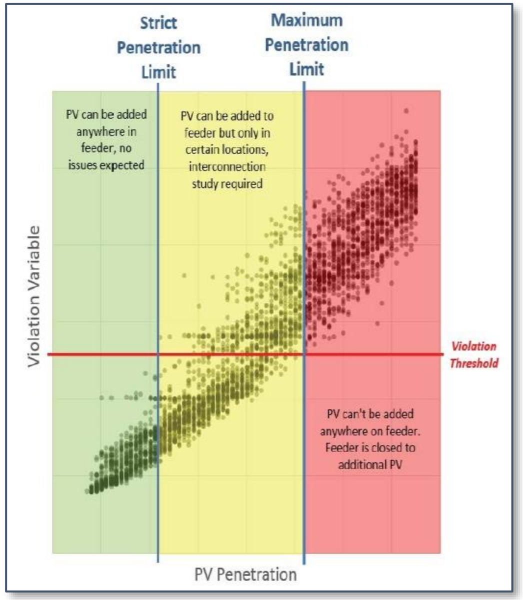


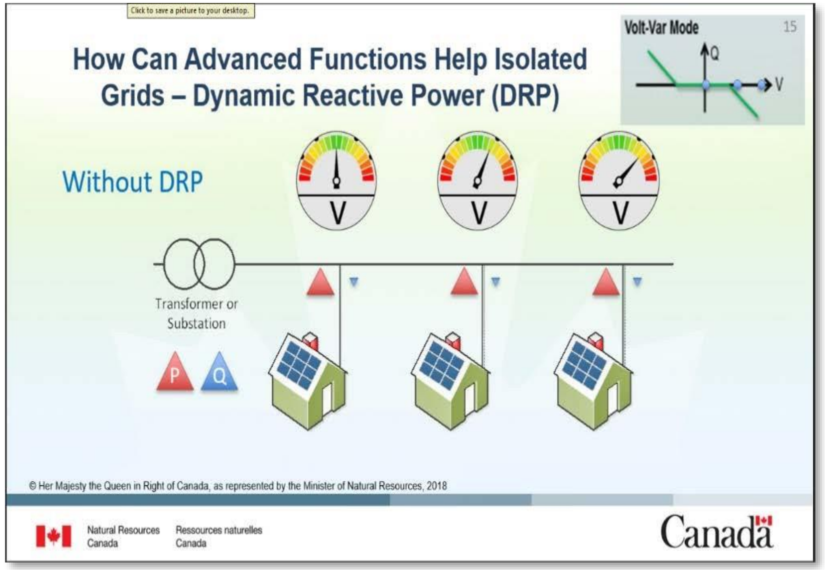


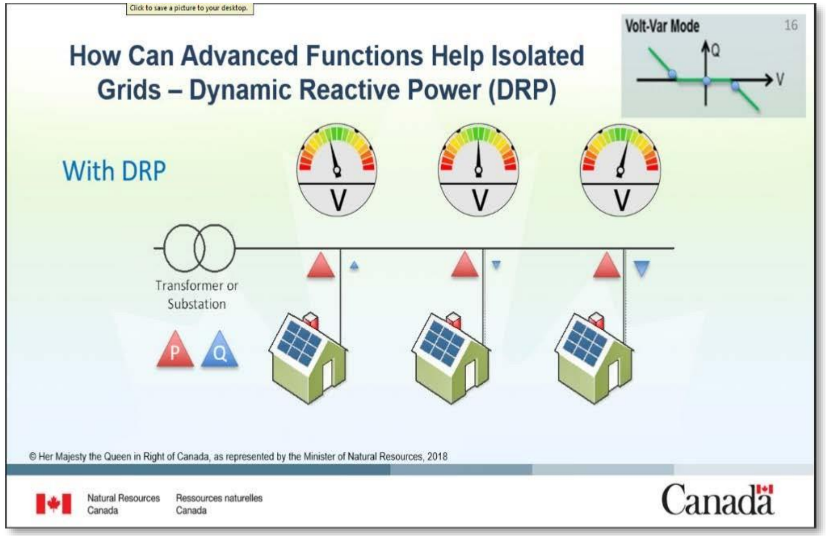
- **Duck Curve Needs Flattening**
- **Lightly loaded feeders need lower PV limits**
- **Solar PV limit 40% of DT → 50-60% with active DR**
- **Solar PV back feed should be limited to 50% of DT**

9. Smart Inverters Enable More Renewables



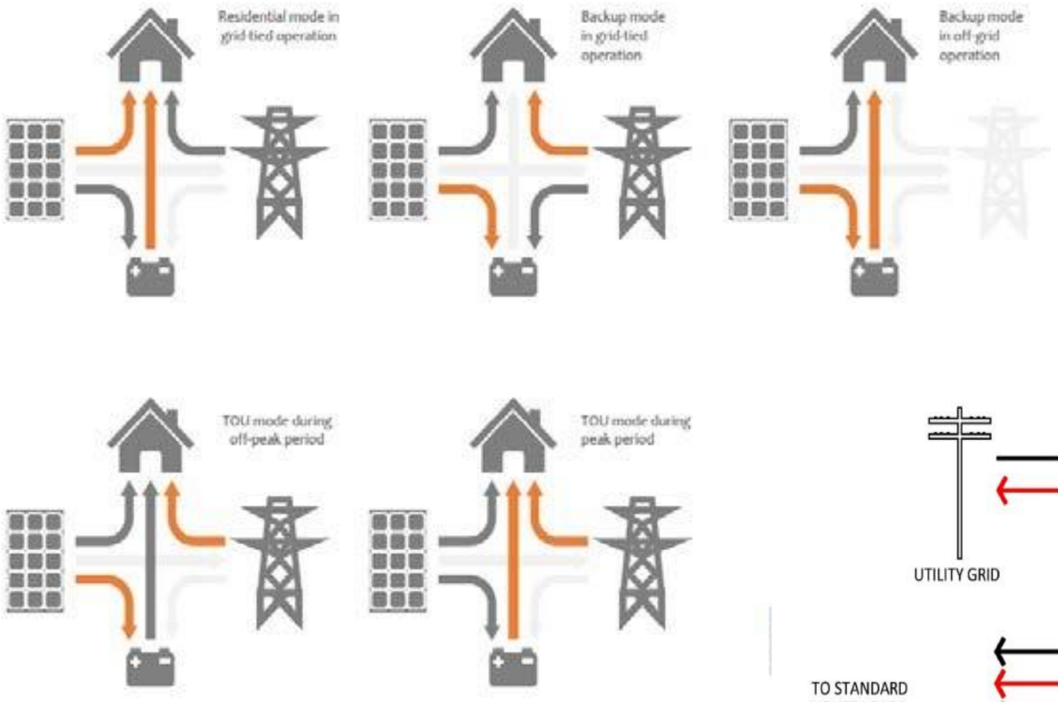






- **VAR Management is key to maximizing PV**
- **Smart Inverter must inject VARs when needed**

10. Hybrid Smart Inverters Enable Customer Choice

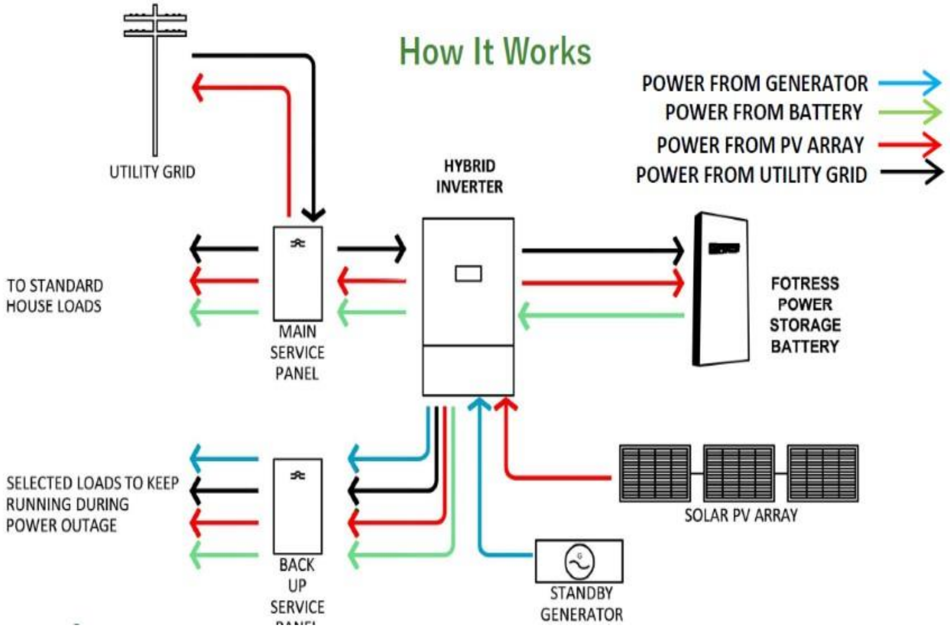


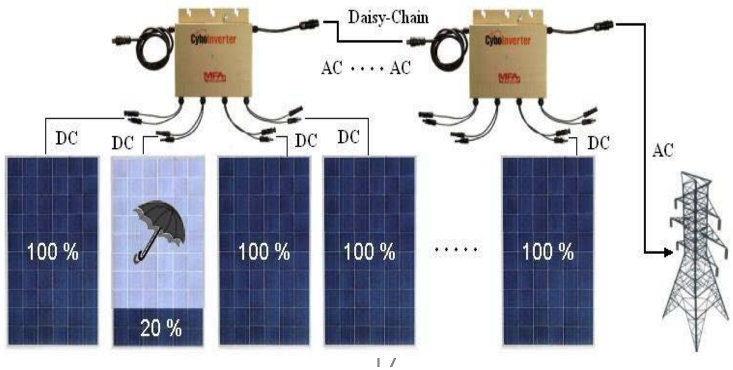
Self generation displaces load growth

- Dx capex deferral on upgrades
- Help utility in peak management

Hybrid inverters enable:

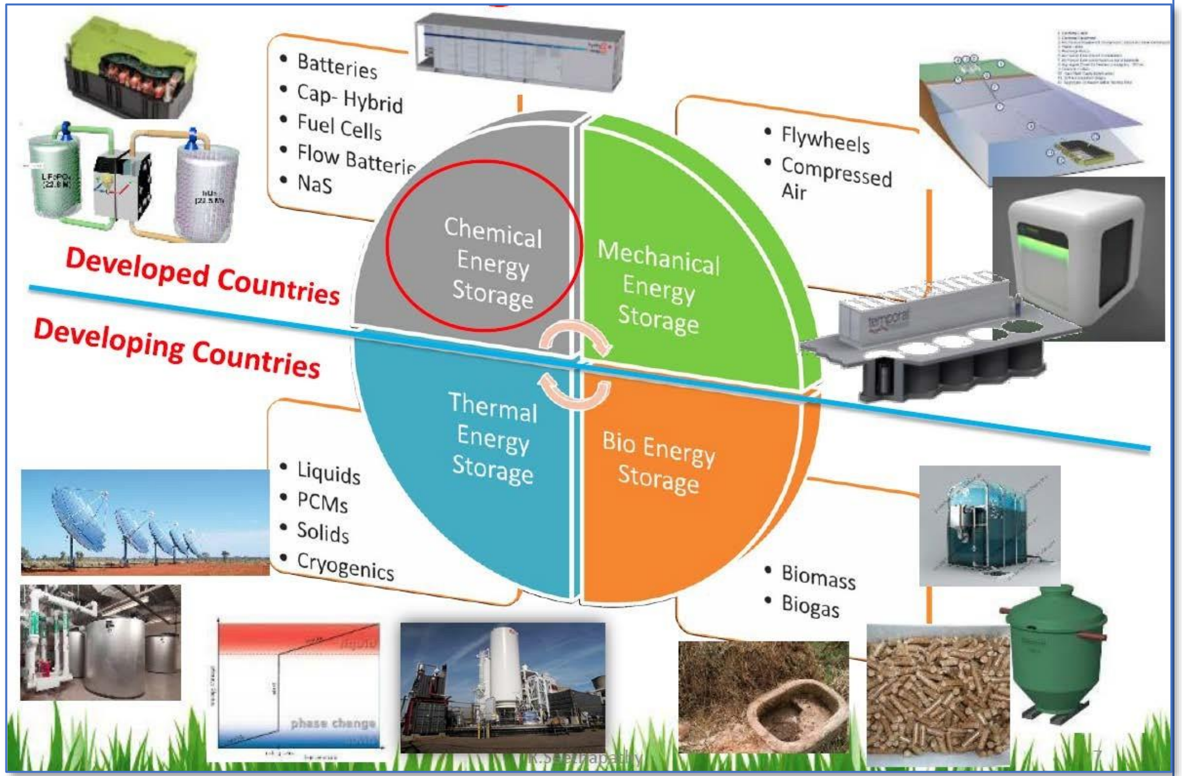
- PV, Storage, Backup Gen.
- Var control
- EV charging

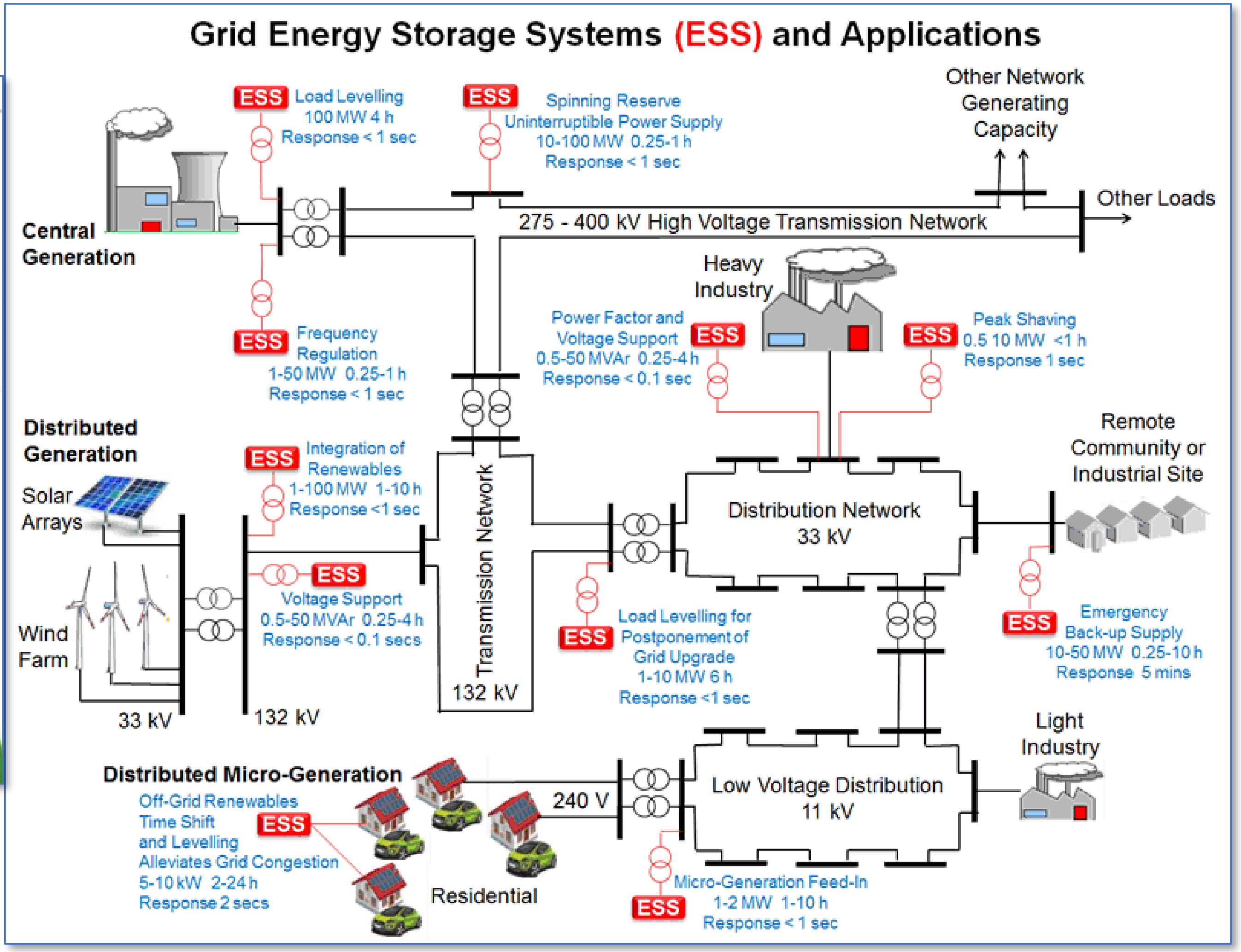




11. Energy Storage Helps Everywhere

Energy Storage Applications





- **ESS is currently expensive**
- **Allows a non-wires alternative**
- **Defers Dx near-term capex expenditure**

Prosumer Growth on Utility’s Technical & Financial Operations

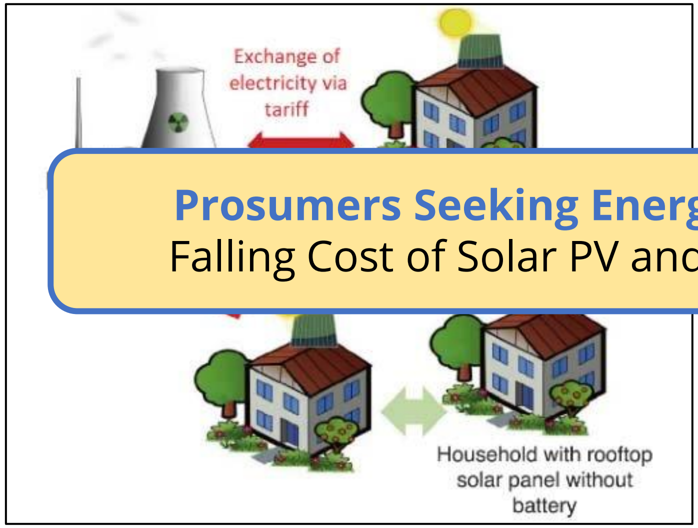
Prosumers Will Grow – Do Not Fight the Trend
RE Affordability and Govt incentives

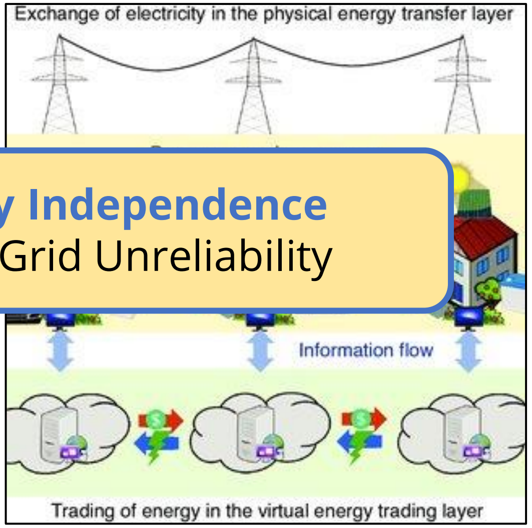
Technical

Upgrade balancing tools to offer better reliability
Add Flexible Capacity (VPP, DR, CDM, ESS)
Set up DERMS Platform
Support Retail Energy Trading
Offer tools to reduce consumer bills

Financial

Reverse revenue loss with non-regulated services
Offer BTM competitive services (PV, ESS, Inverters)
Monetize Prosumer capex (loans, supply chain)
Engage with customers towards their sustainability





Prosumers Seeking Energy Independence
Falling Cost of Solar PV and Grid Unreliability

Key Takeaways / Recommendations

- No “One Size Fits All” solution to DER additions
- High Penetration of DERs > 40% requires careful grid planning studies
- Long, “weak”, rural feeders require more capital upgrades to add DERs
- The “network value” of a DER is based on its size and location
  - Feeder-end DERs rob other DER hosting capacity
  - May decrease network power flows and increase line losses
- Var management is critical for power quality
- Limit DER reverse power flows to 60% of upstream transformer

Thank You

Any questions?

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