Challenges Integrating DER

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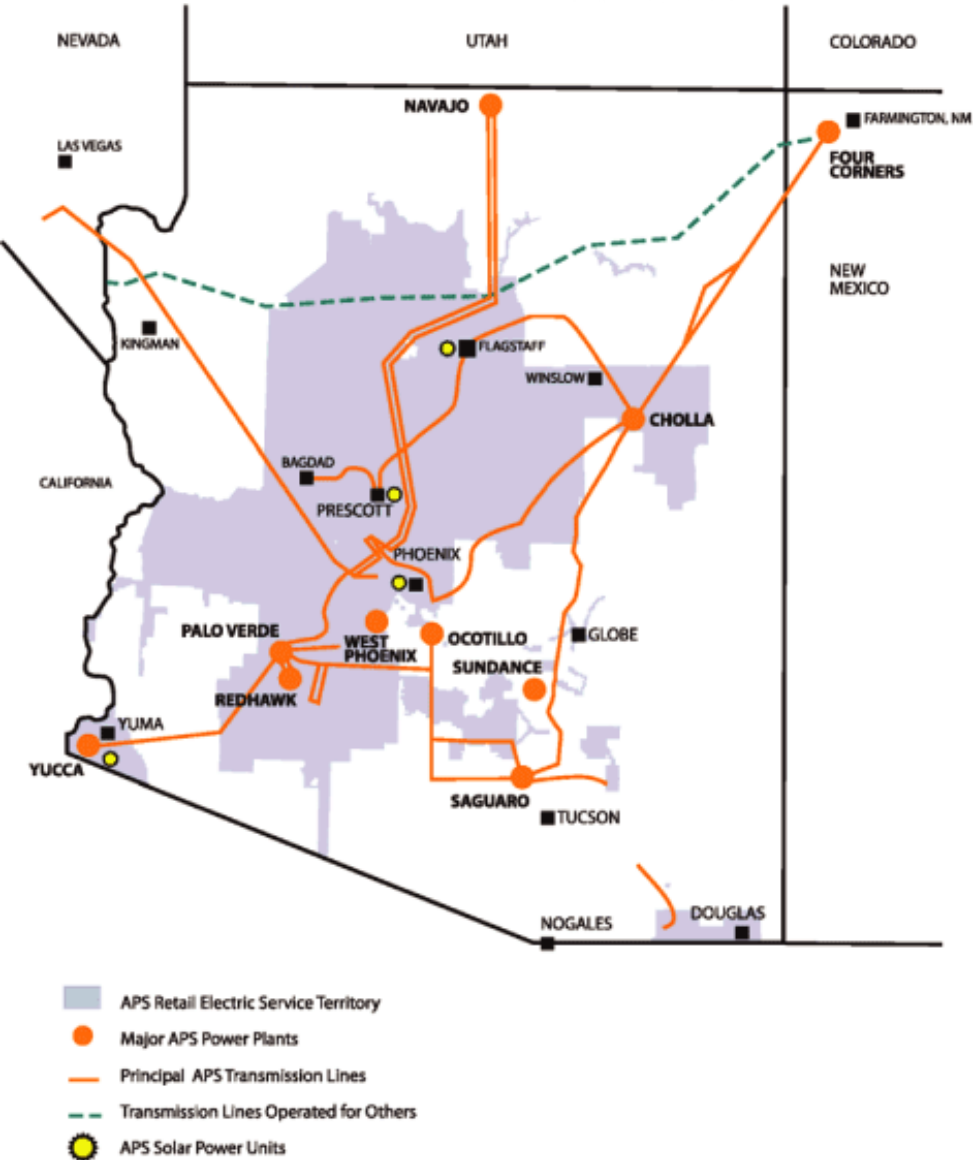
APS System Overview



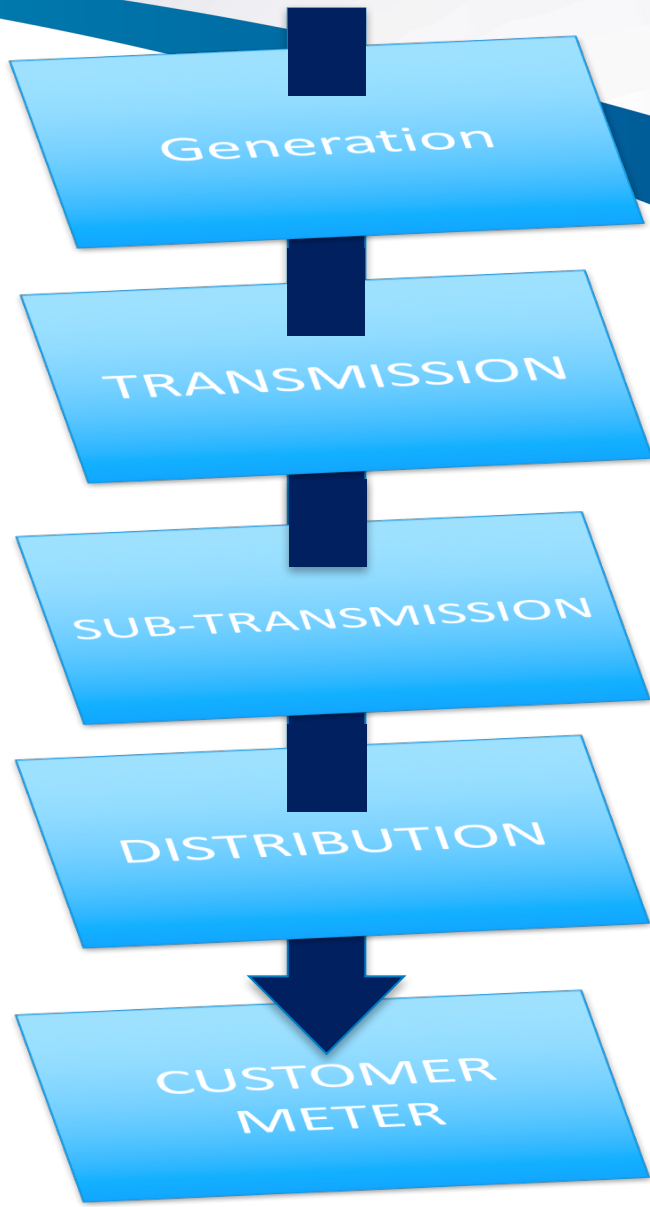
ITEM	STATISTICS
Counties	1
Square miles	34,646
Customers	1.2 million
Substations	43
Distribution line miles	29,148
Transmission line miles	6,068
Generation units	65
Peak demand	7,350 MW (06/20/2017)
Previous peak	7,236 MW (07/21/2006)

Considering Utility Models

- Deregulated market entity
  - T&D companies
  - Wholesale generation market
  - ISO/RTO for transmission, balancing and market clearing
- Vertically integrated utility
  - Generation, T&D, customer interconnection
- 'Wires' companies
  - T&D

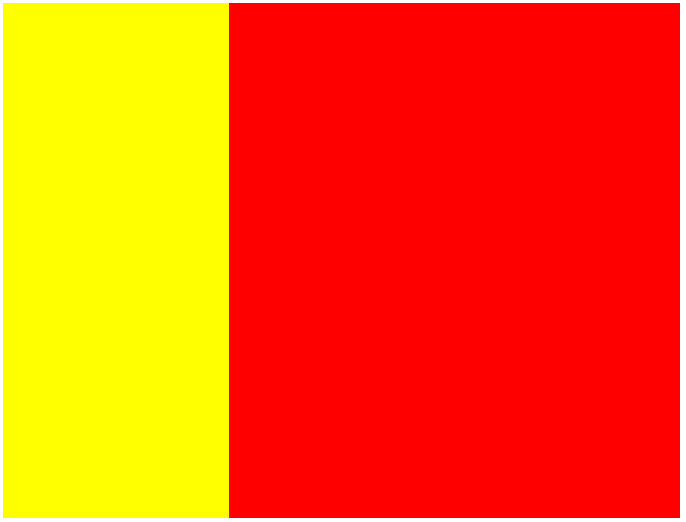
System Layer DER Impacts

- Anything that happens in one area affects the others
- Generation
  - IRP and resource adequacy
  - Balancing, flexibility and ramping
  - Bulk grid /wholesale impacts
- Transmission/Sub-transmission
  - Masked load: line and transformer flows
  - N-1 reliability criteria and disturbance response
  - Operating flexibility
  - Capital infrastructure planning
- Distribution
  - Monitoring, control and operational flexibility
  - Hosting capacity, high penetration impacts
  - Reliability (voltage, thermal, protection) impacts
  - Locational value of customer technology
- Customer meter
  - Technology adoption drivers and needs
  - Retail rates and impacts
  - Changing customer behaviors



DER Interconnection Impacts

Penetration

Impact	**Low**	**Moderate**	**High**
Thermal			
Voltage & PQ			
Protection			

Potential benefits
Some benefits – highly dependent
Negative impacts

Interconnection Processes

- At the meter
  - Safety and reliability
  - Interconnection drawings, certified equipment, protection coordination
  - NEC, NESC, NFPA
- At the transformer
  - Sizing electrical equipment
    - To serve load (ie. PV production = 0 at night)
    - To back-feed the grid (production >> load)
- On the grid
  - Aggregate impacts of all interconnected systems
  - Thermal capacity of transformers, wires, devices
  - Voltage and power quality impacts
  - Protection equipment impacts

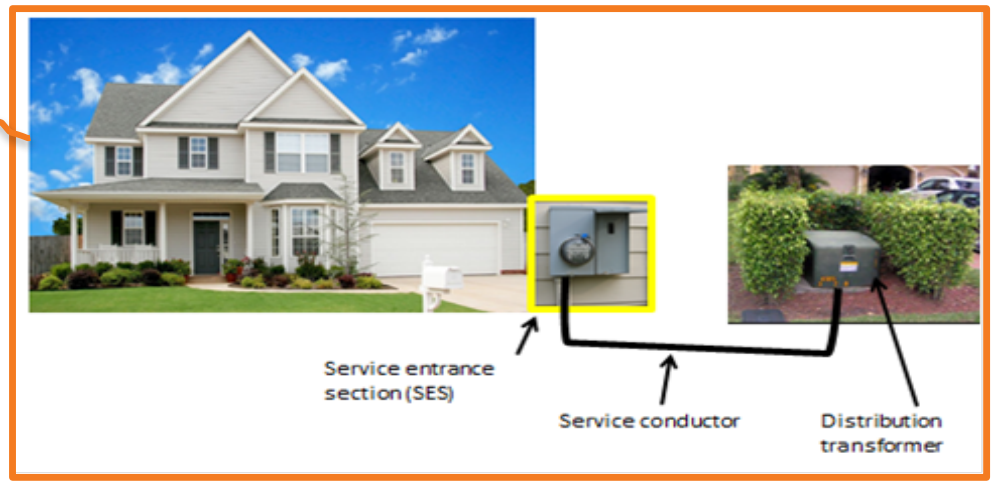
DER Integration Costs

Out of scope

- DER policy implications
- Cost/investment recovery
- Rates, net metering
- Locational value

- Hard costs
  - Infrastructure
    - Required to maintain safe, reliable operation, and maintain power quality
  - Upgrades required due to existing/emerging issues
  - DG application that causes the grid upgrade
- Soft costs
  - Application interface portal
  - Administrative and engineering resources to determine impacts and conduct analysis
- Other costs
  - Tools, technology, data
  - Operational modifications that affect other assets

- At the meter
  - Inverter, controls & communications
  - Switches
  - Protective devices
- At the transformer
  - Panel
  - Service conductor
  - Transformer
- On the grid
  - Primary conductors
  - Voltage regulating equipment
  - Substation (relays, breakers) or line (reclosers, fuses) protective devices



Other Considerations

- Integration costs are but a piece of the pie
- Utility structure
  - Vertically integrated? Wires Only? Deregulated Market?
  - Bulk grid and generation impacts
- Investment recovery mechanisms
  - Net metering?
  - Rate structure (kWh only charges)?
  - Billing reflective of infrastructure vs. energy?
- Operational impacts
  - Production alignment with consumption?
  - Challenged existing balancing and operations
    - Seasonal (spring/fall vs. summer)
    - Infrastructure deferral possible (sensitive to assumptions)

Conclusions

- Utility structure matters
- Costs of integrating DER
  - Hard costs (infrastructure)
  - Soft costs (support)
- Other considerations are significant
  - Rate structure
  - Investment recovery
  - Customer benefit and grid benefit
- DER grid benefits
  - Needs proactive planning and awareness

Peak Day Generation Stack June 19, 2016