Grid Accommodation of Dynamic HPC Demand

SC19 Workshop

Grant Stewart
Utilities Project Director

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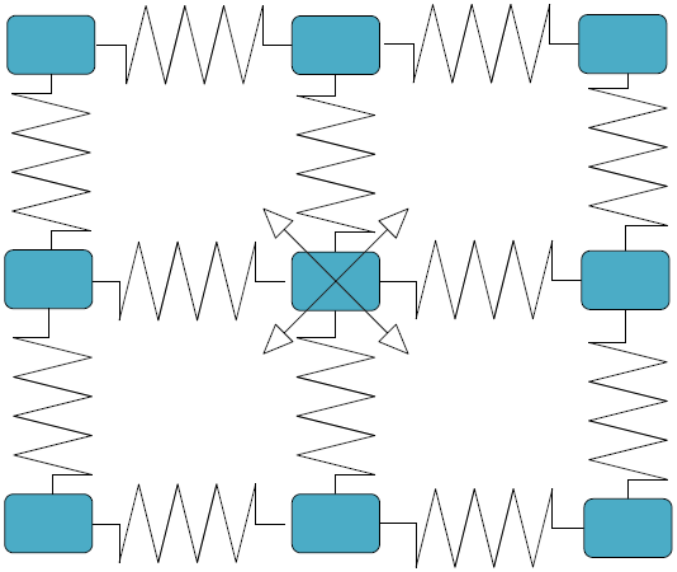
Challenge

- HPCs have highly variable power demand
- Variability is increasing, driven by power conservation desire
- Power flow changes are sometimes abrupt
- Abrupt power flow change on a utility power grid is undesirable
  - voltage drop or rise
  - poor power quality
  - equipment damage
  - miss-operation (breaker trip, activation of automatic switch)
- Grid stiffness is necessary to mitigate voltage change and avoid miss-operations

Grid Stiffness

Circuit "stiffness" is the ability to rapidly stabilize voltage after an abrupt power-flow change



Stiffness is associated with higher fault current and lower impedance

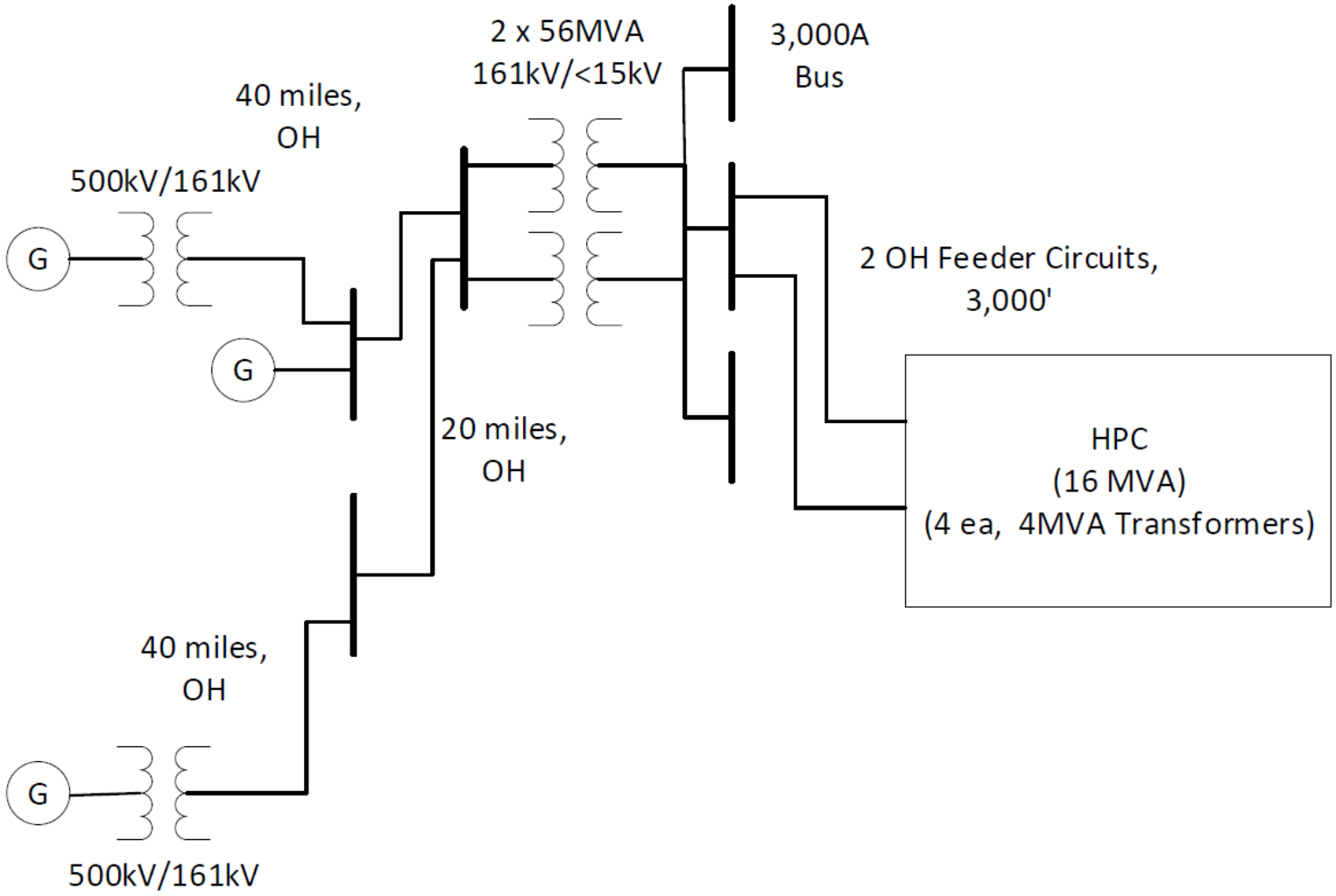
Helpful Grid Components

- Close proximity to higher voltage
- Advanced power transformers have automatic tap changers that control output voltage (slow)
- Capacitor banks, automatically switched to make step-function changes in power factor (slow)
- Nearby generator that has an automatic exciter, adjusts to manage power factor and regulate voltage (very fast)
- Static VAR Compensator (SVC) or Static Synchronous Compensator (STATCOM), devices that automatically control voltage by generating leading or lagging VARs (very fast)
- Smart inverters on battery bank or photovoltaic array can provide VARs support and voltage control (very fast)
- UPS can provide power quality support (limited load coverage)

Grid Setting – Case Studies

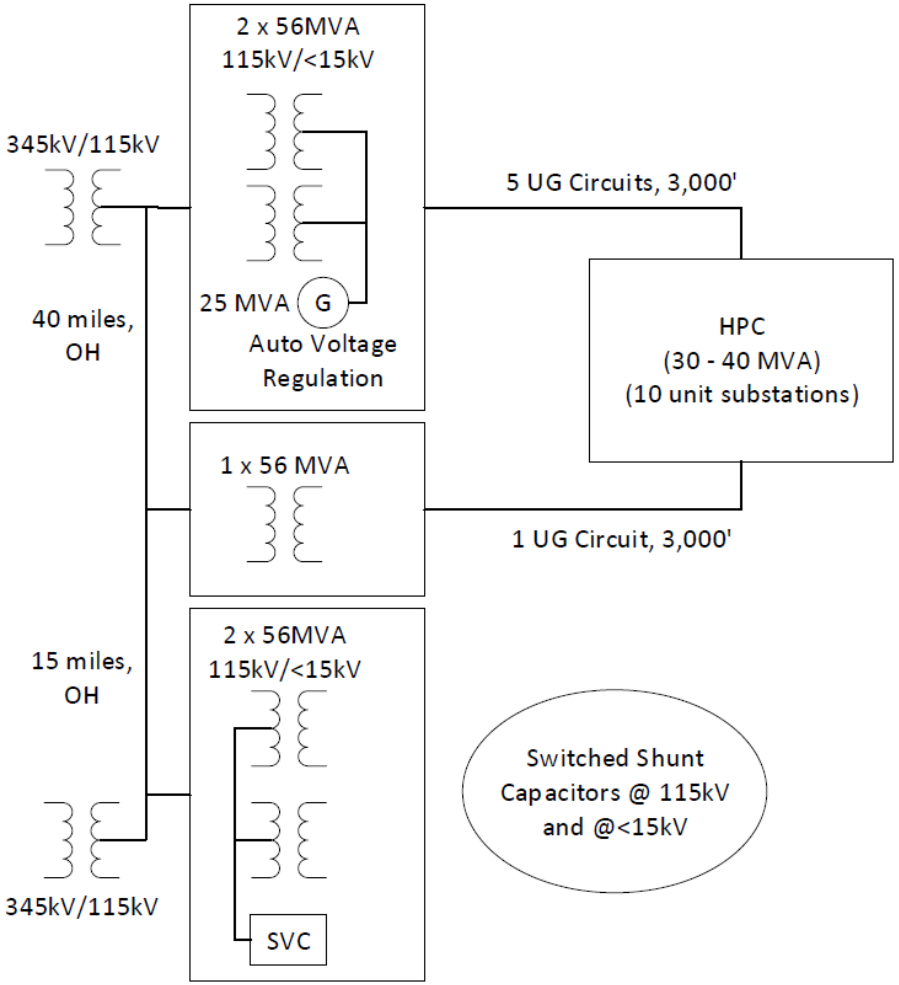
Case Study, HPC-B

Most Stiff



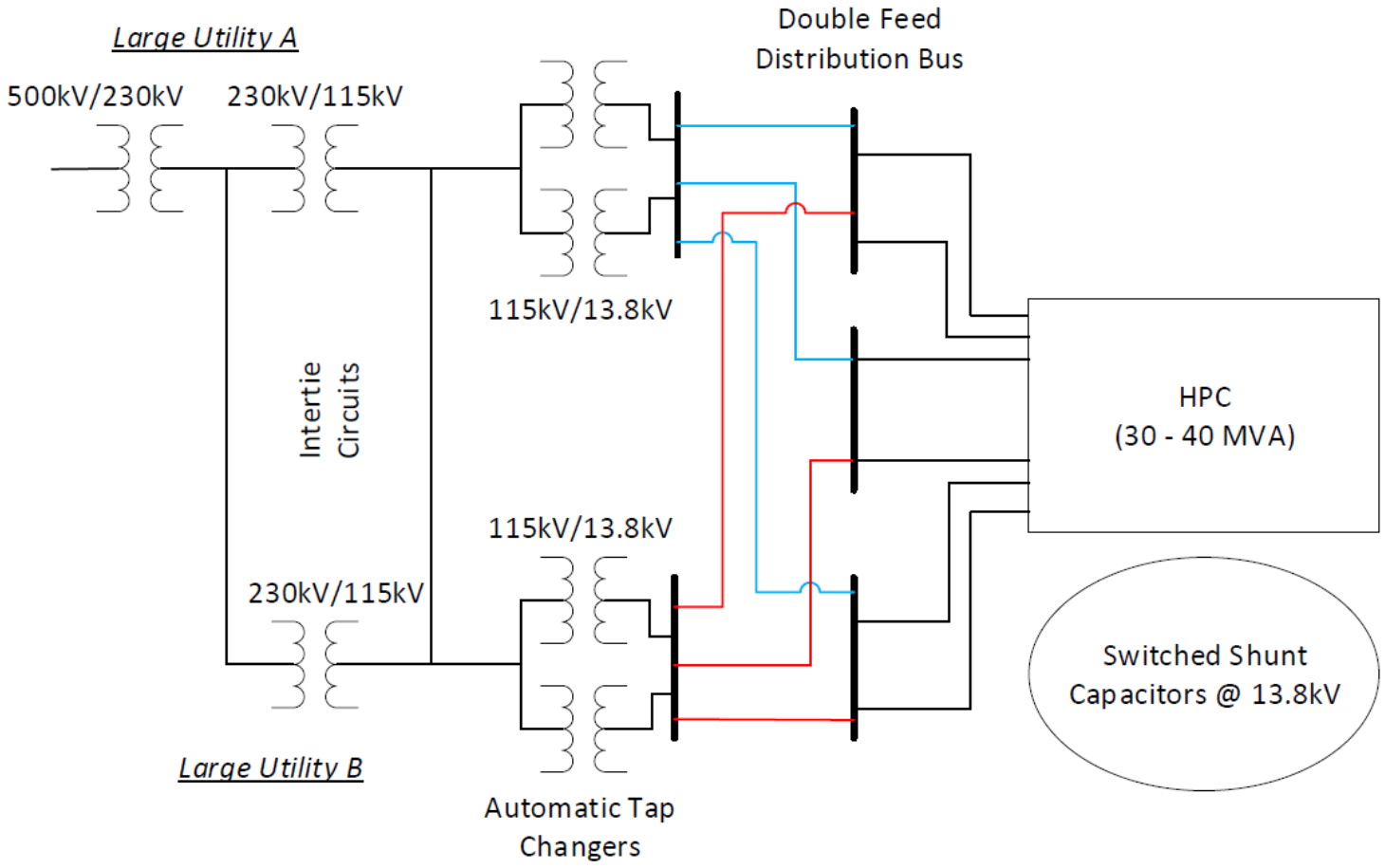
Case Study, HPC-C

Many VARs Support Components



Case Study, HPC-D

High Reliability & Stiffness



Conclusion

- The power supply infrastructure necessary for large HPCs is expensive and takes years to develop
- Each site has a unique grid setting that is an artifact of its development over the years
- Optimized planning for a supercomputer and its supporting power grid requires a clear understanding of grid stiffness characteristics and the magnitude and ramp rate of dynamic power fluctuations