

# Coastal Clean Energy Impact on South Carolina Transmission System

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# Definitions

- **KV (KiloVolt)** : unit for voltage
- **MVA (MegaVoltAmper)**: unit for apparent power
- **MW (MegaWatt)**: unit for active power
- **MVAR(MegaVoltAmperReactive)**: unit for reactive power
- **P.U.** : per unit (dimensionless)
- **R** : resistance in Ohms
- **X** : reactance in Ohms
- **Interface bus**: injection point of wind energy



# Scope of the project

- Study consists of 3 phases
  - I: 80 MW in state water by 2014
  - II: 1080MW in federal water by 2020
  - III: 3080MW in federal water by 2030
- The project uses the provided data which is 2018



# Overview of phase I

- 80 MW injected into the coastal network at 115KV buses
- Six different 115 KV coastal buses are available
- Two wind farms – One interface bus per wind farm

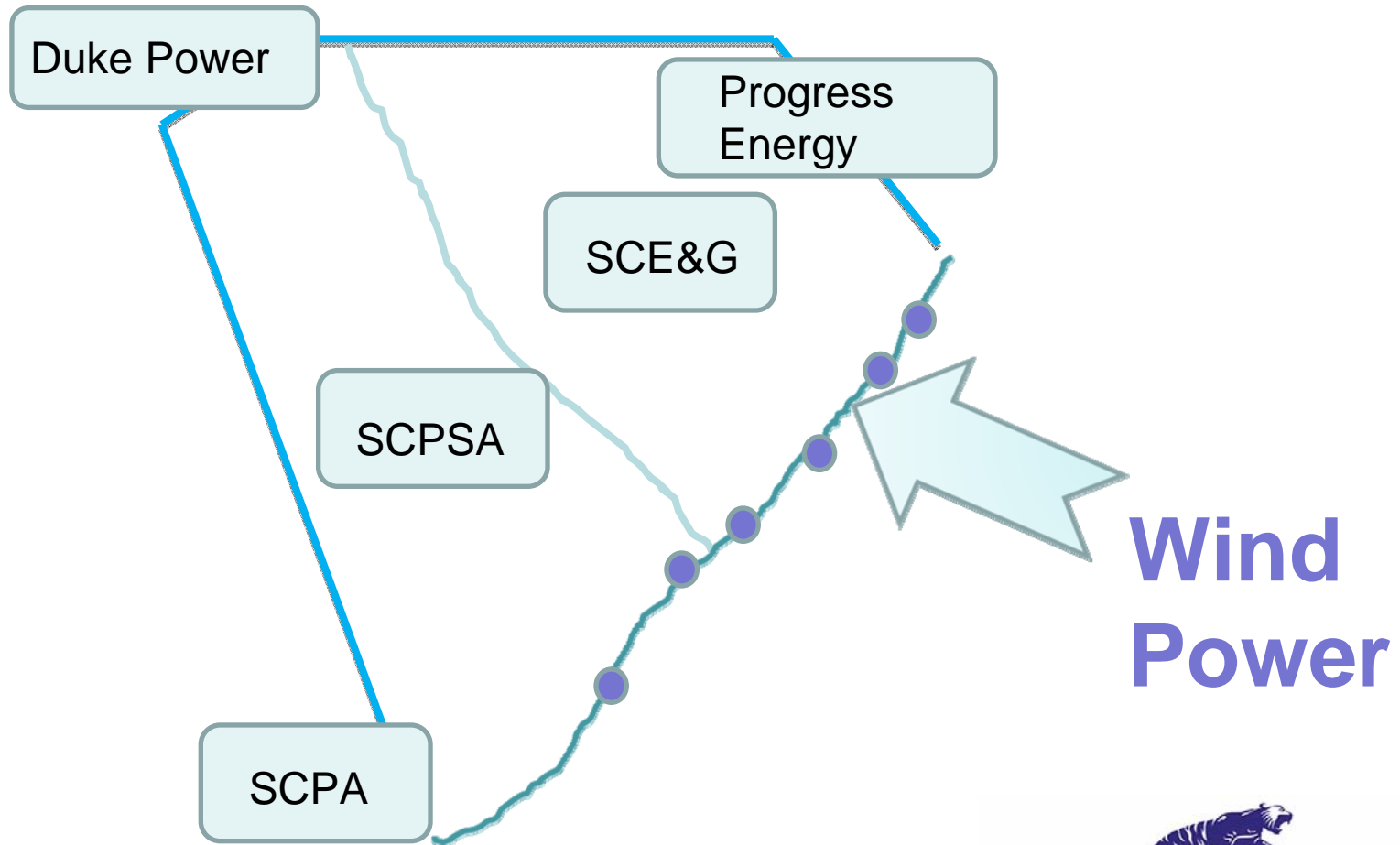


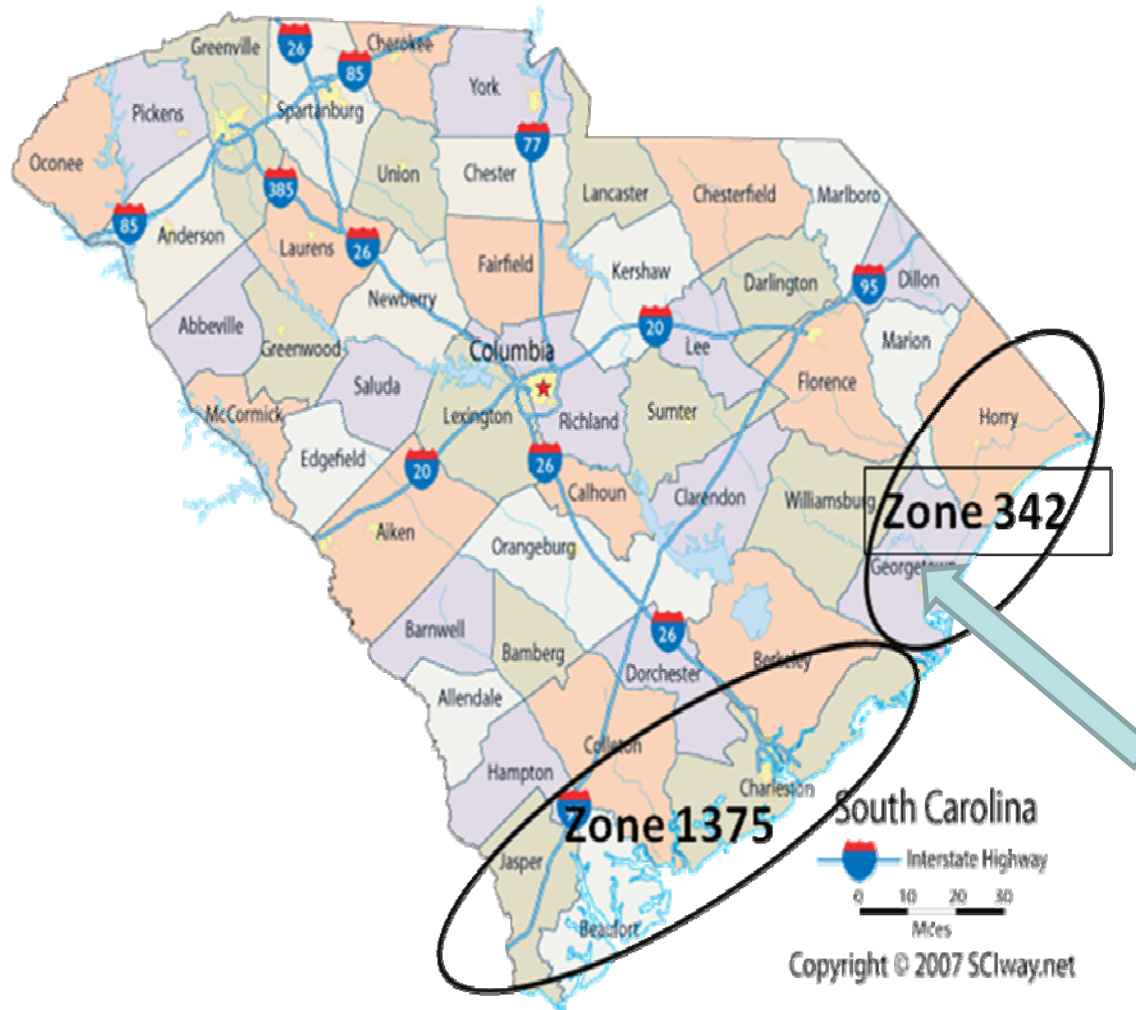
# Overview of phase II

- 1080MW is injected into Power system by 2020
- The same six 115 KV coastal interface buses
- Two wind farms—same idea as for phase I



# Wind energy distribution





Map of South Carolina with wind penetration in zone 342



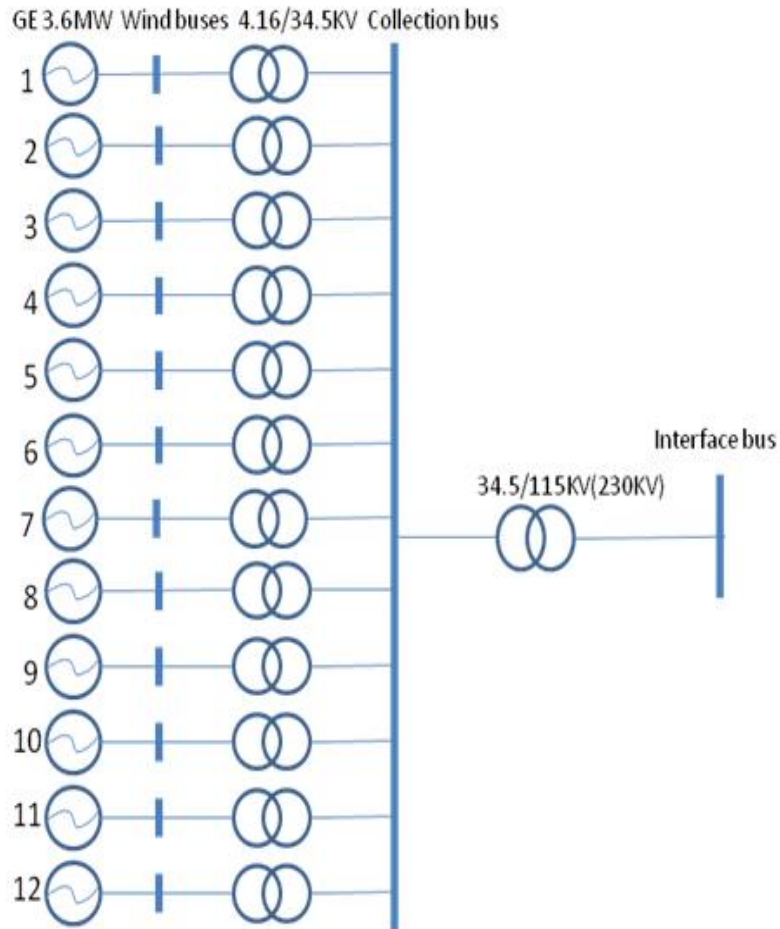
# Wind turbine parameters

GE 3.6 Wind turbine	value
Qmax	1.74MVAR
Qmin	-1.74 MVAR
Rating capacity	4MW
Pmax	3.6MW
Pmin	0.5MW
R	0
X	0.302 p.u.
Power factor	0.9





# Wind farm connection

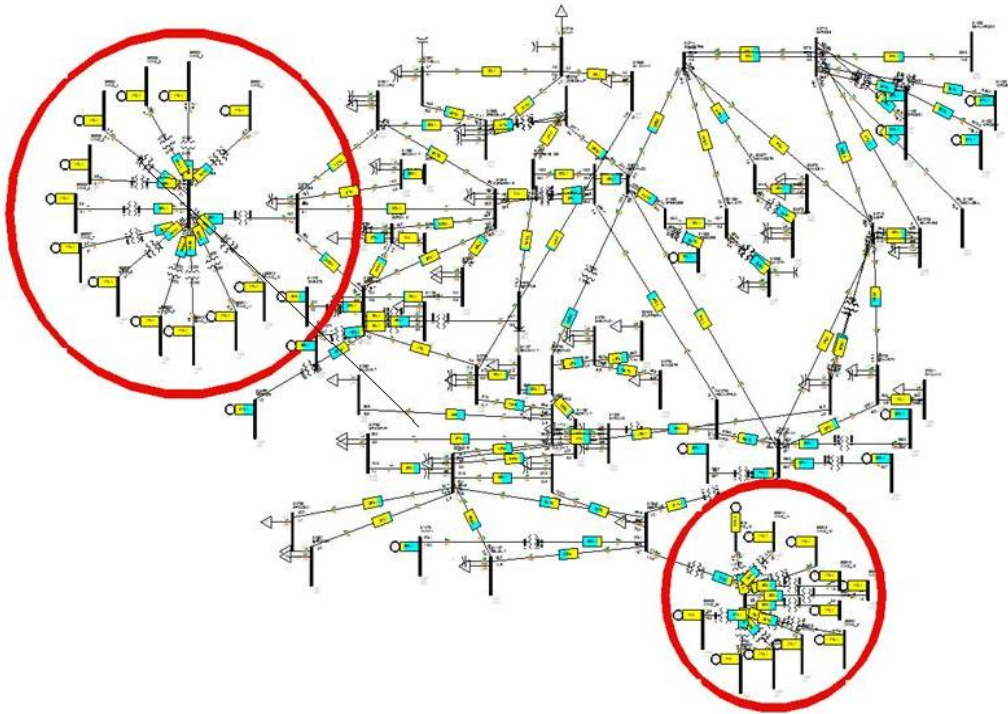


# Simulation-PSSE / PowerWorld

- Phase I
  - 2013 summer
  - 2013/14winter
- Phase II
  - 2018summer
- Compare result based:
  - Voltage violation ( $V < 0.94$  p.u. or  $V > 1.06$  p.u. )
  - Branch loading condition (must be less than 100%)



# Effect of 80 MW injection

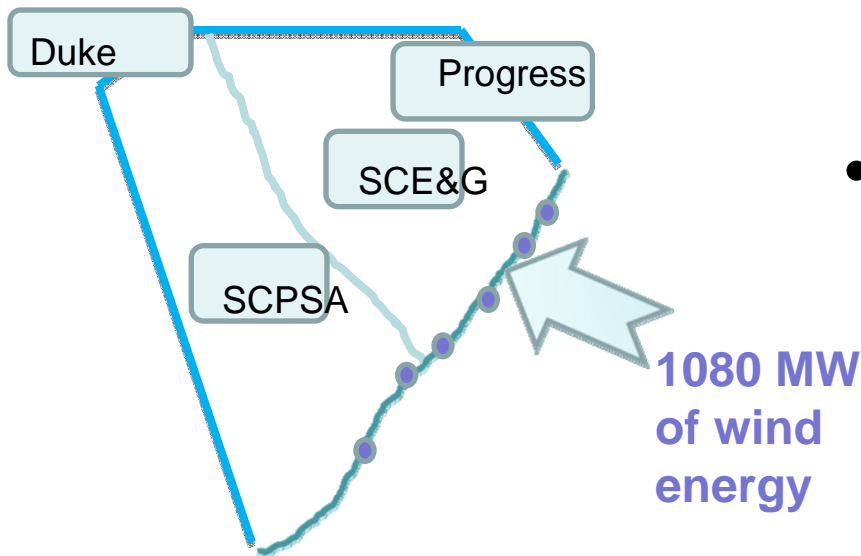


Power flow diagram with 80 MW injection

- No transmission line or transformer loaded at or above 100% its rating
- The voltage violations are the same in as the original system



# Wind energy distribution for phase II

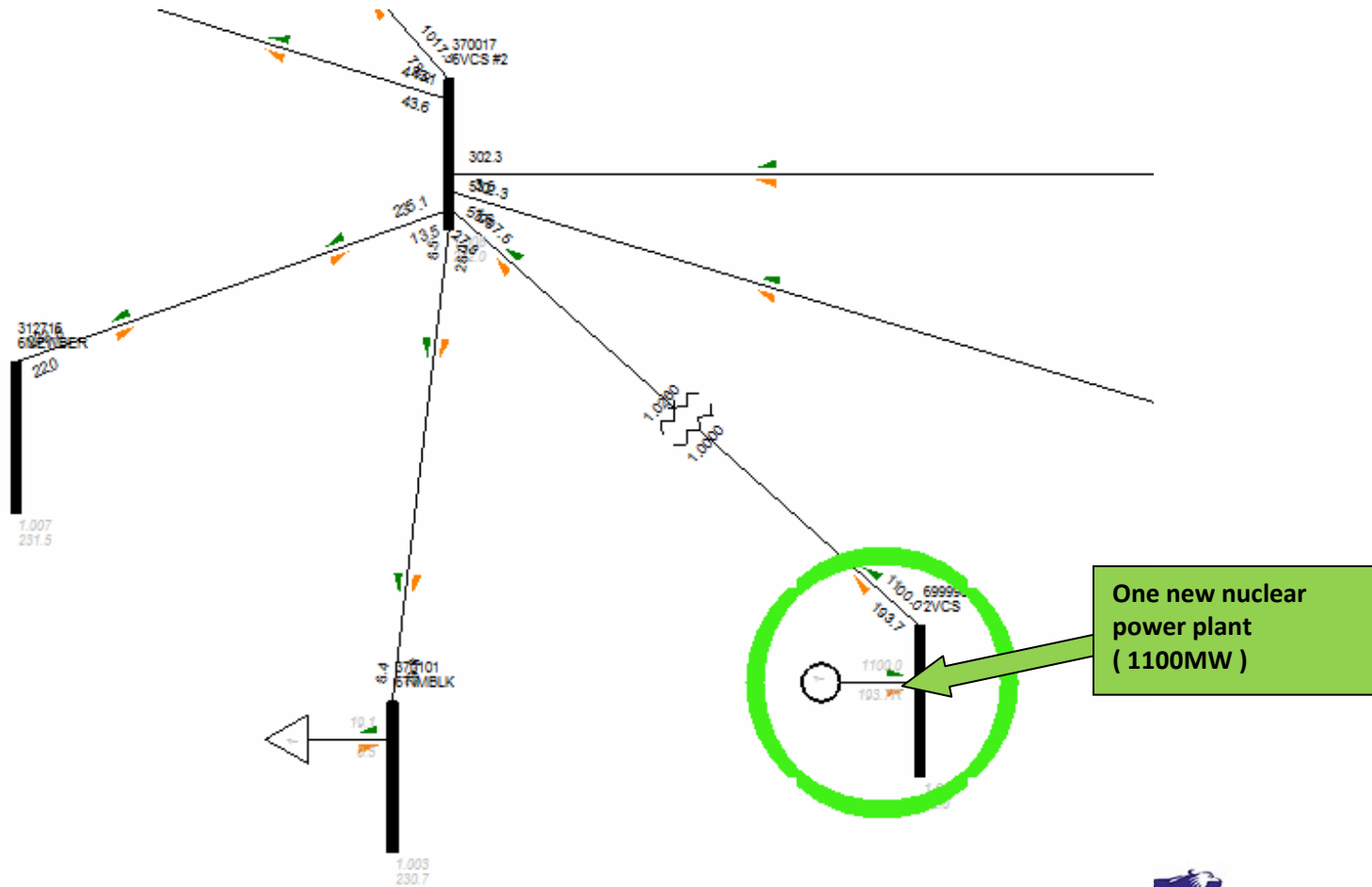


- According to the load ratio of the four utilities using the summer 2009 base case

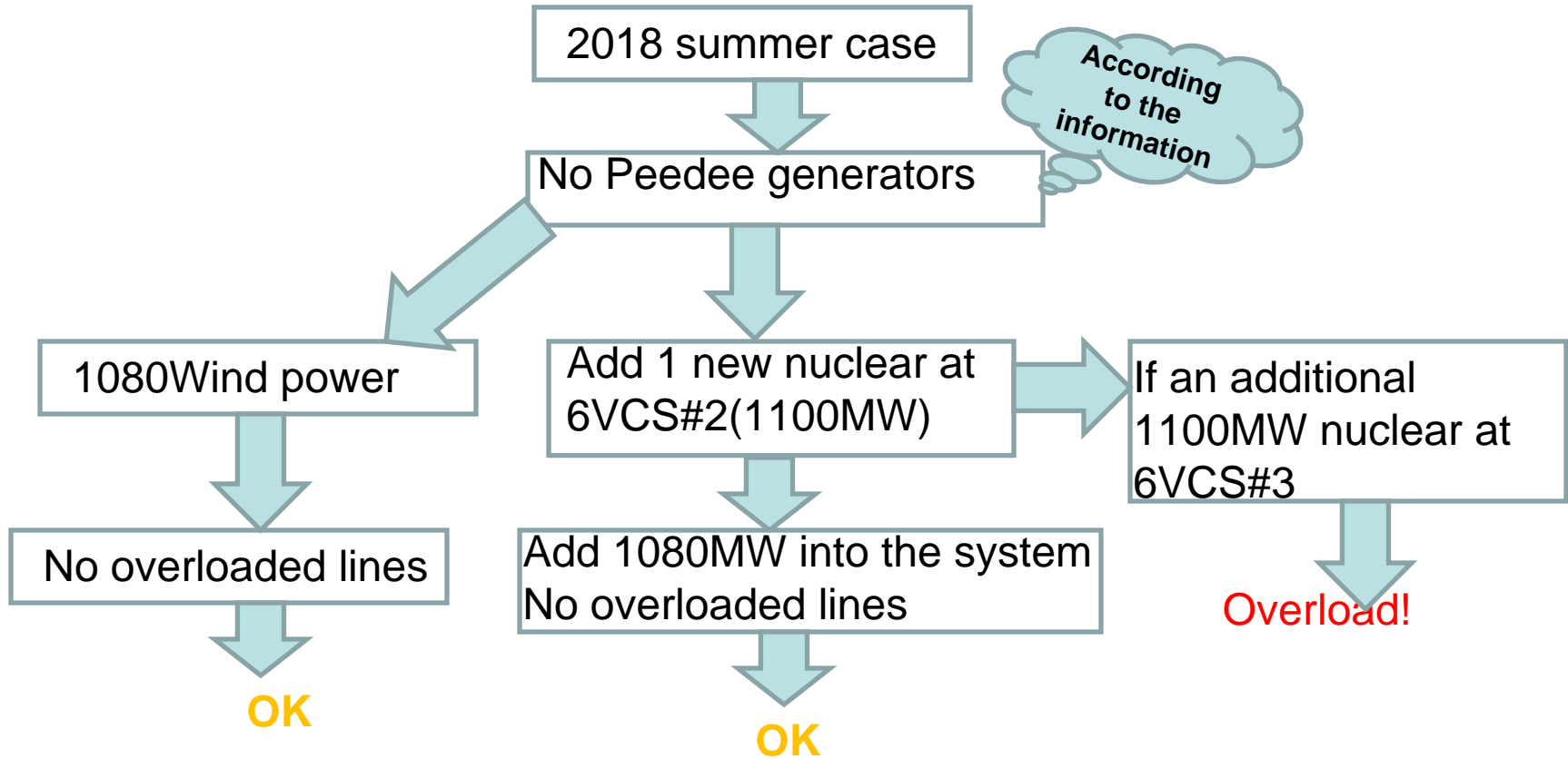
Area Name	Area #	Zone # Range	Bus # Range	P Load (MW)	Load ratio	Load ratio In Percent	Wind energy (MW)
SCEG	343	1375 - 1384	370000 - 371999	4673.967	0.1158	12%	120
SCPSA	344	340 - 349	311000 - 312999	4774.263	0.1183	12%	120+80
CP&L-E	340	315 - 324	304000 - 305999	11961.915	0.2964	30%	300
DUKE	342	325 - 339	306000 - 309999	18948.089	0.4695	46%	460
Total				40358.234	1	100%	1080



# One new nuclear power plant



# Simulation results



# Conclusion

- The state of South Carolina can easily handle the addition of 80 MW by 2014
- It can also sustain an additional 1 GW wind energy when the generation reduction in Santee Cooper system is done at the Rainey plant.



# Future research

- Phase 3 will be completed
- Recommendation for redesigning or upgrading the transmission system
- The following studies will be evaluated:
  - Voltage stability
  - Transient stability
  - Contingency and short circuit analysis

