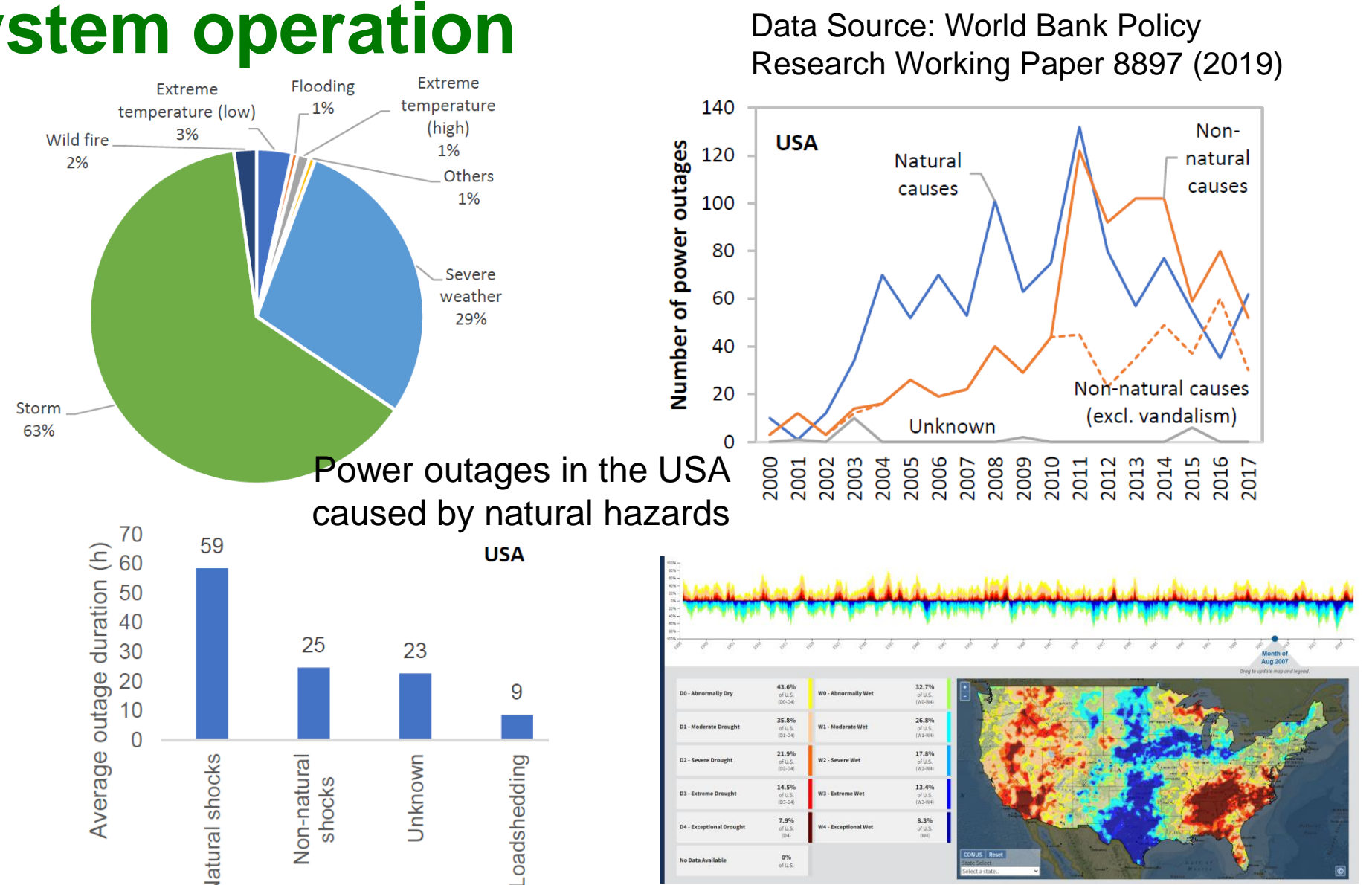


Impacts of Extreme Drought on Power Grid Resilience: A Study of the Extended PJM

Hang Shuai¹, Fangxing Li¹, William Jerome Tingen II¹, and Srijib Mukherjee²
¹ The University of Tennessee, Knoxville ² Oak Ridge National Laboratory

Natural hazards increasingly threaten the power system operation

- In the US, natural shocks account for the majority of outages at the national level.
- Overall, between 2000 and 2017, **54.8% of all recorded power outage events have been caused by natural shocks**, and 44.2% by non-natural causes (26.9% if excluding vandalism).
- Summer drought** frequently affects the western and southeastern United States.

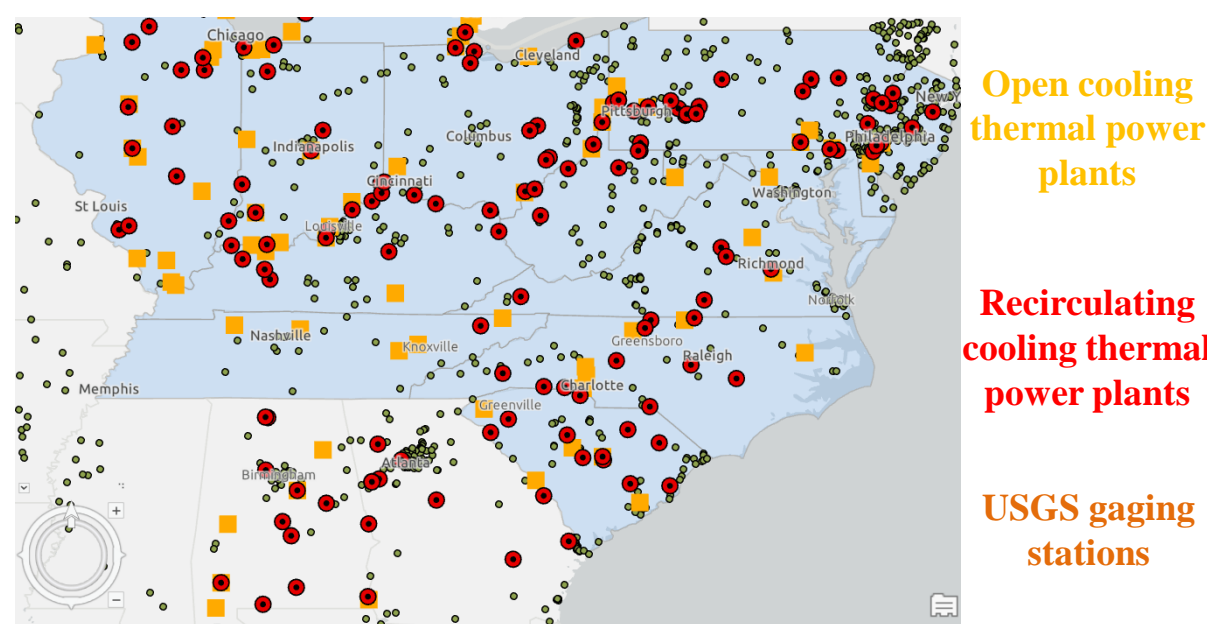


Modeling the impacts of summer drought on power grid

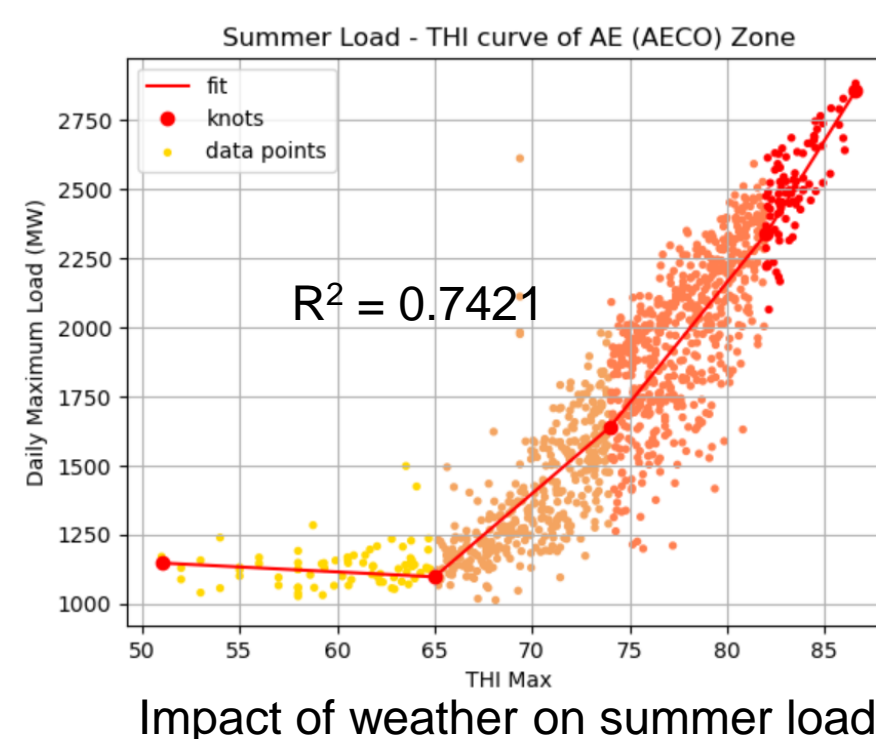
- Summer drought events affect the usable capacity of thermoelectric plants (with once-through cooling or recirculating cooling systems) using surface fresh water to cool the plant. Plants with combustion turbines are also at-risk. For example, capacity of thermal plant with once-through cooling systems is mainly affected by available water, water temperature, and air temperature/humidity.

$$P_{on} = \frac{\min(\gamma Q_i, W_{on}) \cdot \rho_w \cdot c_{p,w} \cdot \max(\min(T_{l,max} - T_w, \Delta T_{l,max}), 0)}{1 - \eta_{net,i} - k_{os}} \cdot \eta_{net,i}$$

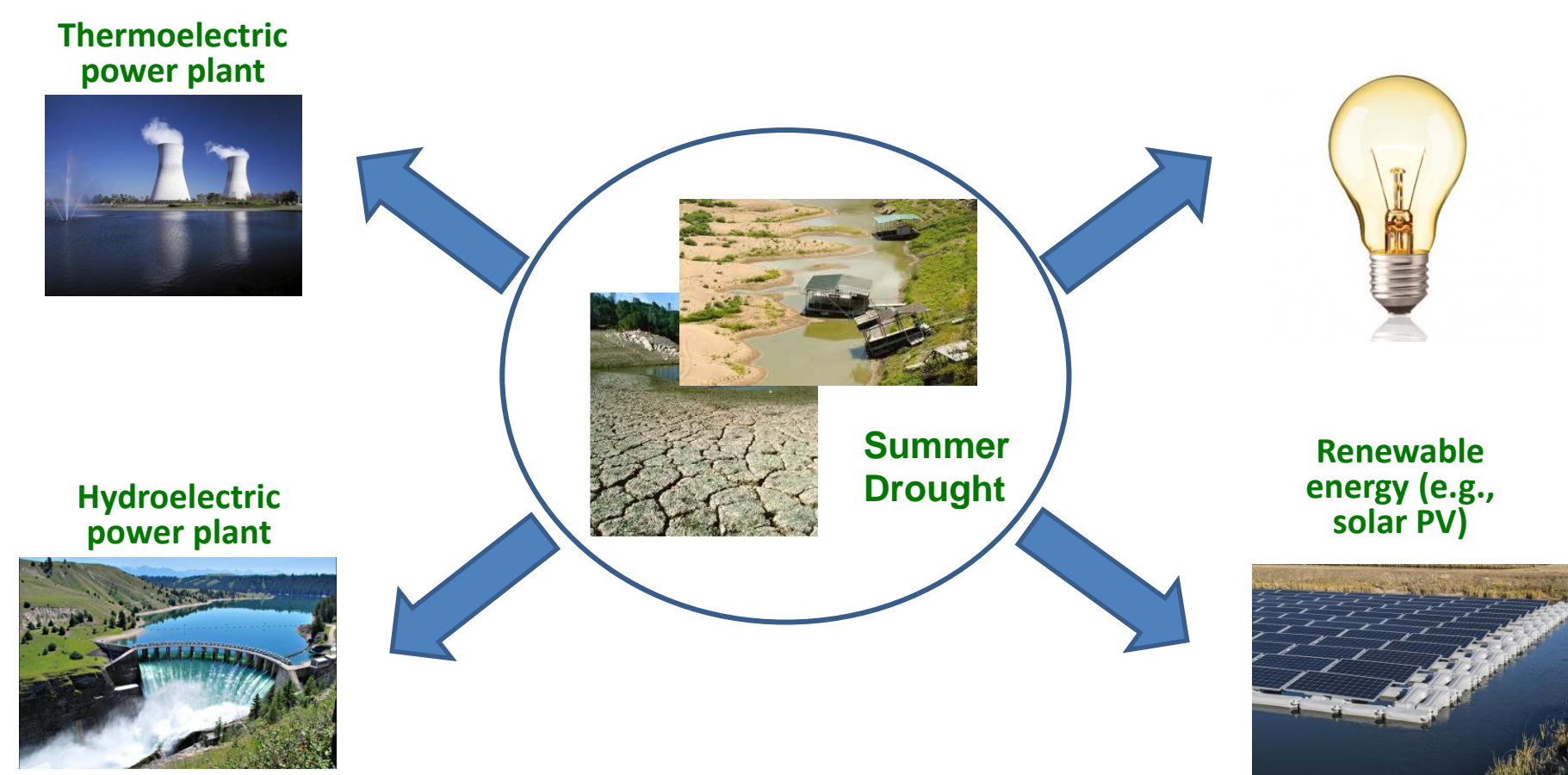
- Hydroelectric generation reduction is proportional to water flow decrease.
- In general, daily peak load increases as the THI (Temperature-Humidity Index) increasing.



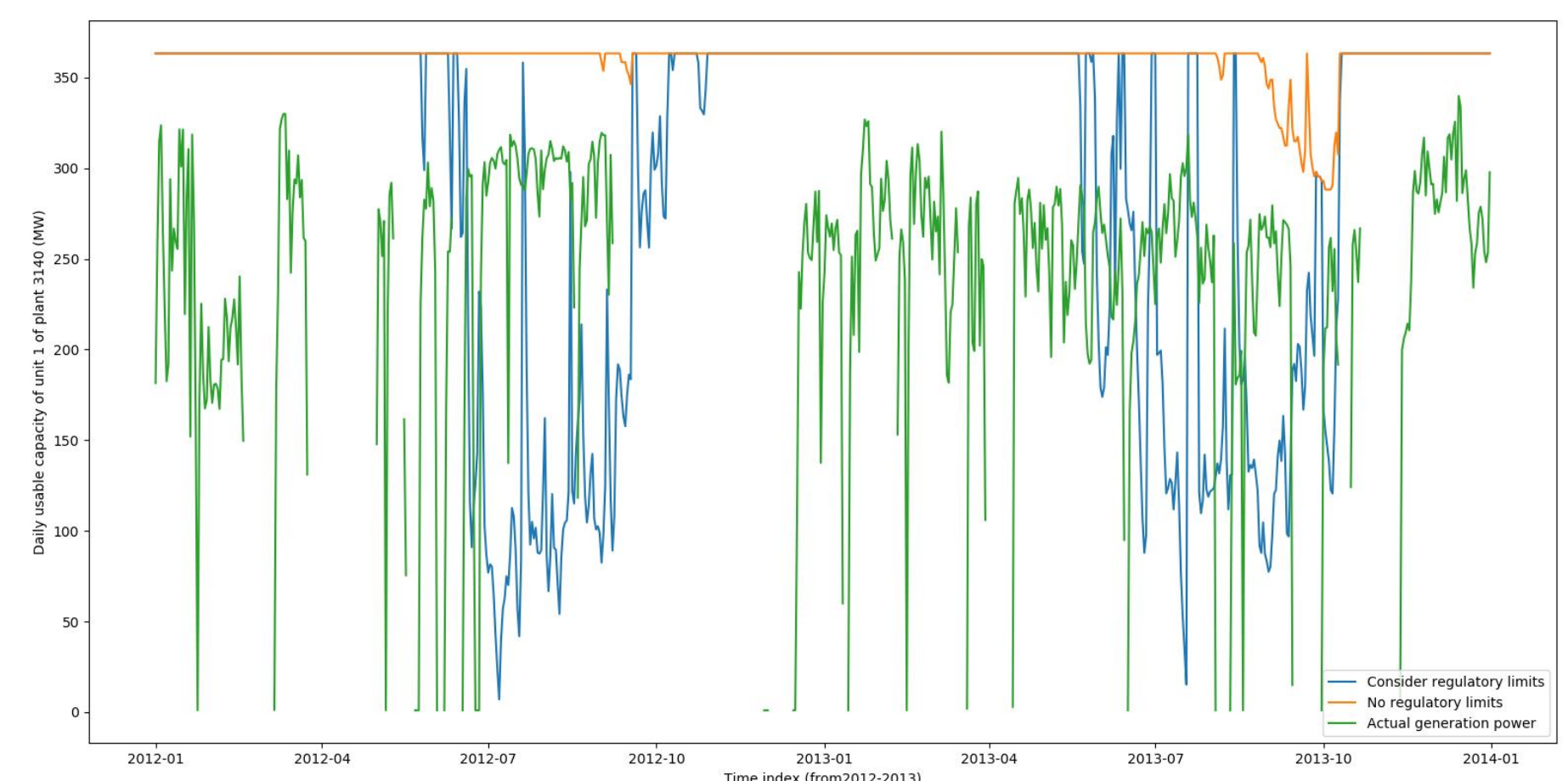
At-risk thermal power plants in extended PJM region



Impact of weather on summer load



Summer drought impact modeling framework

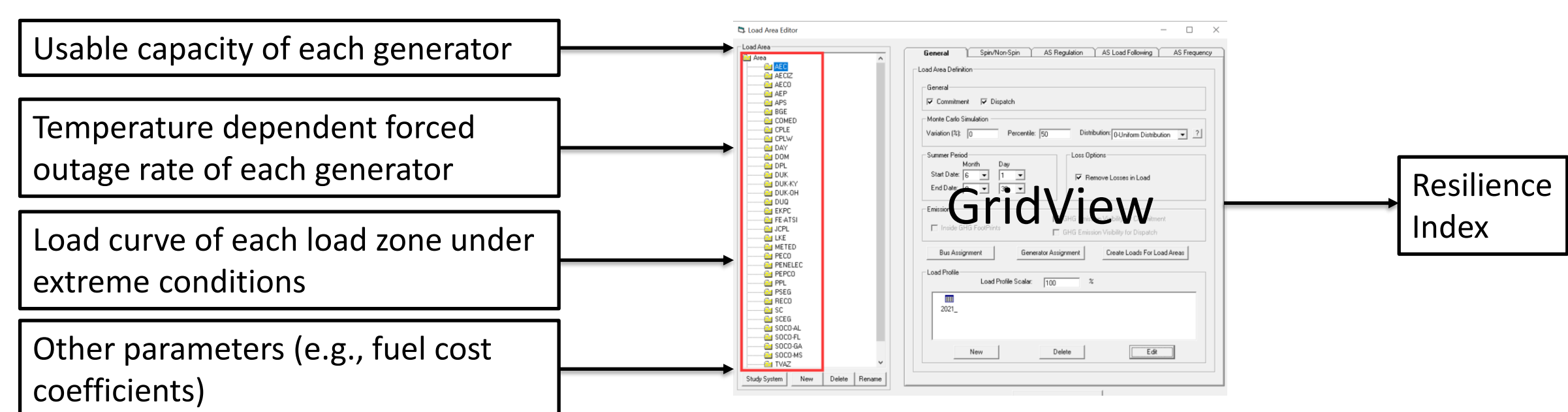


Usable capacity derating of Brunner Island thermal plant (with once-through cooling) in PA

Case study

Fuel Composition (2025)	PJM+SERC (GW)	Percentage
Natural Gas Fired Combined Cycle	114.24	27%
Conventional Steam Coal	91.07	21%
Combustion Turbine	73.12	17%
Nuclear	59.03	14%
Hydro	26.34	6%
PV	24.76	6%
Natural Gas Steam Turbine	15.38	4%
Wind Turbine	12.41	3%
Wood/Wood Waste Biomass	39.53	1%
Other	31.94	<1%
Total	423.50	100%

Data Source: EIA-860 form (2019 version)



- ✓ The daily available capacity of all at-risk thermoelectric power plants will be reduced by 12.6 - 18.1% if a drought event comparable to 2007 summer drought in the southeastern United States strikes the extended PJM system in near future.
- ✓ By NERC standard, the LOLE standard is **0.1 day/year**. Thus, in the near future, the extended PJM power grid cannot meet reliability requirements under summer drought event as 2007 southeastern United States.

2007 Summer Drought Scenario	LOLE (day/year)
PJM	0.178
SERC	0.033

