System Resilience Benefits of Dual-Fuel Capable Generators

Daniel Levie, Jiazi Zhang, Gregory Brinkman, Matthew Irish, Jessica Lau
National Renewable Energy Laboratory

Motivation

- The U.S. has become increasingly dependent on natural gas (NG) for power generation.
- Extreme cold weather has occurred more frequently in the Northeast U.S. in recent years, increasing both heating and electricity gas demand.
- Regional power systems are now vulnerable to NG unit outages resulting from gas unavailability.
- It is vital to fully evaluate the impacts of gas unavailability on power system and propose mitigation solutions.

Objective

- Retrofit NG generators to make them dual-fuel capable is currently the most cost-effective mitigation solution [1] to gas unavailability event.
- This work:
  - Develop a dual-fuel generator model with fuel switching, dual fuel tank capacity, and tank refueling constraints.
  - Introduce an extreme event timeline model to simulate realistic power system operation under gas unavailability event.
  - Assess the impacts of gas unavailability events and the resilience benefits provided by dual-fuel generators.

System and Dual Fuel Scenario

Dual-fuel capability validation:

- Dual fuel switching constraint:
  - The relationship between dual-fuel generator fuel offtake and generation
  \[ v_p^k + v_d^k = H_k(g_k^1) \]
- Fuel tank balance and capacity limit constraint:
  \[ e_k^t = e_k^{t-1} + f_k^d \]
  \[ 0 \leq e_k^t \leq E_{k, max} \]
- Fuel deliveries constraint:
  \[ d_k^1 = E_{k, max} \forall t \in T_D \]
- Final unit commitment (UC) formulation

Numerical Results and Conclusion

Gas Unavailability Event Model

- Gas unavailability event results in unserved energy during the event.
- Even 25% dual-fuel generators can reduce near 90% of the total unserved energy, and avoid loss loads after the first day.
- 75% dual-fuel generators can avoid unserved energy issue.

Conclusion:

- In the test system, all load can be provisioned when at least 75% of NG generator capacity is equipped with dual-fuel capabilities, saving a large amount of system cost in the event of serious fuel shortage.
- The system is more resilient with the increase coverage rate of dual-fuel generators.

Reference: