

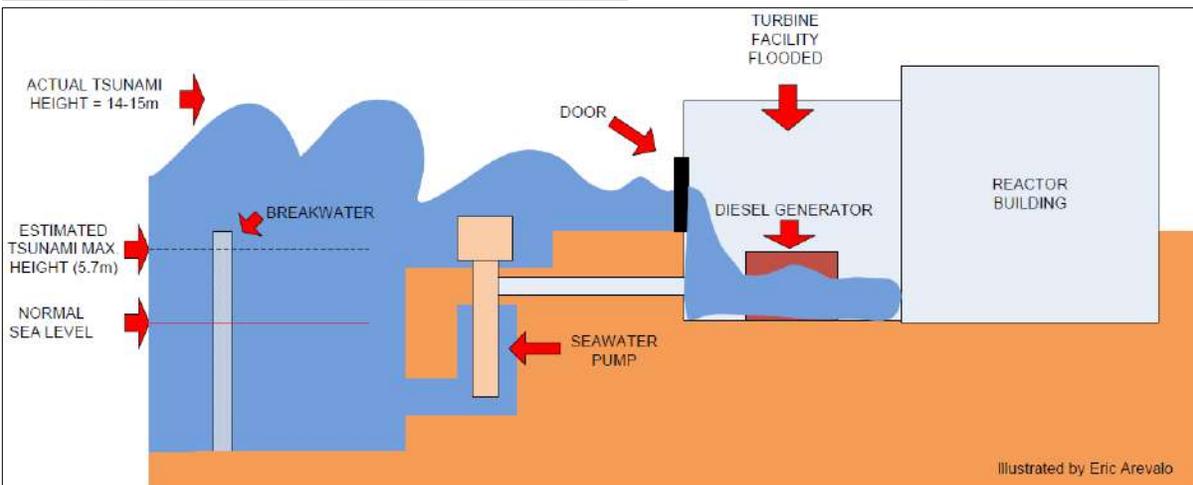
## Trends in Generator Location

### Background

Diesel generators are used in nuclear power plants in the event that a nuclear plant loses power from the electric grid. Perhaps one of the most significant industrial design error in locating a generator set was realized in the Fukushima Daiichi Nuclear Power Plant disaster in March 2011 after a magnitude 9.0 earthquake 70 kilometers east of the Oshika Peninsula triggered a tsunami which overcame the breakwaters expected to protect the power plant. The tsunami sent 14 to 15 meter high waves overcoming the 5.7 meter high breakwater and flooded the low-level rooms of the Fukushima Daiichi Power Plant where the emergency generators were housed. The generators failed, stopping coolant flow that was being pumped through the reactors, causing reactors explosion and melting.



The Fukushima Daiichi Nuclear Power Plant flooded by tsunami on March 11, 2011. On the horizon is the Pacific Ocean where the tsunami overcame the 5.7m breakwater and flooded the low-level rooms of the plant where the emergency generators were housed. The generators failed, stopping coolant flow that was being pumped through the reactors, causing reactors explosion and melting.



Plant design of the Fukushima Daiichi Power Plant. There were 13 diesel generator sets. 10 were in the basement of the reactor building near the ocean, 3 are aboveground. Most generator sets are built in harm's way becoming the linchpin of a disaster.

## Lessons Learned

The Asia Pacific Research Center of Stanford University in California pointed out three variables crucial at the early stages of the crisis at the Fukushima disaster, namely: plant elevation, breakwater or sea wall elevation, and the **location of backup generators**. Higher elevations for these variables, or waterproofing protection of backup generators, could have mitigated or prevented the disaster.



Flooded switchgears of the Fukushima Daiichi Power Plant.

## Standards Recommendation

Paragraph 7.2.4 of the **NFPA 110 – Standards for Emergency and Standby Power Systems**, 2016 edition, recommends that emergency power supply systems (EPSS) shall be designed and located to minimize damage from flooding, including that caused by the following: (1) flooding resulting from fire-fighting, (2) sewer water backup, and (3) other disasters or occurrences. This paragraph is further explained that EPSS's should be located above known previous flooding elevations where possible.



A 125 KVA Powercity generator set placed on a roof deck of a guard house; on standby to provide backup power to a 2-storey building behind. Though this is a flood-free area, it would take a 4.5 meter high of flood before this generator becomes inoperable.



A 1000 KVA Powercity generator set elevated from ground to keep away from at least a meter high flood.

## Advantages and Disadvantages

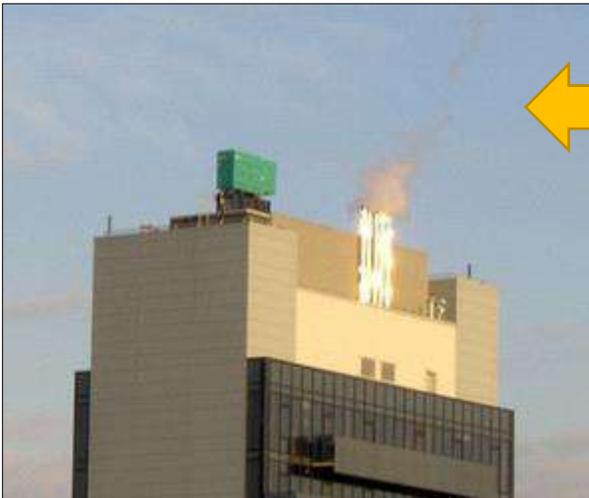
Some owners of generator set prefer roof deck location. There are advantage and disadvantage though.

### Advantages:

1. The generator avoids flooding during adverse weather.
2. Secured. The roof is above street level away from vandalism and theft.
3. In densely populated cities sometimes roof deck would be the only available space to utilize.
4. Better ventilation. Reduces ventilation ducts.
5. Eliminates or only short exhaust pipes.
6. Increased isolation distance from noise produced by the generator.

### Disadvantages:

1. Roof deck structure may need to be reinforced to bear the weight of the generator set.
2. Would require crane for lifting the generator and placing on roof deck.
3. Manually, would require dismantling of the generator to deliver and place on roof deck.
4. Could require longer feeder cables.
5. Fuel storage may also be required to place on roof deck to reduce fuel pipe length.
6. Could complicate fuel delivery.
7. Could impose difficulty in servicing the generator set.
8. Higher exposure to lightning strike or surge.



This generator set on a high rise building may be an exaggerated flood prevention approach. It may have avoided flooding but it can be blown away by hurricanes and prone to a direct hit of a lightning strike.