Coastal Energy Infrastructure

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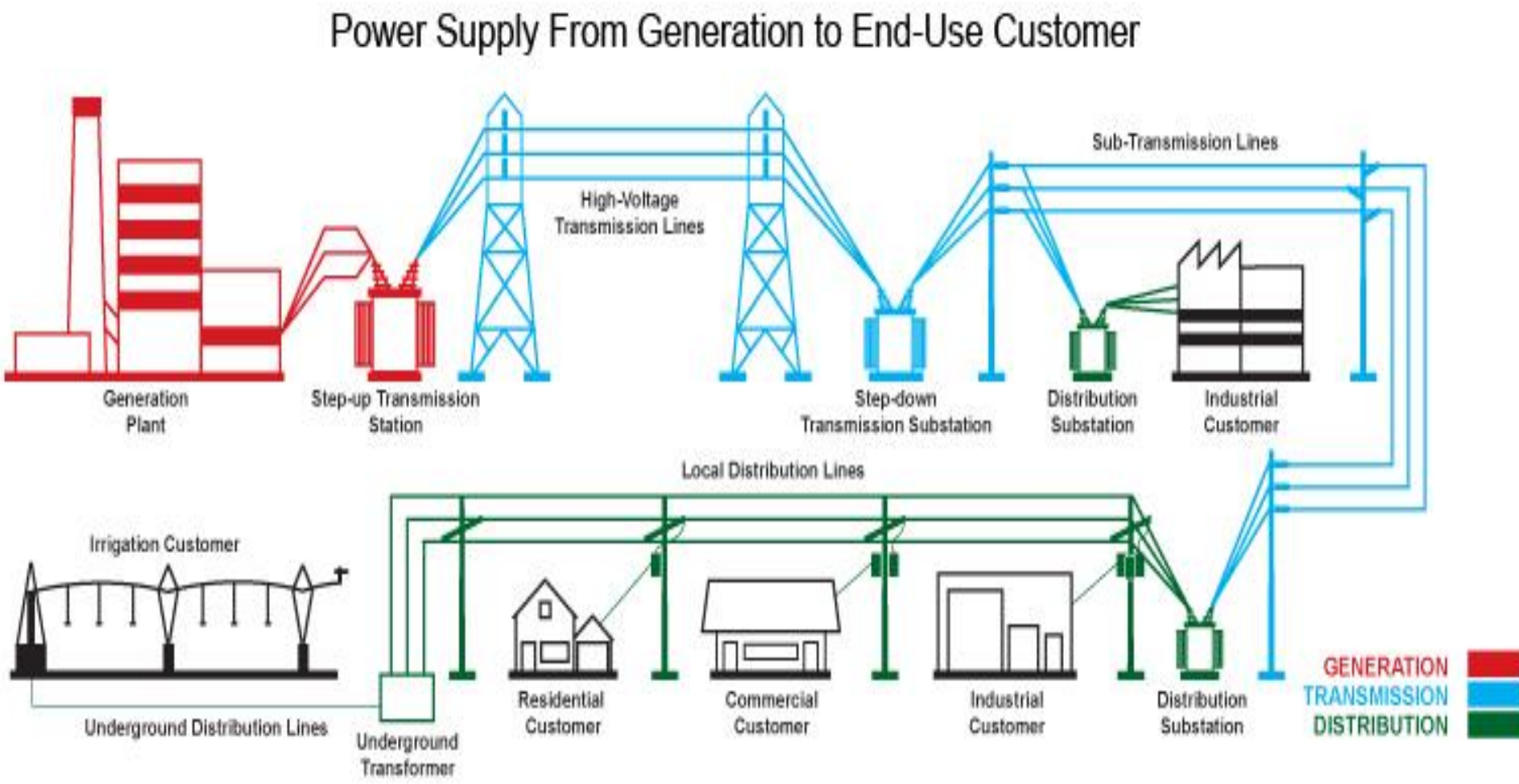
Scope

- To consider the electrical energy network and how it might be affected over the next 100 years and beyond to 2500.
- Coastal Energy infrastructure is assumed to be mainly electrical.
- The electrical energy being generated from a number sources (eg nuclear, wind, wave)

Review of the electrical network

- How is the electrical network arranged from generation point (e.g. nuclear) to you?
- We can consider what are the vulnerabilities of the electrical network as it is at present?
- How would changes in sea level and storm surges exploit those vulnerabilities?
- What are the short term mitigation options?
- What ware the longer term solutions?

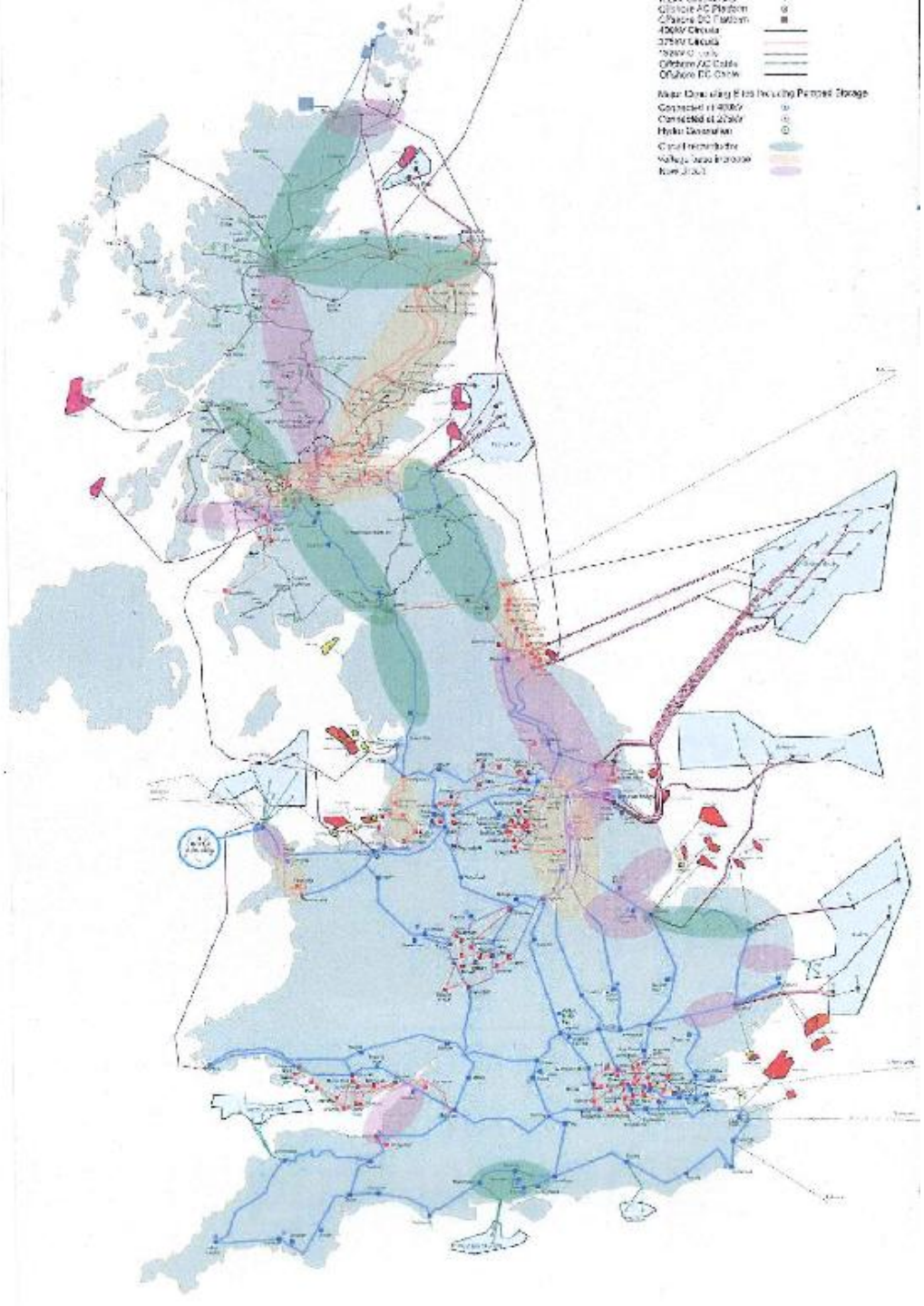
Generation – Transmission – Distribution – To you



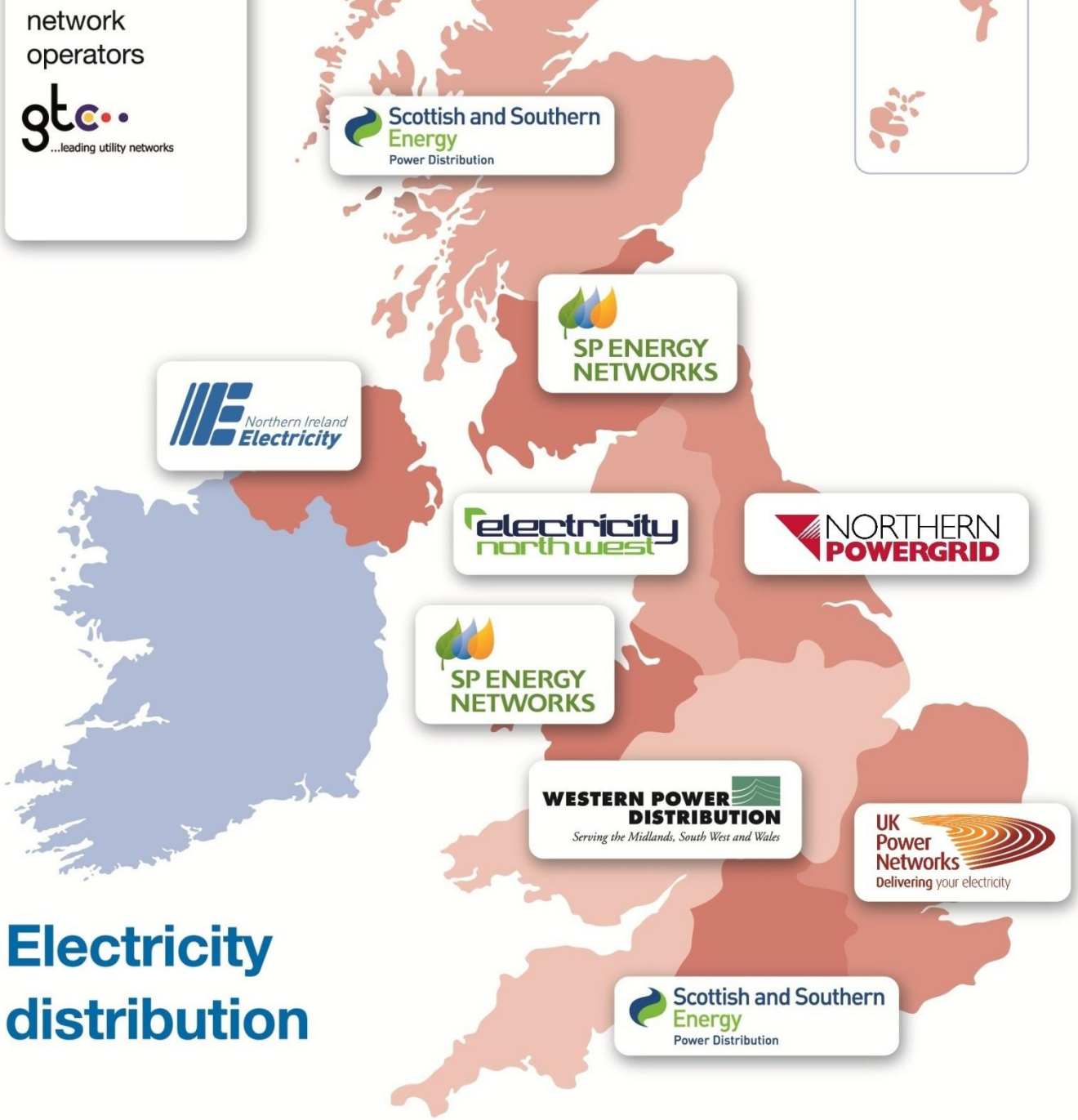
Generation – Nuclear

(Off shore wind and tidal assumed to have been designed to deal with storm surges etc)

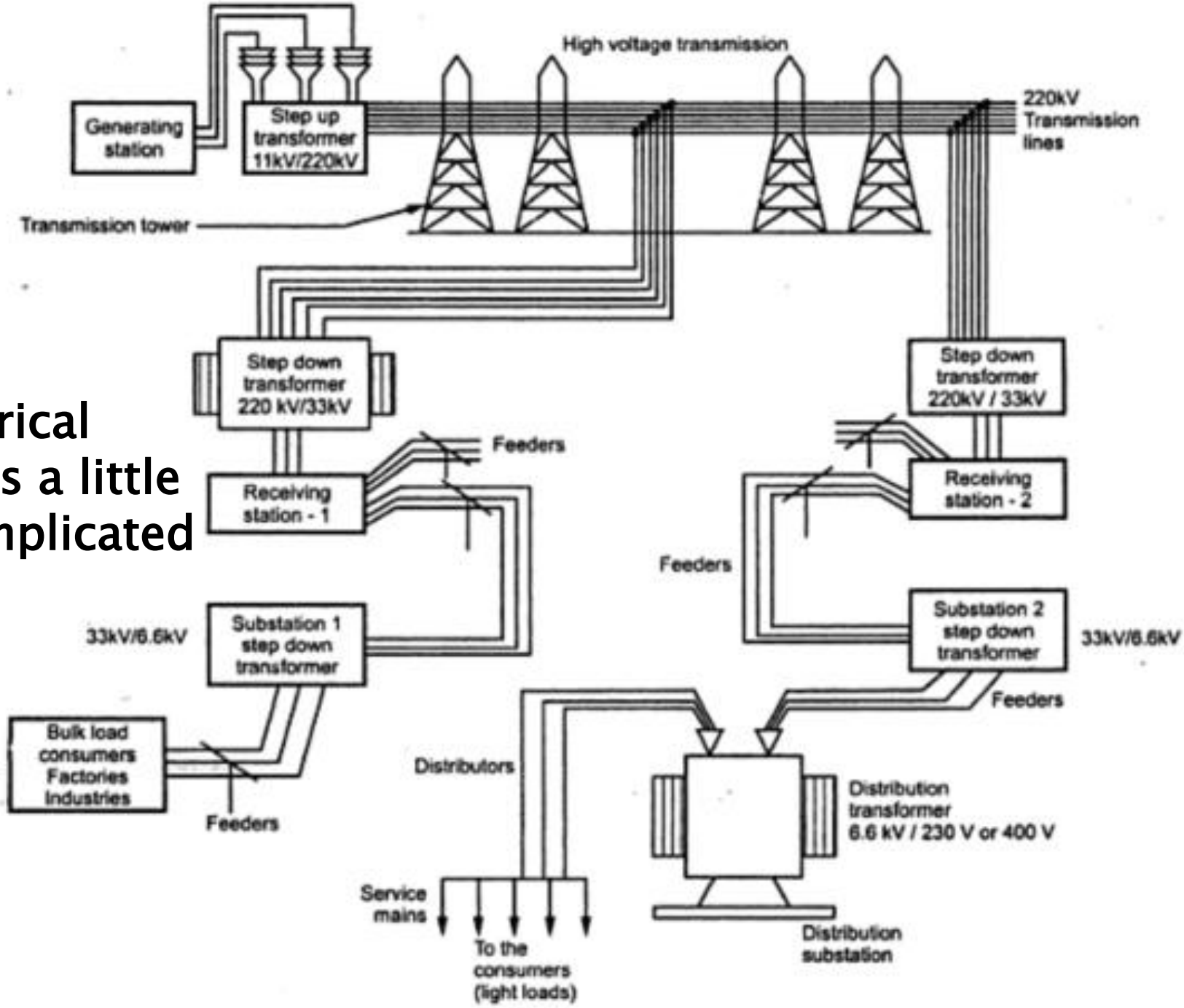
Transmission Network



Distribution



The electrical network is a little more complicated



- Nuclear plant are located near the coast.
- They are protected by flood defences.
- Costly but acceptable for a limited number of plant and given the value of the assets.
- But what about the unexpected?
- First vulnerability is the coastal generation.

- Hinkley Point Power Station
- Location of nuclear generation and for the development of Hinkley C.

- The area surround Hinkley as it might have looked on 30th January 1607 following severe storms.

- All nuclear power stations have under gone a stress test (flooding, tsunami and earth quakes) and appropriate measures taken to ensure the necessary safeguards are in place.
- So the risks have been identified and appropriate measures have been put in place (eg more protection for the electrical infrastructure for services to the reactor).
- Main risks are loss of power can connection to the grid; failure of control and ancillary equipment (eg pumps etc).


An electrical substation
Note the size
Assorted cables
ALIVE
Bund area

Flooding / tidal surges

Transmission Substation with temporary flood defence

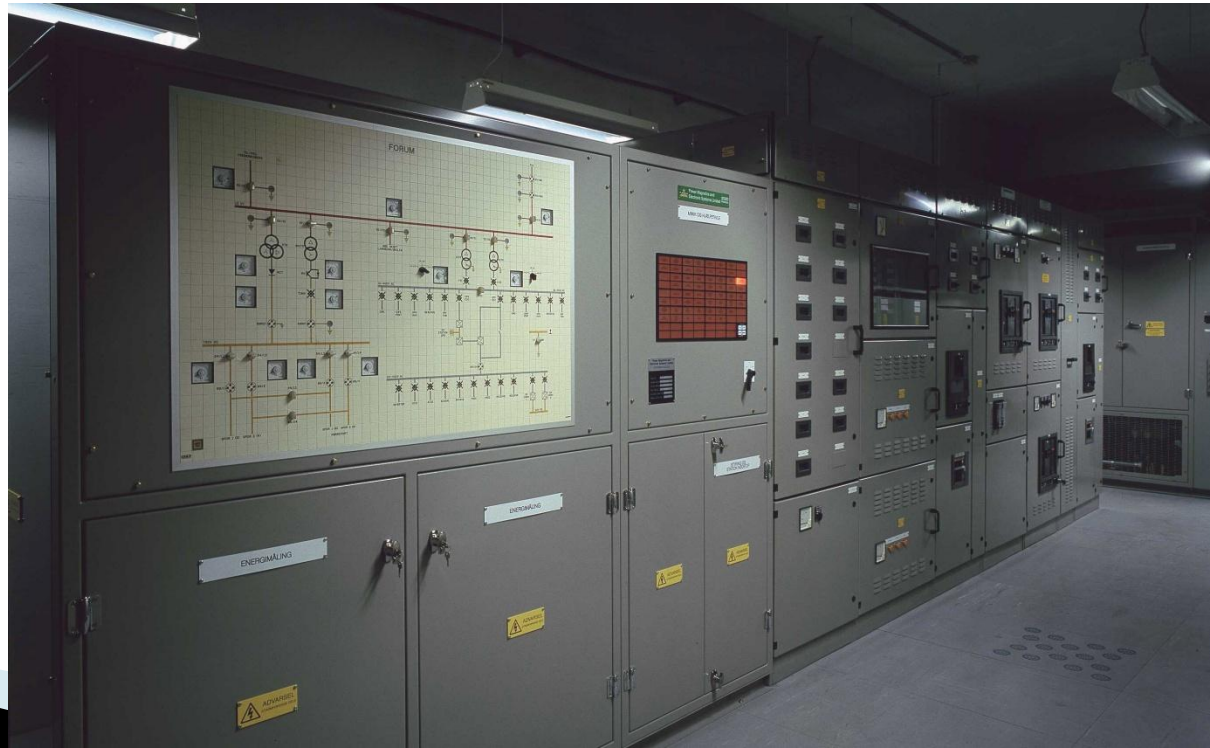
Substation with permanent flood defence

Vulnerabilities

- Electricity and water are an explosive mix. (http://wtvr.com/2012/10/30/explosion-at-new-york-substation-caught-on-tape/).
- Considerable damage can be done if the substation remains operational and if damaged it cannot be easily fixed.
- Water shorts out high voltage and low voltage terminals. The fault current can be several tens of thousands of amperes can cause copper “busbars” to melt.
- Transformers and control equipment are vulnerable.
- Transformers are filled with oil so potential pollution.
- Many transformers are “free breathers” ie have a vent to the atmosphere.
- Water in oil can lead to reduced insulation and leads to flashovers.

Vulnerabilities – continued

- Control and protection equipment for the network is often located on the ground.
- Battery back up systems are also located on the ground floor in a substation.

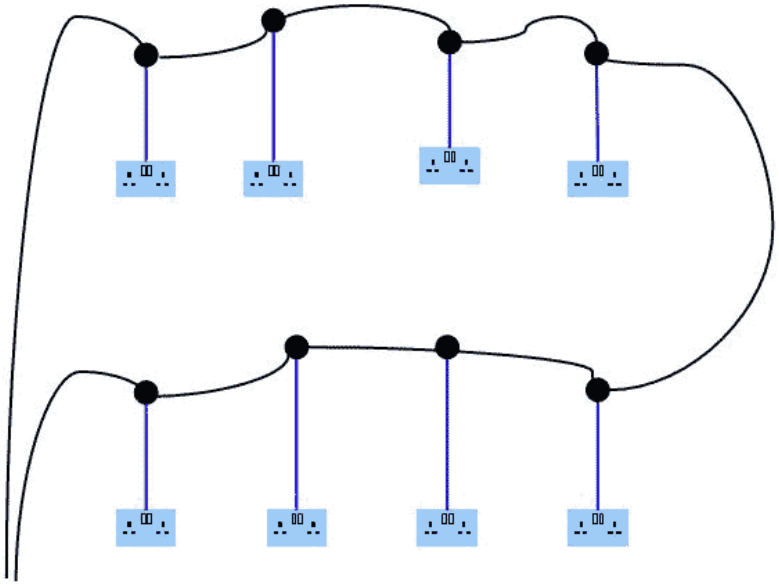


- The number of transformers increase as the voltage level reducers.
  - At transmission ~ 400
  - At distribution level to the home ~ tens of thousands.
- The number of customers disconnected
  - Transmission transformer ~ thousands
  - Distribution transformer to the home ~ tens
- Replacement costs
  - Transmission ~ a few £M
  - Distribution ~ a few £10k

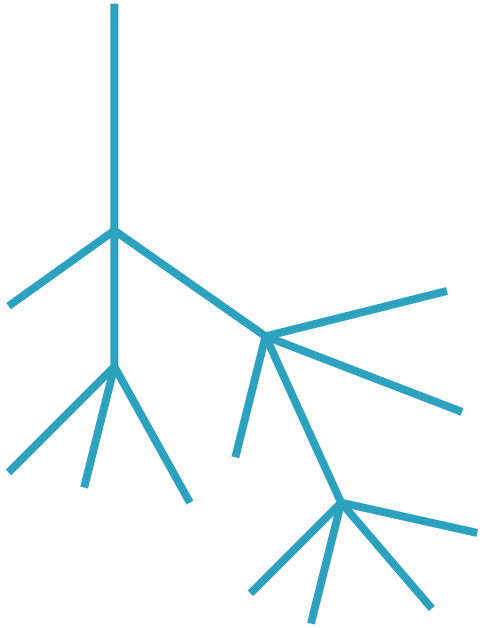
Options – Short term

- Cannot alter the network infrastructure in the short term.
- Assess the risk, probability and impact of flooding for substations.
- Mitigate the risks (eg build flood barriers around the most likely and critical substations ie Transmission and some distribution.
- Install water proof transformers when replacing older transformers.
- Design and location of new substations to withstand flooding etc (not in low lying areas or areas deemed at risk of flooding).
- More ring rather than radial connections.

Ring versus radial network



Ring



Radial

Options – Long term

- Reconfiguration of the power network to avoid areas prone to flooding. This may also happen as populations move away from these areas.
- More resilient power equipment.
- Substations design to mitigate the risks of flooding.
- New forms of electrical power generation may not need to be located on the coast. If they are located on the coast better design, location etc will reduce the risks.

ABB undersea transformer

An off shore substation

Conclusion

- The present electrical power infrastructure in coastal and other areas is vulnerable to sea level rise and storm surges.
- Mitigation through flood defences can reduce the risk in the short term.
- Changing the topology of the network could help to alleviate some of the disconnection problems but will not stop the flooding.
- As the power network is “renewed” better design of substations and generation units with better rated equipment .
- There is a balance between cost and risk.

End