Plant Systems Modeling

Workshop 3

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Learning Objectives

- Introductory knowledge of typical NPP systems, structures, and components (SSCs) modeled in PRAs
- Practice with thought process, elements, and mechanics of NPP PRA

Important:

a) The workshop problems can be performed as group exercises.

b) The purpose is to exercise the modeling thought process, not to get the "right answer."

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Fenwick 1 NPP – Background

In an effort to expand its footprint in a global marketplace, the Grand Duchy of Fenwick has decided to build a distillery to mass produce a brandy based on their famous Pinot Grand Fenwick wine. akaKaro Engineering, a boutique firm known in some circles for its excellence in technical editing but not yet well-practiced in nuclear power plant design, has proposed that the Duchy use a small boiling water reactor to provide process heat to the distillery, as well as electric power for domestic use and export.

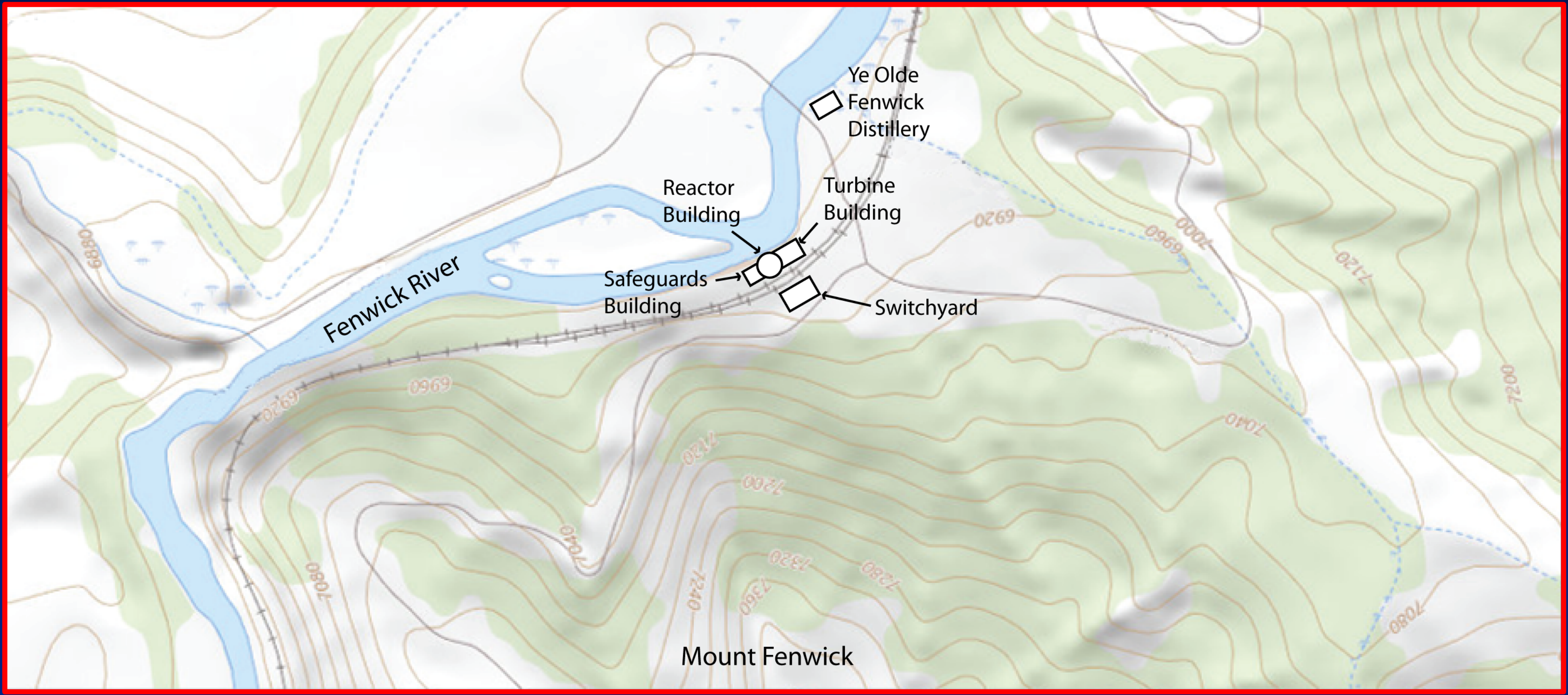
The proposed plant would be located at the foot of Mount Fenwick and overlooking the scenic Fenwick River, the Duchy’s lone river. (This location would provide a unique and attractive location for aprés skiing events.) Substantial capital cost reductions would be achieved through: a) the elimination of multiple components found in most nuclear power plant designs and b) the use of identical components (e.g., for valves and electrical breakers) whenever possible.

Fenwick 1 NPP – Other Notable Features

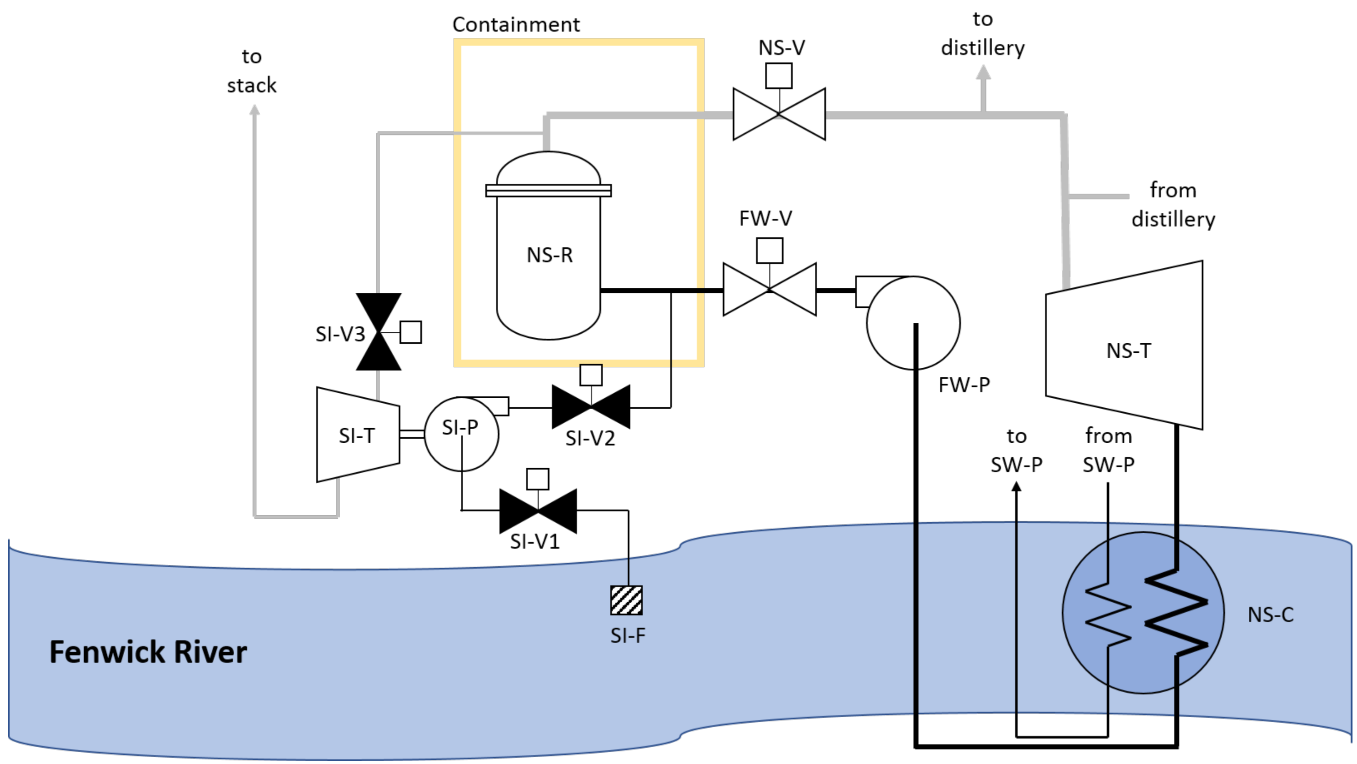
Other notable features of the proposed, conceptual design are as follows.

- Use of the Fenwick River to provide the normal and emergency ultimate heat sinks
- Direct use of reactor steam to provide process heat to the distillery
- A novel, submerged condenser for normal heat rejection
- A backup, water-cooled emergency diesel generator to provide onsite power should offsite power be lost
- A backup, dual-drive safety injection pump to provide cooling water. The pump would normally be electric-motor driven, but a steam-driven turbine could be connected to the pump should all power be lost.
- A direct vent to the atmosphere for reactor steam used to drive the backup safety injection system turbine
- A containment building to contain radioactive releases, should a severe accident occur
- Major components in the Nuclear Steam Supply System (NSSS) and electrical distribution system (with key loads) are shown on the following pages. The mechanical components are designated by system (e.g., “SI” for safety injection” and type (e.g., “P” for pump). The electrical components are designated by electrical bus (e.g., “A” for the 6.9 kV emergency power bus) and type (e.g., “X” for transformer).

Fenwick 1 Location and Plan



Fenwick 1 – NSSS and Safety System (Schematic)



Designator	Description
Pre-hyphen	
FW	Feedwater
NS	NSSS
SI	Safety Injection
SW	Service Water
Post-hyphen	
C	Condenser
F	Filter
P	Pump
R	Reactor
V	Valve
T	Turbine
Other	
NSSS	Nuclear Steam Supply

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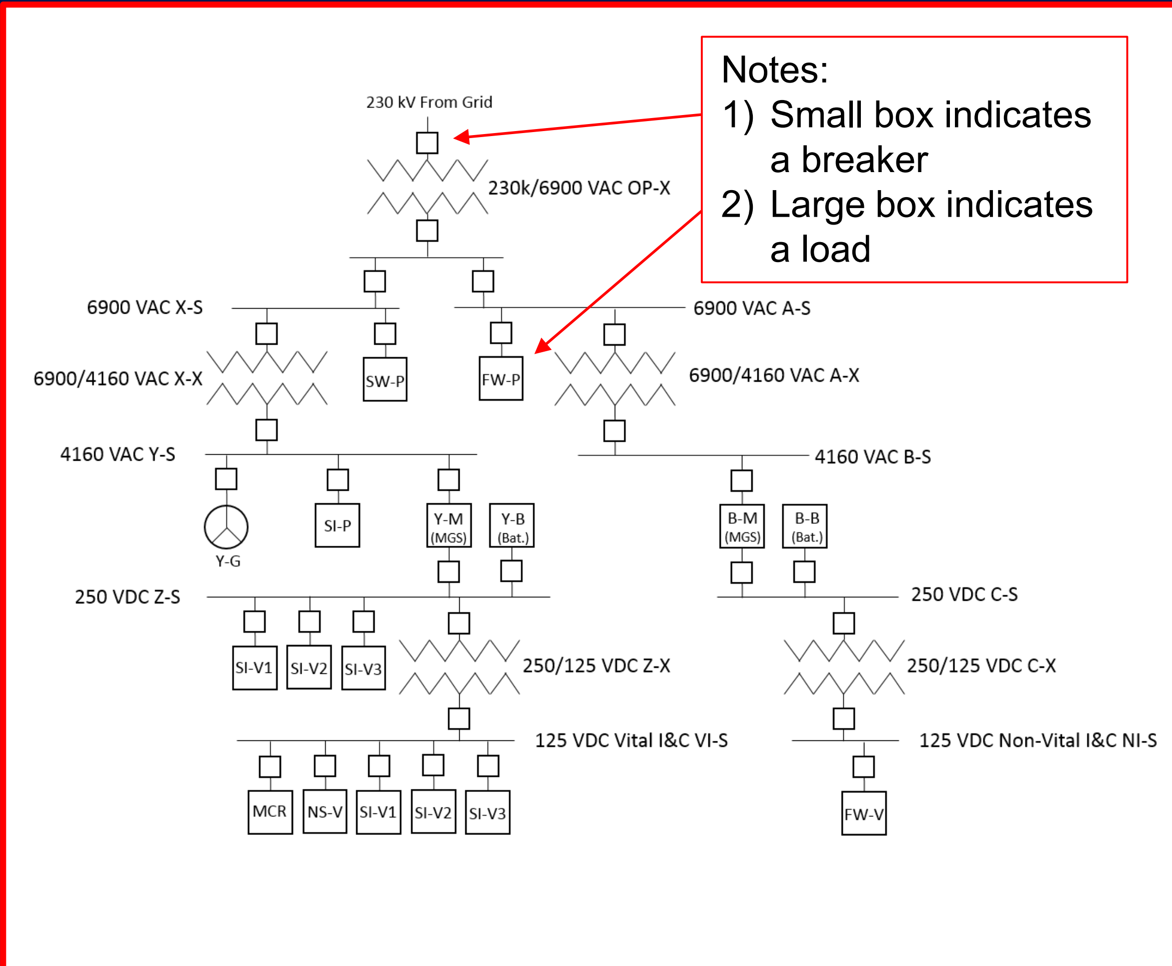
Fenwick 1 – Electrical Distribution



Designator	***Description***
Pre-hyphen	
A	6900 VAC non-vital bus A
B	4160 VAC non-vital bus B
C	250 VDC non-vital bus C
FW	Feedwater
NI	125 VDC non-vital I&C bus NV
NS	NSSS
SI	Safety Injection
SW	Service Water
VI	125 VDC vital I&C bus VI
X	6900 VAC vital bus X
Y	4160 VAC vital bus Y
Z	250 VDC vital bus Z
Post-hyphen	
B	Battery
C	Condenser
F	Filter
G	Emergency Diesel Generator
M	MGS
P	Pump
R	Reactor
S	Switchgear/M-CC/Distribution Panel
V	Valve
T	Turbine
X	Transformer
Other	
Bat.	Battery
M-CC	Motor Control Center
MCR	Main Control Room
MGS	Motor Generator Set
NSSS	Nuclear Steam Supply System
VAC	Volts (Alternating Current)
VDC	Volts (Direct Current)

Exercises*

1. Initiating Event Identification
   a. Identify some potentially important initiating events for the plant. For each event, describe: (i) why you think it is an initiating event, and (ii) why you think it's potentially important.
   b. Identify some potentially important external hazards for the plant. For each hazard, describe why you think it's potentially important.
2. Event Tree Development

   Select an initiating event and develop an event tree for plant response following that initiating event.
3. Fault Tree Development
   a. Develop a fault tree for the SI system. Identify the minimal cut sets.
   b. If time permits, (i) develop fault trees for all of the top events in your event tree and (ii) identify some minimal cut sets for core damage.