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Thermodynamic Evaluation of Coupling APR-1400 with a Thermal Desalination Plant

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Abstract : Growing human populations have placed increased demands on water supplies and a heightened interest in desalination infrastructure. Key elements of the economics of desalination projects are thermal and electrical inputs. With growing concerns over the use of fossil fuels to (indirectly) supply these inputs, coupling of desalination with nuclear power production represents a significant opportunity. Individually, nuclear and desalination technologies have a long history and are relatively mature. For desalination, Reverse Osmosis (RO) has the lowest energy inputs. However, the economically driven output quality of the water produced using RO, which uses only electrical inputs, is lower than the output water quality from thermal desalination plants. Therefore, modern desalination projects consider that RO should be coupled with thermal desalination technologies (MSF, MED, or MED-TVC) with attendant steam inputs to permit blending to produce various qualities of water. A large nuclear facility is well positioned to dispatch large quantities of both electrical and thermal power. This paper considers the supply of thermal energy to a large desalination facility to examine heat balance impact on the nuclear steam cycle. The APR1400 nuclear plant is selected as prototypical from both a capacity and turbine cycle heat balance perspective to examine steam supply and the impact on electrical output. Extraction points and quantities of steam are considered parametrically along with various types of thermal desalination technologies to form the basis for further evaluations of economically optimal approaches to the interface of nuclear power production with desalination projects. In our study, the thermodynamic evaluation will be executed by DE-TOP which is the IAEA desalination program, it is approved to be capable of analyzing power generation systems coupled to desalination systems through various steam extraction positions, taking into consideration the isolation loop between the APR-1400 and the thermal desalination plant for safety concern.

Keywords : APR-1400, desalination, DE-TOP, IAEA, MSF, MED, MED-TVC, RO
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