ECE 558 - Project 5 Solutions

1. Increase in PLCC (at 0.1 day/year) due to additional 60 MW unit is 45 MW.
   In Project 4, problem 2, the risk level is met at 153.95 MW.
   In Project 4, problem 3, the risk level is met at 198.86 MW.

2. 100 MW installed capacity, 70 MW peak load at 80% load factor
   Calculate LOEE, EIR, EENS, and EES by each unit

Total energy demand = 100 days * 24 hours/day * 70 MW * .8 load factor = 134,400 MWh

40 MW unit only

Cap Out	Cap Avail	Ind Prob	Energy Cut	Prob Curtail (MWh)
0	40	8.600e-001	38400.0	3.302e+004
20	20	6.000e-002	86400.0	5.184e+003
40	0	8.000e-002	134400.0	1.075e+004
			LOEE	4.896e+004
			LOEEpu	0.364286
			EIR	0.635714

EES by 40 MW unit = 134400 - 48960 = 85440 MWh

40 MW, 30 MW units

Cap Out	Cap Avail	Ind Prob	Energy Cut	Prob Curtail (MWh)
0	70	7.912e-001	0.0	0.000e+000
10	60	0.000e+000	4285.7	0.000e+000
20	50	5.520e-002	17142.9	9.463e+002
30	40	6.880e-002	38400.0	2.642e+003
40	30	7.360e-002	62400.0	4.593e+003
50	20	4.800e-003	86400.0	4.147e+002
60	10	0.000e+000	110400.0	0.000e+000
70	0	6.400e-003	134400.0	8.602e+002
			LOEE	9.456e+003
			LOEEpu	0.070355
			EIR	0.929645

EES by 30 MW unit = 48960 - 9456 = 39504 MWh

40 MW, 30 MW, 20 MW units

Cap Out	Cap Avail	Ind Prob	Energy Cut	Prob Curtail (MWh)
0	90	7.279e-001	0.0	0.000e+000
10	80	0.000e+000	0.0	0.000e+000
20	70	1.141e-001	0.0	0.000e+000
30	60	6.330e-002	4285.7	2.713e+002
40	50	7.213e-002	17142.9	1.236e+003
50	40	9.920e-003	38400.0	3.809e+002
60	30	5.888e-003	62400.0	3.674e+002
70	20	6.272e-003	86400.0	5.419e+002
80	10	0.000e+000	110400.0	0.000e+000
90	0	5.120e-004	134400.0	6.881e+001
			LOEE	2.867e+003
			LOEEpu	0.021330
			EIR	0.978670

EES by 20 MW unit = 9456 - 2867 = 6589 MWh

All units

Cap Out	Cap Avail	Ind Prob	Energy Cut	Prob Curtail (MWh)
0	100	6.697e-001	0.0	0.000e+000
10	90	5.823e-002	0.0	0.000e+000
20	80	1.050e-001	0.0	0.000e+000
30	70	6.736e-002	0.0	0.000e+000
40	60	7.142e-002	4285.7	3.061e+002
50	50	1.490e-002	17142.9	2.554e+002
60	40	6.211e-003	38400.0	2.385e+002
70	30	6.241e-003	62400.0	3.895e+002
80	20	5.018e-004	86400.0	4.335e+001
90	10	4.710e-004	110400.0	5.200e+001
100	0	4.096e-005	134400.0	5.505e+000

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                                          LOEE 1.290e+003
                                        LOEEpu 0.009600
                                           EIR 0.990400
EES by 10 MW unit = 2867 - 1290 = 1577 MWh
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3. 230 MW installed capacity, 150 MW to 200 MW peak load at 70% load factor
   Calculate LOLEs given a load forecast distribution

NOTE: The LOLE values at each deviation level come from last week's project.

Dev (MW)	Ind Prob	LOLE	Prob LOLE
-10	0.2	0.0490	0.0098
0	0.6	0.0857	0.0514
10	0.2	0.1205	0.0241

LOLE (150 MW peak load) = 0.0854

Dev (MW)	Ind Prob	LOLE	Prob LOLE
-10	0.2	0.0857	0.0171
0	0.6	0.1205	0.0723
10	0.2	0.1513	0.0303

LOLE (160 MW peak load) = 0.1197

Dev (MW)	Ind Prob	LOLE	Prob LOLE
-10	0.2	0.1205	0.0241
0	0.6	0.1513	0.0908
10	0.2	0.8311	0.1662

LOLE (170 MW peak load) = 0.2811

Dev (MW)	Ind Prob	LOLE	Prob LOLE
-10	0.2	0.1513	0.0303
0	0.6	0.8311	0.4987
10	0.2	2.0576	0.4115

LOLE (180 MW peak load) = 0.9404

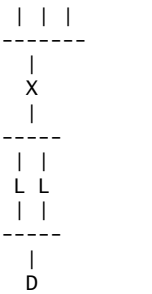
Dev (MW)	Ind Prob	LOLE	Prob LOLE
-10	0.2	0.8311	0.1662
0	0.6	2.0576	1.2345
10	0.2	3.5952	0.7190

LOLE (190 MW peak load) = 2.1198

Dev (MW)	Ind Prob	LOLE	Prob LOLE
-10	0.2	2.0576	0.4115
0	0.6	3.5952	2.1571
10	0.2	4.9863	0.9973

LOLE (200 MW peak load) = 3.5659

4. 100 MW installed capacity, 70 MW peak load at 80% load factor
   Calculate LOLE for the following system:



   where G represents a 25 MW generator unit, X represents a 110 MVA transformer, L represents a 50 MW transmission line, and D represents a 70 MW peak load.

LOLE for generation only

Cap Out	Cap Avail	Cum Prob	Time Interval	Prob Curtail (day)
0	100	1.000e+000	0.00	0.000e+000
25	75	7.763e-002	0.00	0.000e+000
50	50	2.336e-003	260.71	6.092e-001

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     75         25  3.152e-005         104.29          3.287e-003
    100          0  1.600e-007           0.00          0.000e+000
                                                 LOLE 6.124e-001
LOLE for transformer only
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Cap Out  Cap Avail    Cum Prob  Time Interval  Prob Curtail (day)
      0        110  1.000e+000           0.00          0.000e+000
    110          0  2.000e-003         365.00          7.300e-001
                                                 LOLE 7.300e-001
U=MTTR/(MTTF+MTTR)=1/(365/2 + 1)=0.0054
LOLE for trans. lines only
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Cap Out  Cap Avail    Cum Prob  Time Interval  Prob Curtail (day)
      0        100  1.000e+000           0.00          0.000e+000
     50         50  1.087e-002         260.71          2.834e+000
    100          0  2.970e-005         104.29          3.097e-003
                                                 LOLE 2.837e+000

The "union" of cumulative probabilities yields
   Pr(G&Xout >=   0) = Pr(Gout >=   0) + Pr(Xout >=   0) - Pr(Gout >=   0)*Pr(Xout >=   0)
               .
               .
   Pr(G&Xout >= 100) = Pr(Gout >= 100) + Pr(Xout >= 100) - Pr(Gout >= 100)*Pr(Xout >= 100)

Cum Prob for gen and xfmr
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Cap Out  Cap Avail    Cum Prob
      0        100  1.000e+000
     25         75  7.948e-002
     50         50  4.332e-003
     75         25  2.031e-003
    100          0  2.000e-003

Combine G&X subsystem above with transmission line subsystem via the union of cum. probs.

LOLE for entire system
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Cap Out  Cap Avail    Cum Prob  Time Interval  Prob Curtail (day)
      0        100  1.000e+000           0.00          0.000e+000
     25         75  8.948e-002           0.00          0.000e+000
     50         50  1.515e-002         260.71          3.951e+000
     75         25  2.061e-003         104.29          2.149e-001
    100          0  2.030e-003           0.00          0.000e+000
                                                 LOLE 4.166e+000
NOTE:  sum of individual LOLEs
   0.6124+0.73+2.837 = 4.179
is greater than actual system LOLE, since independent systems (e.g., generation, transformer
and transmission lines) can have outages at the same time.
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