Appendix

Results and Computer Code

Table A1.

RuMod_Opt_200703 RESULTS from Peter Lohmander

kW	y1opt	ytopt	ytotopt	OBJFopt	PVWopt	PVRopt	PVCopt	WFINALopt	XppmTopt
0.000	4.900	38.000	186.200	201.889	2159.419	537.946	336.057	85.716	385.824
30.000	5.200	38.000	197.600	2773.885	2159.894	564.933	363.813	85.759	385.665
60.000	5.400	38.000	205.200	5347.011	2160.210	582.544	382.777	85.787	385.559
90.000	5.700	38.000	216.600	7921.195	2160.684	608.387	411.913	85.830	385.400
120.000	5.900	38.000	224.200	10496.486	2160.999	625.234	431.798	85.859	385.294
150.000	6.200	38.000	235.600	13072.843	2161.474	649.934	462.315	85.901	385.134
180.000	5.700	56.000	319.198	15652.145	2160.291	660.084	492.727	86.027	384.667
210.000	5.900	58.000	342.198	18233.824	2160.665	679.065	523.402	86.086	384.442
240.000	6.100	60.000	365.998	20817.336	2161.037	697.000	554.745	86.146	384.218
270.000	6.300	60.000	377.998	23402.313	2161.380	712.530	580.050	86.185	384.074
300.000	6.600	60.000	395.997	25988.730	2161.892	734.953	618.856	86.242	383.857
330.000	6.800	60.000	407.997	28576.561	2162.234	749.321	645.291	86.280	383.712
360.000	7.100	60.000	425.997	31165.795	2162.745	770.000	685.791	86.338	383.495
390.000	7.300	60.000	437.997	33756.434	2163.087	783.206	713.356	86.376	383.351
420.000	7.600	60.000	455.997	36348.449	2163.598	802.142	755.551	86.433	383.134
450.000	7.800	60.000	467.997	38941.898	2163.939	814.185	784.246	86.471	382.989
480.000	8.000	60.000	479.997	41536.684	2164.280	825.763	813.392	86.509	382.844
510.000	8.300	60.000	497.997	44132.883	2164.791	842.258	857.960	86.566	382.627
540.000	8.500	60.000	509.997	46730.430	2165.131	852.674	888.236	86.604	382.483
570.000	8.800	60.000	527.997	49329.324	2165.641	867.426	934.498	86.660	382.266
600.000	9.000	60.000	539.997	51929.605	2165.980	876.679	965.904	86.698	382.121

```
REM
REM RuModPL_200703
REM Peter Lohmander

OPEN "Out_RuMod_Opt_200703.txt" FOR OUTPUT AS #1

DIM x(100), xppm(100), y(100), u(100)
DIM W(100), R(100), C(100), disc(100)

REM Allprint = 1 if all results should be printed
AllPrint = 0

REM x0_ppm = x0/(2.13*3.664)
x0 = 3230.747
x0_ppm = 413.96911

a0 = 40.951
ax = -0.0187191
R = 0.03

wx = 0.7142857
wxx = -0.001275510
Ry = 0.2
Ryy = -0.0002
Cu = 2
Cuu = 0.2

REM objective function weights
kW = 1
kR = 1
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```
kC = 1


FOR t = 0 TO 100
   disc(t) = EXP(-R * t)
NEXT t

PRINT #1, "RuMod_Opt_200703 RESULTS from Peter Lohmander"
PRINT ""
PRINT #1, "      kW    y1opt    ytopt  ytotopt  OBJFopt   PVWopt   PVRopt   PVCopt
WFINALopt  XppmTopt"

FOR kWindex = 0 TO 20
   kW = kWindex * 30

   REM t = 0 in year 2020 and t = 80 at the horizon, year 2100.
   REM y1 = d(area)/dt from year 2020 until yt.

   REM yt is the end of the area expansion period.

   OBJFopt = -1
   y1opt = -1
   ytopt = -1
   ytotopt = -1
   PVWopt = -1
   PVRopt = -1
   PVCopt = -1


   FOR y1 = 0 TO 10 STEP 0.1
      FOR yt = 10 TO 60 STEP 0.1

         REM Period 1 (year 2020 until year 2020 + yt)
         x0 = 3230.747
         m0 = 38.8818
         m1 = -0.48602 - 0.003 * y1
         k1 = -m1 / ax
         k0 = -(a0 + m0 + m1 / ax) / ax



         FOR t = 0 TO yt
            x(t) = (x0 - k0) * EXP(ax * t) + k0 + k1 * t

            y(t) = y1 * t
            u(t) = y1
         NEXT t

         REM Period 2 (year 2020+yt+1 until year 2100)
         x02 = x(yt)
```

```
m02 = m0 + m1 * yt
m12 = -0.48602
k12 = -m12 / ax
k02 = -(a0 + m02 + m12 / ax) / ax

FOR t = (yt + 1) TO 80
   t2 = t - yt
   x(t) = (x02 - k02) * EXP(ax * t2) + k02 + k12 * t2
   y(t) = y1 * yt
   u(t) = 0
NEXT t
FOR t = 0 TO 80
   xppm(t) = x(t) / (2.13 * 3.664)
NEXT t

REM Objective function values
FOR t = 0 TO 80
   W(t) = wx * xppm(t) + wxx * xppm(t) * xppm(t)
   R(t) = Ry * y(t) + Ryy * y(t) * y(t)
   C(t) = Cu * u(t) + Cuu * u(t) * u(t)
NEXT t

REM Objective function calculations
PVW = 0
PVR = 0
PVC = 0
WFINAL = W(80)
FOR t = 0 TO 80
   PVW = PVW + W(t) * disc(t)
   PVR = PVR + R(t) * disc(t)
   PVC = PVC + C(t) * disc(t)
   OBJF = kW * WFINAL + kR * PVR - kC * PVC
NEXT t


REM The latest preliminary optimum is selected

IF OBJF > OBJFopt THEN y1opt = y1
IF OBJF > OBJFopt THEN ytopt = yt
IF OBJF > OBJFopt THEN ytotopt = y1 * yt
IF OBJF > OBJFopt THEN PVWopt = PVW
IF OBJF > OBJFopt THEN PVRopt = PVR
IF OBJF > OBJFopt THEN PVCopt = PVC
IF OBJF > OBJFopt THEN WFINALopt = WFINAL
IF OBJF > OBJFopt THEN XppmTopt = xppm(80)
IF OBJF > OBJFopt THEN OBJFopt = OBJF


IF AllPrint < 1 THEN GOTO 100
```

```
PRINT #1, ""
PRINT #1, "(y1, yt) = "; "("; y1; ","; yt; ") **********"
PRINT #1, "OBJF = "; OBJF
PRINT #1, "PVW = "; PVW
PRINT #1, "PVR = "; PVR
PRINT #1, "PVC = "; PVC

PRINT #1, "t = ";
FOR t = 0 TO 80 STEP 10
   PRINT #1, USING "#######"; t;
NEXT t
PRINT #1, ""

PRINT #1, "x(t) = ";
FOR t = 0 TO 80 STEP 10
   PRINT #1, USING "#######"; x(t);
NEXT t
PRINT #1, ""

PRINT #1, "xppm(t)";
FOR t = 0 TO 80 STEP 10
   PRINT #1, USING "#######"; xppm(t);
NEXT t
PRINT #1, ""

PRINT #1, "y(t) = ";
FOR t = 0 TO 80 STEP 10
   PRINT #1, USING "#####.#"; y(t);
NEXT t
PRINT #1, ""

PRINT #1, "u(t) = ";
FOR t = 0 TO 80 STEP 10
   PRINT #1, USING "####.##"; u(t);
NEXT t
PRINT #1, ""

PRINT #1, "W(t) = ";
FOR t = 0 TO 80 STEP 10
   PRINT #1, USING "#####.#"; W(t);
NEXT t
PRINT #1, ""

PRINT #1, "R(t) = ";
FOR t = 0 TO 80 STEP 10
   PRINT #1, USING "#####.#"; R(t);
NEXT t
PRINT #1, ""

PRINT #1, "C(t) = ";
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```
        FOR t = 0 TO 80 STEP 10
           PRINT #1, USING "#####.#"; C(t);
        NEXT t
        PRINT #1, ""

        100 REM

      NEXT yt
   NEXT y1

   PRINT #1, USING "######.###"; kW; y1opt; ytopt; ytotopt; OBJFopt; PVWopt; PVRopt;
PVCopt; WFINALopt; XppmTopt

NEXT kWindex
CLOSE #1
END
```