

```

1
2 *****»
3 ***
4 $ontext
5 The Dispatch and Investment Evaluation Tool with Endogenous Renewables (DIETE»
6 R).
7 Version 1.2.0, February 2017.
8 Written by Alexander Zerrahn and Wolf-Peter Schill.
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11 t-license.php.
12 Whenever you use this code, please refer to http://www.diw.de/dieter.
13 We are happy to receive feedback under azerrahn@diw.de and wschill@diw.de.
14 $offtext
15 *****»
16 ***
17
18 *****
19 ***** GLOBAL OPTIONS *****
20 *****
21
22 * Set star to skip Excel upload and load data from.gdx
23 $setglobal skip_Excel ""
24
25 * Choose base year
26 $setglobal base_year "'2013'"
27
28 * Set star to activate options
29 $setglobal DSM ""
30 $setglobal reserves ""
31 $setglobal EV ""
32 $setglobal prosumage "*"
33
34 $setglobal EV_EXOG ""
35
36 * Set star to indicate renewables constraint on electric vehicles - DEFAULT i»
37 s same quota as for the rest of the electricity system
38 $setglobal EV_DEFAULT ""
39 $setglobal EV_100RES ""
40 $setglobal EV_FREE ""
41
42 * Set star to select run-of-river options either as a simple exogenous parame»
43 ter or as an endogenous variable including reserve provision:
44 * if nothing is selected, ROR capacity will be set to zero
45 * if parameter option is selected, set appropriate values in fix.gmx
46 * if variable option is selected, set appropriate bound in data_input excel
47 $setglobal ror_parameter "*"
48 $setglobal ror_variable ""
49
50 * Set star to determine loops, otherwise default 100% renewables
51 $setglobal loop_over_renewable_share "*"
52
53 * Set star to run test variant with each second hour
54 $setglobal second_hour ""
55
56 * Set star for no crossover to speed up calculation time by skipping crossove»
57 r in LP solver
58 $setglobal no_crossover "*"
59
60 * Set reporting sensitivity. All results below will be reported as zero
61 $setglobal eps_rep_rel Sensitivity for shares defined between 0 and 1 / 1e»

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-4 / ;
55 Scalar eps_rep_abs Sensitivity for absolute values - e.g. hourly / 1e»
-2 / ;
56 Scalar eps_rep_ins Sensitivity for absolute values - e.g. installed MW / 1 »
/ ;
57
58 *****»
***
59
60 * Definition of strings for report parameters and sanity checks
61 * (Do not change settings below)
62 $setglobal sec_hour "1"
63
64 %second_hour%$ontext
65 $setglobal sec_hour "8760/2208"
66 $ontext
67 $offtext
68
69 * Sanity checks
70 $if "%ror_parameter%" == "" $if "%ror_variable%" == "" $abort Choose approp»
riate ROR option! ;
71
72 $if "%EV%" == "" $if "%EV_EXOG%" == "" $abort Switch on EV! ;
73
74 $if "%EV%" == "" $if "%EV_DEFAULT%%EV_100RES%%EV_FREE%" == "" $abort Choose »
exactly one EV option! ;
75 $if "%EV%" == "" $if "%EV_DEFAULT%%EV_100RES%%EV_FREE%" == "" $abort Choos»
e exactly one EV option! ;
76 $if "%EV%" == "" $if "%EV_DEFAULT%%EV_100RES%%EV_FREE%" == "" $abort Choo»
se exactly one EV option! ;
77
78 $if "%EV_EXOG%" == "" $if "%EV_DEFAULT%%EV_100RES%%EV_FREE%" == "" $abort Ch»
oose exactly one EV option! ;
79 $if "%EV_EXOG%" == "" $if "%EV_DEFAULT%%EV_100RES%%EV_FREE%" == "" $abort »
Choose exactly one EV option! ;
80 $if "%EV_EXOG%" == "" $if "%EV_DEFAULT%%EV_100RES%%EV_FREE%" == "" $abort»
Choose exactly one EV option! ;
81
82 *****»
***
83
84 *****
85 ***** SOLVER OPTIONS *****
86 *****
87
88 options
89 optcr = 0.00
90 reslim = 10000000
91 lp = cplex
92 mip = cplex
93 nlp = conopt
94 ;
95
96 options
97 dispwidth = 15
98 limrow = 0
99 limcol = 0
100 solprint = off
101 sysout = off
102 ;
103

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104 *****»
105 ***
106 Sets
107 year      yearly time data          /2011, 2012, 2013, 2013_wind»
108          onsmooth/
109 ct      Dispatchable Technologies      /ror, nuc, lig, hc, CCGT, OC»
110          GT_eff, OCGT_ineff, bio/
111 ct_ren(ct)      Renewable dispatchable technologies      /ror, bio/
112 ct_the(ct)      Thermal dispatchable technologies      /nuc, lig, hc, CCGT,»
113          OCGT_eff, OCGT_ineff/
114 res      Renewable technologies      /Wind_on, Wind_off, Solar/
115 sto      Storage technolgies      /Sto1*Sto7/
116 ev      Set of 28 EV profiles      /ev1*ev28/
117 dsm_shift DSM shifting technologies      /DSM_shift1*DSM_shift5/
118 dsm_curt Set of load curtailment technologies      /DSM_curt1*DSM_curt3/
119 reserves Set of reserve qualities      /PR_up, PR_do, SR_up, SR_do,»
120          MR_up, MR_do/
121 reserves_up(reserves) Set of positive reserve qualities      /PR_up, SR_up»
122          , MR_up/
123 reserves_do(reserves) Set of positive reserve qualities      /PR_do, SR_do»
124          , MR_do/
125 reserves_spin(reserves) Set of spinning reserves      /PR_up, PR_do»
126          , SR_up, SR_do/
127 reserves_nonspin(reserves) Set of nonspinning reserves      /MR_up, MR_do»
128          /
129 %second_hour%h hour      /h1*h8760/
130 %second_hour%$ontext
131 $include second_hour.gms
132 $ontext
133 $offtext
134 %loop_over_renewable_share%$ontext
135 loop_res_share      Solution loop for different shares of renewables      /eps/
136 $ontext
137 $offtext
138 %EV%$ontext
139 loop_ev      Solution loop for different fleets of EVs      /0, 1»
140          e+6, 2e+6, 4e+6, 8e+6, 16e+6, 32e+6/
141 $ontext
142 $offtext
143 %prosumage%$ontext
144 loop_prosumage      Solution loop for different prosumer self-consumption levels»
145          /40, 45, 50, 55, 60, 65, 70/
146 $ontext
147 $offtext
148 %loop_over_renewable_share%      loop_res_share      /100»
149          /
150 %EV%      loop_ev      /0/
151 %prosumage%      loop_prosumage      /0/
152 ;
153 Alias (h, hh) ;
154 alias (res, resres) ;
155 alias (reserves, reservesreserves) ;
156

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153
154 *****»
    ***
155
156 $include dataload.gms
157 *$stop
158
159 *****»
    ***
160
161 Variables
162 Z                Value objective function
163 ;
164
165 Positive Variables
166 G_L(ct,h)        Generation level in hour h in MWh
167 G_UP(ct,h)        Generation upshift in hour h in MWh
168 G_DO(ct,h)        Generation downshift in hour h in MWh
169
170 G_RES(res,h)      Generation renewables type res in hour h in MWh
171 CU(res,h)         Renewables curtailment technology res in hour h in MWh
172
173 STO_IN(sto,h)     Storage inflow technology sto hour h in MWh
174 STO_OUT(sto,h)    Storage outflow technology sto hour h in MWh
175 STO_L(sto,h)      Storage level technology sto hour h in MWh
176
177 EV_CHARGE(ev,h)   Electric vehicle charging vehicle profile ev hour h i»
    n MWh
178 EV_DISCHARGE(ev,h) Electric vehicle discharging vehicle profile ev hour »
    h in MWh
179 EV_L(ev,h)        Electric vehicle charging level vehicle profile ev ho»
    ur h in MWh
180 EV_PHEVFUEL(ev,h) Plug in hybrid electric vehicle conventional fuel use»
    vehicle profile ev hour h in MWh
181 EV_GED(ev,h)      Grid electricity demand for mobility vehicle profile »
    ev hour h in MWh
182
183 N_CON(ct)         Conventional technology ct built in MW
184 N_RES(res)        Renewable technology built in MW
185 N_STO_E(sto)      Storage technology built - Energy in MWh
186 N_STO_P(sto)      Storage loading and discharging capacity built - Capacity in»
    MW
187
188 DSM_CU(dsm_curt,h) DSM: Load curtailment hour h in MWh
189 DSM_UP(dsm_shift,h) DSM: Load shifting up hour h technology dsm in MWh
190 DSM_DO(dsm_shift,h,hh) DSM: Load shifting down in hour hh to account for up»
    shifts in hour h technology dsm in MWh
191
192 DSM_UP_DEMAND(dsm_shift,h) DSM: Load shifting up active for wholesale deman»
    d in hour h of technology dsm in MWh
193 DSM_DO_DEMAND(dsm_shift,h) DSM: Load shifting down active for wholesale dem»
    and in hour h of technology dsm in MWh
194
195 N_DSM_CU(dsm_curt) DSM: Load curtailment capacity in MW
196 N_DSM_SHIFT(dsm_shift) DSM: Load shifting capacity in MWh
197
198 RP_CON(reserves,ct,h) Reserve provision by conventionals »
    in hour h in MW
199 RP_RES(reserves,res,h) Reserve provision by renewables in »
    hour h in MW
200 RP_STO_IN(reserves,sto,h) Reserve provision by storage in in »

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    hour h in MW
201 RP_STO_OUT(reserves,sto,h)          Reserve provision by storage out in»
    hour h in MW
202 RP_EV_V2G(reserves,ev,h)           Reserve provision by electric vehic»
    les V2G hour h in MW
203 RP_EV_G2V(reserves,ev,h)           Reserve provision by electric vehic»
    les G2V hour h in MW
204 RP_DSM_CU(reserves,dsm_curt,h)      Reserve provision by DSM load curta»
    ilment in hour h in MW
205 RP_DSM_SHIFT(reserves,dsm_shift,h)  Reserve provision by DSM load shift»
    ing in hour h in MW
206
207 CU_PRO(res,h)                      Prosumage: curtailment of renewable generati»
    on
208 G_MARKET_PRO2M(res,h)              Prosumage. energy sent to market
209 G_MARKET_M2PRO(h)                  Prosumage: withdrawal of energy from market
210 G_RES_PRO(res,h)                   Prosumage: hourly renewables generation
211 STO_IN_PRO2PRO(res,sto,h)          Prosumage: storage loading from generation f»
    or discharging to consumption
212 STO_IN_PRO2M(res,sto,h)            Prosumage: storage loading from generation f»
    or discharging to market
213 STO_IN_M2PRO(sto,h)                 Prosumage: storage loading from market for d»
    ischarging to consumption
214 STO_IN_M2M(sto,h)                  Prosumage: storage loading from market for d»
    ischarging to market
215 STO_OUT_PRO2PRO(sto,h)             Prosumage: storage discharging to consumptio»
    n from generation
216 STO_OUT_PRO2M(sto,h)               Prosumage: storage discharging to market fro»
    m generation
217 STO_OUT_M2PRO(sto,h)               Prosumage: storage discharging to consumptio»
    n from market
218 STO_OUT_M2M(sto,h)                 Prosumage: storage discharging to market fro»
    m market
219 STO_L_PRO2PRO(sto,h)               Prosumage: storage level generation to consu»
    mption
220 STO_L_PRO2M(sto,h)                 Prosumage: storage level generation to marke»
    t
221 STO_L_M2PRO(sto,h)                 Prosumage: storage level market to consumoti»
    on
222 STO_L_M2M(sto,h)                   Prosumage: storage level market to market
223 N_STO_E_PRO(sto)                   Prosumage: installed storage energy
224 N_STO_P_PRO(sto)                   Prosumage: installed storage power
225 STO_L_PRO(sto,h)                   Prosumage: overall storage level
226 N_RES_PRO(res)                     Prosumage: installed renewables capacities
227 ;
228
229 *****»
    ***
230
231 Equations
232 * Objective
233 obj                                Objective cost minimization
234
235 * Energy balance
236 con1a_bal(h)                       Supply Demand Balance
237
238 con1b_bal_pro(h)
239
240 * Load change costs
241 con2a_loadlevel                     Load change costs: Level
242 con2b_loadlevelstart                Load change costs: Level for first period

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243
244 * Capacity constraints and flexibility constraints
245 con3a_maxprod_conv      Capacity Constraint conventionals
246 con3b_minprod_conv      Minimum production conventionals if reserves contrac»
    ted
247
248 con3c_flex_reserves_spin    Flexibility of conventionals for reserves provis»
    ion
249 con3d_flex_reserves_nonspin Flexibility of conventionals for reserves provis»
    ion
250
251 con3e_maxprod_ror          Capacity constraint Run-of-river
252 con3f_maxprod_res          Capacity constraints renewables
253 con3g_minprod_res          Minimum production RES if reserves contracted
254
255 * Storage constraints
256 con4a_stolev_start         Storage Level Dynamics Initial Condition
257 con4b_stolev              Storage Level Dynamics
258
259 con4c_stolev_max           Storage Power Capacity
260 con4d_maxin_sto            Storage maximum inflow
261 con4e_maxout_sto           Storage maximum outflow
262 con4f_resrv_sto            Constraint on reserves (up)
263 con4g_resrv_sto            Constraint on reserves (down)
264
265 con4h_maxout_lev           Maximum storage outflow - no more than level of las»
    t period
266 con4i_maxin_lev           Maximum storage inflow - no more than eberg y capaci»
    ty minus level of last period
267 con4j_ending              End level equal to initial level
268 con4k_PHS_EtoP            Maximum E to P ratio for PHS
269
270 * Minimum restrictions for renewables and biomass
271 con5a_minRES              Minimum yearly renewables requirement
272 con5b_maxBIO              Maximum yearly biomass energy
273
274 * DSM conditions: Load curtailment
275 con6a_DSMcurt_duration_max Maximum curtailment energy budget per time
276 con6b_DSMcurt_max         Maximum curtailment per period
277
278 * DSM conditions: Load shifting
279 con7a_DSMshift_upanddown   Equalization of upshifts and downshifts in d»
    ue time
280 con7b_DSMshift_granular_max Maximum shifting in either direction per per»
    iod
281 con7c_DSM_distrib_up       Distribution of upshifts between wholesale a»
    nd reserves
282 con7d_DSM_distrib_do       Distribution of downshifts between wholesale»
    and reserves
283 con7e_DSMshift_recovery    Recovery times
284
285 * Maximum installation conditions
286 con8a_max_I_con            Maximum installable capacity: Conventional
287 con8b_max_I_res            Maximum installable capacity: Renewables
288 con8c_max_I_sto_e          Maximum installable energy: Storage in MWh
289 con8d_max_I_sto_p          Maximum installable capacity: Storage inflow-»
    outflow in MW
290 con8e_max_I_dsm_cu         Maximum installable capacity: DSM load curtai»
    lment
291 con8f_max_I_dsm_shift_pos  Maximum installable capacity: DSM load shifti»
    ng

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292 con8g_max_pro_res          Maximum installable capacity: prosumage renew»
ables
293 con8h_max_pro_sto_e        Maximum installable capacity: prosumage stora»
ge energy
294 con8i_max_sto_pro_p        Maximum installable capacity: prosumage stora»
ge power
295
296 * Reserves
297 con9a_reserve_prov          Reserve provision SR and MR
298 con9b_reserve_prov_PR      Reserve provision PR
299
300 * Electric vehicles
301 con10a_ev_ed                Energy balance of electric vehicles
302 con10b_ev_chargelev_start   Cumulative charging level in the first hour
303 con10c_ev_chargelev         Cumulative charging level in hour h
304 con10d_ev_chargelev_max     Cumulative maximal charging level
305 con10e_ev_maxin             Cumulative maximal charging power
306 con10f_ev_maxout            Cumulative maximal discharging power
307 con10g_ev_chargelev_ending  Cumulative charging level in the last hour
308 con10h_ev_minin             Cumulative minimal charging power
309 con10i_ev_maxin_lev         Cumulative maximal charging limit
310 con10j_ev_minout            Cumulative minimal discharging power
311 con10k_ev_maxout_lev        Cumulative maximal discharging limit
312 con10l_ev_exog              Exogenous EV charging
313
314
315 con11a_pro_distrib          Prosumage: distribution of generated»
energy
316 con11b_pro_balance          Prosumage: energy balance
317 con11c_pro_selfcon          Prosumage: minimum self-generation r»
equirement
318 con11d_pro_stolev_PRO2PRO    Prosumage: storage level prosumager-»
to-prosumagers
319 con11e_pro_stolev_PRO2M      Prosumage: storage level prosumagers»
-to-market
320 con11f_pro_stolev_M2PRO      Prosumage: storage level market-to-p»
rosumagers
321 con11g_pro_stolev_M2M        Prosumage: storage level market-to-m»
arket
322 con11h_1_pro_stolev_start_PRO2PRO Prosumage: storage level initial con»
ditions
323 con11h_2_pro_stolev_start_PRO2M Prosumage: storage level initial con»
ditions
324 con11h_3_pro_stolev_start_M2PRO Prosumage: storage level initial con»
ditions
325 con11h_4_pro_stolev_start_M2M Prosumage: storage level initial con»
ditions
326 con11i_pro_stolev           Prosumage: storage level total
327 con11j_pro_stolev_max       Prosumage: maximum overall storage l»
evel
328 con11k_pro_maxin_sto        Prosumage: maximum storage inflow
329 con11l_pro_maxout_sto       Prosumage: maximum storage outflow
330 con11m_pro_maxout_lev       Prosumage: maximum storage outflow l»
inked to level
331 con11n_pro_maxin_lev        Prosumage: maximum storage inflow li»
nked to level
332 con11o_pro_ending           Prosumage: storage ending condition
333 ;
334
335
336 *****»

```

```

***
337
338 * -----»
- *
339 ***** Objective function *****
340 * -----»
- *
341
342 obj..
343      Z =E=
344      sum( (ct,h) , c_m(ct)*G_L(ct,h) )
345      + sum( (ct,h)$(ord(h)>1) , c_up(ct)*G_UP(ct,h) )
346      + sum( (ct,h) , c_do(ct)*G_DO(ct,h) )
347      + sum( (res,h) , c_cu(res)*CU(res,h) )
348      + sum( (sto,h) , c_m_sto(sto) * ( STO_OUT(sto,h) + STO_IN(sto,h) ) )
349 %DSM%$ontext
350      + sum( (dsm_curt,h) , c_m_dsm_cu(dsm_curt)*DSM_CU(dsm_curt,h) )
351      + sum( (dsm_shift,h) , c_m_dsm_shift(dsm_shift) * DSM_UP_DEMAND(dsm_shift,h) )
352      + sum( (dsm_shift,h) , c_m_dsm_shift(dsm_shift) * DSM_DO_DEMAND(dsm_shift,h) )
353 $ontext
354 $offtext
355 %EV%$ontext
356      + sum( (ev,h) , c_m_ev(ev) * EV_DISCHARGE(ev,h) )
357      + sum( (ev,h) , pen_phevfuel * EV_PHEVFUEL(ev,h) )
358 $ontext
359 $offtext
360      + sum( ct , c_i(ct)*N_CON(ct) )
361      + sum( ct , c_fix_con(ct)*N_CON(ct) )
362
363      + sum( res , c_i_res(res)*N_RES(res) )
364      + sum( res , c_fix_res(res)*N_RES(res) )
365
366      + sum( sto , c_i_sto_e(sto)*N_STO_E(sto) )
367      + sum( sto , c_fix_sto(sto)/2*(N_STO_P(sto)+N_STO_E(sto)) )
368      + sum( sto , c_i_sto_p(sto)*N_STO_P(sto) )
369 %DSM%$ontext
370      + sum( dsm_curt , c_i_dsm_cu(dsm_curt)*N_DSM_CU(dsm_curt) )
371      + sum( dsm_curt , c_fix_dsm_cu(dsm_curt)*N_DSM_CU(dsm_curt) )
372      + sum( dsm_shift , c_i_dsm_shift(dsm_shift)*N_DSM_SHIFT(dsm_shift) )
373      + sum( dsm_shift , c_fix_dsm_shift(dsm_shift)*N_DSM_SHIFT(dsm_shift) )
374 $ontext
375 $offtext
376 %reserves%$ontext
377      + sum( (reserves_up,sto,h) , phi_reserves_call(reserves_up,h)
378      ) * c_m_sto(sto) * (RP_STO_OUT(reserves_up,sto,h) - RP_STO_IN(reserves_up,sto,h)) )
379      - sum( (reserves_do,sto,h) , phi_reserves_call(reserves_do,h)
380      ) * c_m_sto(sto) * (RP_STO_OUT(reserves_do,sto,h) - RP_STO_IN(reserves_do,sto,h)) )
381 $ontext
382 $offtext
383 %reserves%$ontext
384 %EV%$ontext
385 %EV_EXOG%      + sum( (reserves_up,ev,h) , RP_EV_V2G(reserves_up,ev,h) * phi

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    _reserves_call(reserves_up,h) * c_m_ev(ev) )
384 %EV_EXOG%      - sum( (reserves_do,ev,h) , RP_EV_V2G(reserves_do,ev,h) * phi»
    _reserves_call(reserves_do,h) * c_m_ev(ev) )
385 $ontext
386 $offtext
387 %DSM%$ontext
388 %reserves%$ontext
389      + sum( (reserves_up,dsm_curt,h) , RP_DSM_CU(reserves_up,dsm_»
    curt,h) * phi_reserves_call(reserves_up,h) * c_m_dsm_cu(dsm_curt) )
390      + sum( (reserves,dsm_shift,h) , RP_DSM_SHIFT(reserves,dsm_sh»
    ift,h) * phi_reserves_call(reserves,h) * c_m_dsm_shift(dsm_shift) )
391 $ontext
392 $offtext
393 %prosumage%$ontext
394      + sum( res , c_i_res(res)*N_RES_PRO(res) )
395      + sum( res , c_fix_res(res)*N_RES_PRO(res) )
396
397      + sum( sto , c_i_sto_e(sto)*N_STO_E_PRO(sto) )
398      + sum( sto , c_fix_sto(sto)/2*(N_STO_P_PRO(sto)+N_STO_E_PRO(»
    sto)) )
399      + sum( sto , c_i_sto_p(sto)*N_STO_P_PRO(sto) )
400
401      + sum( (sto,h) , c_m_sto(sto) * ( STO_OUT_PRO2PRO(sto,h) + S»
    TO_OUT_M2PRO(sto,h) + STO_OUT_PRO2M(sto,h) + STO_OUT_M2M(sto,h) + sum( res , »
    STO_IN_PRO2PRO(res,sto,h) + STO_IN_PRO2M(res,sto,h)) + STO_OUT_PRO2M(sto,h) +»
    STO_OUT_M2M(sto,h) ) )
402 $ontext
403 $offtext
404 ;
405
406 * -----»
    - *
407 ***** Energy balance and load levels *****
408 * -----»
    - *
409
410 * Energy balance
411 conla_bal(hh)..
412      ( 1 - phi_pro_load ) * d(hh) + sum( sto , STO_IN(sto,hh) )
413 %DSM%$ontext
414      + sum( dsm_shift , DSM_UP_DEMAND(dsm_shift,hh) )
415 $ontext
416 $offtext
417 %EV%$ontext
418      + sum( ev , EV_CHARGE(ev,hh) )
419 $ontext
420 $offtext
421 %prosumage%$ontext
422      + G_MARKET_M2PRO(hh)
423      + sum( sto , STO_IN_M2PRO(sto,hh))
424      + sum( sto , STO_IN_M2M(sto,hh))
425 $ontext
426 $offtext
427      =E=
428      sum( ct , G_L(ct,hh)) + sum( res , G_RES(res,hh)) + sum( sto , STO_O»
    UT(sto,hh) )
429 %reserves%$ontext
430 * Balancing Correction Factor
431      + sum( ct ,
432      sum( reserves_do , RP_CON(reserves_do,ct,hh) * phi_reserves_call(r»
    eserves_do,hh))

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433         - sum( reserves_up , RP_CON(reserves_up,ct,hh) * phi_reserves_call(r»
    reserves_up,hh))
434     )
435 $ontext
436 $offtext
437 %DSM%$ontext
438         + sum(dsm_curt, DSM_CU(dsm_curt,hh))
439         + sum(dsm_shift, DSM_DO_DEMAND(dsm_shift,hh))
440 $ontext
441 $offtext
442 %EV%$ontext
443         + sum( ev , EV_DISCHARGE(ev,hh) )
444 $ontext
445 $offtext
446 %prosumage%$ontext
447         + sum( res , G_MARKET_PRO2M(res,hh) )
448         + sum( sto , STO_OUT_PRO2M(sto,hh))
449         + sum( sto , STO_OUT_M2M(sto,hh))
450 $ontext
451 $offtext
452 ;
453
454 con2a_loadlevel(ct,h)$ (ord(h) > 1) ..
455     G_L(ct,h) =E= G_L(ct,h-1) + G_UP(ct,h) - G_DO(ct,h)
456 ;
457
458 con2b_loadlevelstart(ct,'h1') ..
459     G_L(ct,'h1') =E= G_UP(ct,'h1')
460 ;
461
462 * -----»
    - *
463 ***** Hourly maximum generation caps and constraints related to reserves **»
    ***
464 * -----»
    - *
465
466 con3a_maxprod_conv(ct,h)$ (ord(ct)>1) ..
467     G_L(ct,h)
468 %reserves%$ontext
469         + sum( reserves_up , RP_CON(reserves_up,ct,h))
470 * Balancing Correction Factor
471         + sum( reserves_do , RP_CON(reserves_do,ct,h) * phi_reserves_call(re»
    serves_do,h))
472         - sum( reserves_up , RP_CON(reserves_up,ct,h) * phi_reserves_call(re»
    serves_up,h))
473 $ontext
474 $offtext
475     =L= N_CON(ct)
476 ;
477
478 con3b_minprod_conv(ct,h) ..
479     sum( reserves_do , RP_CON(reserves_do,ct,h))
480     =L= G_L(ct,h)
481 * Balancing Correction Factor
482         + sum( reserves_do , RP_CON(reserves_do,ct,h) * phi_reserves_call(re»
    serves_do,h))
483         - sum( reserves_up , RP_CON(reserves_up,ct,h) * phi_reserves_call(re»
    serves_up,h))
484 ;
485

```

```

486 con3c_flex_reserves_spin(reserves_spin,ct,h)..
487     RP_CON(reserves_spin,ct,h)
488     =L= grad_per_min(ct) * reserves_reaction(reserves_spin) * ( G_L(ct,h)
489 * Balancing Correction Factor
490     + sum( reserves_do , RP_CON(reserves_do,ct,h) * phi_reserves_call(re»
serves_do,h))
491     - sum( reserves_up , RP_CON(reserves_up,ct,h) * phi_reserves_call(re»
serves_up,h)) )
492 ;
493
494 con3d_flex_reserves_nonspin(reserves_nonspin,ct,h)..
495     RP_CON(reserves_nonspin,ct,h)
496     =L= grad_per_min(ct) * reserves_reaction(reserves_nonspin) * N_CON(ct»
)
497 ;
498
499
500 * Constraints on run of river
501 con3e_maxprod_ror(h)..
502     G_L('ror',h)
503 %reserves%$ontext
504     + sum( reserves_up , RP_CON(reserves_up,'ror',h))
505 * Balancing Correction Factor
506     + sum( reserves_do , RP_CON(reserves_do,'ror',h) * phi_reserves_call»
(reserves_do,h))
507     - sum( reserves_up , RP_CON(reserves_up,'ror',h) * phi_reserves_call»
(reserves_up,h))
508 $ontext
509 $offtext
510     =L= phi_ror(h)*N_CON('ror')
511 ;
512
513
514 * Constraints on renewables
515 con3f_maxprod_res(res,h)..
516     G_RES(res,h) + CU(res,h)
517 %reserves%$ontext
518     + sum( reserves_up , RP_RES(reserves_up,res,h))
519 $ontext
520 $offtext
521     =E= phi_res(res,h)*N_RES(res)
522 ;
523
524 con3g_minprod_res(res,h)..
525     sum( reserves_do , RP_RES(reserves_do,res,h))
526     =L= G_RES(res,h)
527 ;
528
529 * -----»
- *
530 ***** Storage constraints *****
531 * -----»
- *
532
533 con4a_stolev_start(sto,'h1')..
534     STO_L(sto,'h1') =E= phi_sto_ini(sto) * N_STO_E(sto) + STO_IN(sto,'h1'»
)*(1+eta_sto(sto))/2 - STO_OUT(sto,'h1')/(1+eta_sto(sto))*2
535 ;
536
537 con4b_stolev(sto,h)$( ord(h)>1) ..
538     STO_L(sto,h) =E= STO_L(sto,h-1) + STO_IN(sto,h)*(1+eta_sto(sto))/2 -»

```

```

        STO_OUT(sto,h)/(1+eta_sto(sto))*2
539 %reserves%$ontext
540     + sum( reserves_do , phi_reserves_call(reserves_do,h) * ( RP_STO_IN(»
        reserves_do,sto,h)*(1+eta_sto(sto))/2 + RP_STO_OUT(reserves_do,sto,h)/(1+eta_»
        sto(sto))*2 ))
541     - sum( reserves_up , phi_reserves_call(reserves_up,h) * ( RP_STO_IN(»
        reserves_up,sto,h)*(1+eta_sto(sto))/2 + RP_STO_OUT(reserves_up,sto,h)/(1+eta_»
        sto(sto))*2 ))
542 $ontext
543 $offtext
544 ;
545
546 con4c_stolev_max(sto,h)..
547     STO_L(sto,h) =L= N_STO_E(sto)
548 ;
549
550 con4d_maxin_sto(sto,h)..
551     STO_IN(sto,h)
552 %reserves%$ontext
553     + sum( reserves_do , RP_STO_IN(reserves_do,sto,h))
554 $ontext
555 $offtext
556     =L= N_STO_P(sto)
557 ;
558
559 con4e_maxout_sto(sto,h)..
560     STO_OUT(sto,h)
561 %reserves%$ontext
562     + sum( reserves_up , RP_STO_OUT(reserves_up,sto,h))
563 $ontext
564 $offtext
565     =L= N_STO_P(sto)
566 ;
567
568 con4f_resrv_sto(sto,h)..
569     sum( reserves_up , RP_STO_IN(reserves_up,sto,h))
570     =L= STO_IN(sto,h)
571 ;
572
573 con4g_resrv_sto(sto,h)..
574     sum( reserves_do , RP_STO_OUT(reserves_do,sto,h))
575     =L= STO_OUT(sto,h)
576 ;
577
578 con4h_maxout_lev(sto,h)..
579     ( STO_OUT(sto,h)
580 %reserves%$ontext
581     + sum( reserves_up , RP_STO_OUT(reserves_up,sto,h))
582 $ontext
583 $offtext
584     ) / (1+eta_sto(sto))*2
585     =L= STO_L(sto,h-1)
586 ;
587
588 con4i_maxin_lev(sto,h)..
589     ( STO_IN(sto,h)
590 %reserves%$ontext
591     + sum( reserves_do , RP_STO_IN(reserves_do,sto,h))
592 $ontext
593 $offtext
594     ) * (1+eta_sto(sto))/2

```

```

595         =L= N_STO_E(sto) - STO_L(sto,h-1)
596 ;
597
598 con4j_ending(sto,h)$( ord(h) = card(h) )..
599         STO_L(sto,h) =E= phi_sto_ini(sto) * N_STO_E(sto)
600 ;
601
602 con4k_PHS_EtoP('Sto5')..
603         N_STO_E('Sto5') =L= etop_max('Sto5') * N_STO_P('Sto5')
604 ;
605
606 * -----»
607 * -----»
608 * -----»
609
610 con5a_minRES..
611 sum( ct_the , sum( h , G_L(ct_the,h) ) )
612         =L= (1-phi_min_res) * sum( h , d(h) + sum( (sto) , STO_IN(sto,h) - ST»
        O_OUT(sto,h) )
613 %prosumage%$ontext
614         + sum( sto , sum( res , STO_IN_PRO2PRO(res,sto,h) + STO_IN_PRO2M(res»
        ,sto,h)) + STO_IN_M2PRO(sto,h) + STO_IN_M2M(sto,h) - STO_OUT_PRO2PRO(sto,h) -»
        STO_OUT_PRO2M(sto,h) - STO_OUT_M2PRO(sto,h) - STO_OUT_M2M(sto,h) )
615 $ontext
616 $offtext
617 %DSM%$ontext
618         - sum( dsm_curt , DSM_CU(dsm_curt,h) )
619         + sum( dsm_shift , DSM_UP(dsm_shift,h) - sum( hh$( ord(hh) >= ord(h)»
        - t_dur_dsm_shift(dsm_shift) AND ord(hh) <= ord(h) + t_dur_dsm_shift(dsm_shi»
        ft) ) , DSM_DO(dsm_shift,h,hh)) )
620 $ontext
621 $offtext
622 %EV%$ontext
623         + sum( ev , EV_CHARGE(ev,h) - EV_DISCHARGE(ev,h) )
624 %EV_DEFAULT%%EV_FREE% - sum( ev , EV_GED(ev,h) )
625 %EV_DEFAULT%%EV_100RES% + phi_min_res/(1-phi_min_res)*sum( ev , EV_GED(ev,h)»
        )
626 $ontext
627 $offtext
628 %reserves%$ontext
629         + phi_mean_reserves_call('PR_up') * phi_reserves_pr * sum( reserves$(»
        ord(reserves) > 2) , 1000 * phi_reserves_share(reserves) * (reserves_interce»
        pt(reserves) + sum( res , reserves_slope(reserves,res) * N_RES(res)/1000 ) ) »
        )
630         + phi_mean_reserves_call('SR_up') *( 1000 * phi_reserves_share('SR_up»
        ') * (reserves_intercept('SR_up') + sum( res , reserves_slope('SR_up',res) * »
        N_RES(res)/1000 ) ) )
631         + phi_mean_reserves_call('MR_up') *( 1000 * phi_reserves_share('MR_up»
        ') * (reserves_intercept('MR_up') + sum( res , reserves_slope('MR_up',res) * »
        N_RES(res)/1000 ) ) )
632         - phi_mean_reserves_call('PR_do') * phi_reserves_pr * sum( reserves$(»
        ord(reserves) > 2) , 1000 * phi_reserves_share(reserves) * (reserves_interce»
        pt(reserves) + sum( res , reserves_slope(reserves,res) * N_RES(res)/1000 ) ) »
        )
633         - phi_mean_reserves_call('SR_do') *( 1000 * phi_reserves_share('SR_do»
        ') * (reserves_intercept('SR_do') + sum( res , reserves_slope('SR_do',res) * »
        N_RES(res)/1000 ) ) )
634         - phi_mean_reserves_call('MR_do') *( 1000 * phi_reserves_share('MR_do»
        ') * (reserves_intercept('MR_do') + sum( res , reserves_slope('MR_do',res) * »

```

```

N_RES(res)/1000 ) ) )
635
636     + sum( sto ,
637         sum( reserves_do , phi_reserves_call(reserves_do,h) * (RP_STO_IN(r»
        eserves_do,sto,h) + RP_STO_OUT(reserves_do,sto,h)))
638     - sum( reserves_up , phi_reserves_call(reserves_up,h) * (RP_STO_IN(r»
        eserves_up,sto,h) + RP_STO_OUT(reserves_up,sto,h))) )
639 $ontext
640 $offtext
641 %DSM%$ontext
642 %reserves%$ontext
643     - sum( (dsm_curt,reserves_up) , RP_DSM_CU(reserves_up,dsm_curt,h) * ph»
        i_reserves_call(reserves_up,h) )
644 $ontext
645 $offtext
646 %reserves%$ontext
647 %EV%$ontext
648 %EV_EXOG% + sum( ev ,
649 %EV_EXOG%     sum( reserves_do , phi_reserves_call(reserves_do,h) * (RP_EV_G»
        2V(reserves_do,ev,h) + RP_EV_V2G(reserves_do,ev,h)))
650 %EV_EXOG%     - sum( reserves_up , phi_reserves_call(reserves_up,h) * (RP_EV_G»
        2V(reserves_up,ev,h) + RP_EV_V2G(reserves_up,ev,h))) )
651 $ontext
652 $offtext
653 )
654 ;
655
656 con5b_maxBIO..
657     sum( h , G_L('bio',h) ) =L= m_con_e('bio')
658 ;
659
660 * -----»
661 - *
662 ***** DSM constraints - curtailment *****
663 * -----»
664 - *
665
666 con6a_DSMcurt_duration_max(dsm_curt,h)..
667     sum( hh$( ord(hh) >= ord(h) AND ord(hh) < ord(h) + t_off_dsm_cu(dsm_»
        curt) ) , DSM_CU(dsm_curt,hh)
668 %reserves%$ontext
669     + sum( reserves_up , RP_DSM_CU(reserves_up,dsm_curt,hh) * phi_reserve»
        s_call(reserves_up,hh) )
670 $ontext
671 $offtext
672     )
673     =L= N_DSM_CU(dsm_curt) * t_dur_dsm_cu(dsm_curt)
674 ;
675
676 con6b_DSMcurt_max(dsm_curt,h)..
677     DSM_CU(dsm_curt,h)
678 %reserves%$ontext
679     + sum( reserves_up , RP_DSM_CU(reserves_up,dsm_curt,h) )
680 $ontext
681 $offtext
682     =L= N_DSM_CU(dsm_curt)
683 ;
684 * -----»
685 - *
686 ***** DSM constraints - shifting *****

```

```

685 * -----»
- *
686
687 con7a_DSMshift_upanddown(dsm_shift,h)..
688     DSM_UP(dsm_shift,h) * (1 + eta_dsm_shift(dsm_shift))/2 =E= 2/(1+eta_»
dsm_shift(dsm_shift)) * sum( hh$( ord(hh) >= ord(h) - t_dur_dsm_shift(dsm_shi»
ft) AND ord(hh) <= ord(h) + t_dur_dsm_shift(dsm_shift) ) , DSM_DO(dsm_shift,h»
, hh))
689 ;
690
691 con7b_DSMshift_granular_max(dsm_shift,h)..
692     DSM_UP_DEMAND(dsm_shift,h) + DSM_DO_DEMAND(dsm_shift,h)
693 %reserves%$ontext
694     + sum( reserves , RP_DSM_SHIFT(reserves,dsm_shift,h) )
695 $ontext
696 $offtext
697     =L= N_DSM_SHIFT(dsm_shift)
698 ;
699
700 con7c_DSM_distrib_up(dsm_shift,h)..
701     DSM_UP(dsm_shift,h) =E= DSM_UP_DEMAND(dsm_shift,h)
702 %reserves%$ontext
703     + sum( reserves_do , RP_DSM_SHIFT(reserves_do,dsm_shift,h) * phi_res»
erves_call(reserves_do,h))
704 $ontext
705 $offtext
706 ;
707
708 con7d_DSM_distrib_do(dsm_shift,h)..
709     sum( hh$( ord(hh) >= ord(h) - t_dur_dsm_shift(dsm_shift) AND ord(hh)»
<= ord(h) + t_dur_dsm_shift(dsm_shift) ) , DSM_DO(dsm_shift,h,h) )
710     =E=
711     DSM_DO_DEMAND(dsm_shift,h)
712 %reserves%$ontext
713     + sum( reserves_up , RP_DSM_SHIFT(reserves_up,dsm_shift,h) * phi_res»
erves_call(reserves_up,h))
714 $ontext
715 $offtext
716 ;
717
718 con7e_DSMshift_recovery(dsm_shift,h)..
719     sum( hh$( ord(hh) >= ord(h) AND ord(hh) < ord(h) + t_off_dsm_shift(d»
sm_shift) ) , DSM_UP(dsm_shift,hh))
720     =L= N_DSM_SHIFT(dsm_shift) * t_dur_dsm_shift(dsm_shift)
721 ;
722
723 * -----»
- *
724 ***** Maximum installation constraints *****
725 * -----»
- *
726
727 con8a_max_I_con(ct)..
728     N_CON(ct) =L= m_con(ct)
729 ;
730
731 con8b_max_I_res(res)..
732     N_RES(res) =L= m_res(res)
733 ;
734
735 con8c_max_I_sto_e(sto)..

```

```

736         N_STO_E(sto) =L= m_sto_e(sto)
737 ;
738
739 con8d_max_I_sto_p(sto)..
740         N_STO_P(sto) =L= m_sto_p(sto)
741 ;
742
743 con8e_max_I_dsm_cu(dsm_curt)..
744         N_DSM_CU(dsm_curt) =L= m_dsm_cu(dsm_curt)
745 ;
746
747 con8f_max_I_dsm_shift_pos(dsm_shift)..
748         N_DSM_SHIFT(dsm_shift) =L= m_dsm_shift(dsm_shift)
749 ;
750
751 con8g_max_pro_res(res)..
752         N_RES_PRO(res) =L= m_res_pro(res)
753 ;
754
755 con8h_max_pro_sto_e(sto)..
756         N_STO_E_PRO(sto) =L= m_sto_pro_e(sto)
757 ;
758
759 con8i_max_sto_pro_p(sto)..
760         N_STO_P_PRO(sto) =L= m_sto_pro_p(sto)
761 ;
762
763 * -----»
764 - *
765 ***** Reserve constraints *****
766 * -----»
767 - *
768
769 con9a_reserve_prov(reserves,h)$( ord(reserves) > 2)..
770         sum(ct, RP_CON(reserves,ct,h))
771         + sum(res, RP_RES(reserves,res,h))
772         + sum(sto, RP_STO_IN(reserves,sto,h) + RP_STO_OUT(reserves,sto,h))
773 %DSM%$ontext
774         + sum(dsm_curt, RP_DSM_CU(reserves,dsm_curt,h))
775         + sum(dsm_shift, RP_DSM_SHIFT(reserves,dsm_shift,h))
776 $ontext
777 $offtext
778 %EV%$ontext
779 %EV_EXOG% + sum(ev, RP_EV_G2V(reserves,ev,h) + RP_EV_V2G(reserves,ev,h))
780 $ontext
781 $offtext
782         =E= (
783         1000 * phi_reserves_share(reserves) * (
784         reserves_intercept(reserves) + sum(res, reserves_slope(reserves»
785 ,res) * (N_RES(res)
786 %prosumage%$ontext
787         + N_RES_PRO(res)
788 $ontext
789 $offtext
790         )/1000 ) ) )$(ord(h) > 1)
791 ;
792
793 con9b_reserve_prov_PR(reserves,h)$( ord(reserves) < 3)..
794         sum(ct, RP_CON(reserves,ct,h))
795         + sum(res, RP_RES(reserves,res,h))
796         + sum(sto, RP_STO_IN(reserves,sto,h) + RP_STO_OUT(reserves,sto,h))

```



```

794 %EV%$ontext
795 %EV_EXOG% + sum(ev, RP_EV_G2V(reserves,ev,h) + RP_EV_V2G(reserves,ev,h) )
796 $ontext
797 $offtext
798 =E= phi_reserves_pr* sum( reservesreserves$( ord(reservesreserves) >>
2), 1000 * phi_reserves_share(reservesreserves) * (
799 reserves_intercept(reservesreserves) + sum( res , reserves_slope»
(reservesreserves,res) * (N_RES(res)
800 %prosumage%$ontext
801 + N_RES_PRO(res)
802 $ontext
803 $offtext
804 )/1000 ) ) )$(ord(h) > 1)
805
806 ;
807
808 * -----»
- *
809 ***** Electric vehicle constraints *****
810 * -----»
- *
811
812 con10a_ev_ed(ev,h)..
813 ev_ed(ev,h) * phi_ev(ev) * ev_quant
814 =e= EV_GED(ev,h) + EV_PHEVFUEL(ev,h)$(ev_phev(ev)=1)
815 ;
816
817 con10b_ev_chargelev_start(ev,'h1')..
818 EV_L(ev,'h1') =E= phi_ev_ini(ev) * n_ev_e(ev) * phi_ev(ev) * ev QUAN»
t
819 + EV_CHARGE(ev,'h1') * eta_ev_in(ev)
820 - EV_DISCHARGE(ev,'h1') / eta_ev_out(ev)
821 - EV_GED(ev,'h1')
822 ;
823
824 con10c_ev_chargelev(ev,h)$( (ord(h)>1) )..
825 EV_L(ev,h) =E= EV_L(ev,h-1)
826 + EV_CHARGE(ev,h) * eta_ev_in(ev)
827 - EV_DISCHARGE(ev,h) / eta_ev_out(ev)
828 %reserves%$ontext
829 %EV_EXOG% + sum( reserves_do , phi_reserves_call(reserves_do,h) * (RP_EV_G2»
V(reserves_do,ev,h)*eta_ev_in(ev) + RP_EV_V2G(reserves_do,ev,h)/eta_ev_out(ev»
)) )
830 %EV_EXOG% - sum( reserves_up , phi_reserves_call(reserves_up,h) * ( RP_EV_G»
2V(reserves_up,ev,h)*eta_ev_in(ev) + RP_EV_V2G(reserves_up,ev,h)/eta_ev_out(e»
v)) )
831 $ontext
832 $offtext
833 - EV_GED(ev,h)
834 ;
835
836 con10d_ev_chargelev_max(ev,h)..
837 EV_L(ev,h) =L= n_ev_e(ev) * phi_ev(ev) * ev_quant
838 ;
839
840 con10e_ev_maxin(ev,h)..
841 EV_CHARGE(ev,h)
842 %reserves%$ontext
843 + sum( reserves_do , RP_EV_G2V(reserves_do,ev,h))
844 $ontext
845 $offtext

```

```

846         =L= n_ev_p(ev,h) * phi_ev(ev) * ev_quant
847 ;
848
849 con10f_ev_maxout(ev,h)..
850         EV_DISCHARGE(ev,h)
851 %reserves%$ontext
852         + sum( reserves_up , RP_EV_V2G(reserves_up,ev,h))
853 $ontext
854 $offtext
855         =L= n_ev_p(ev,h) * phi_ev(ev) * ev_quant
856 ;
857
858 con10g_ev_chargelev_ending(ev,h)$ ( ord(h) = card(h) )..
859         EV_L(ev,h) =E= phi_ev_ini(ev) * n_ev_e(ev) * phi_ev(ev) * ev_quant
860 ;
861
862 con10h_ev_minin(ev,h)..
863         0 =L= EV_CHARGE(ev,h)
864         - sum( reserves_up , RP_EV_G2V(reserves_up,ev,h))
865 ;
866
867 con10i_ev_maxin_lev(ev,h)..
868         ( EV_CHARGE(ev,h)
869         + sum( reserves_do , RP_EV_G2V(reserves_do,ev,h))) * eta_ev_in(ev)
870         =L= n_ev_e(ev) * phi_ev(ev) * ev_quant - EV_L(ev,h-1)
871 ;
872
873 con10j_ev_minout(ev,h)..
874         0 =L= EV_DISCHARGE(ev,h)
875         - sum( reserves_do , RP_EV_V2G(reserves_do,ev,h))
876 ;
877
878 con10k_ev_maxout_lev(ev,h)..
879         ( EV_DISCHARGE(ev,h)
880         + sum( reserves_up , RP_EV_V2G(reserves_up,ev,h))) / eta_ev_out(ev)
881         =L= EV_L(ev,h-1)
882 ;
883
884 con10l_ev_exog(ev,h)..
885         EV_CHARGE(ev,h) =E= ev_ged_exog(ev,h) * phi_ev(ev) * ev_quant
886 ;
887
888 * -----»
889 - *
890 ***** Prosumage constraints *****
891 * -----»
892 - *
893
894 con11a_pro_distrib(res,h)..
895         phi_res(res,h) * N_RES_PRO(res)
896         =E=
897         CU_PRO(res,h) + G_MARKET_PRO2M(res,h) + G_RES_PRO(res,h) + sum( sto »
898         , STO_IN_PRO2PRO(res,sto,h) + STO_IN_PRO2M(res,sto,h) )
899 ;
900
901 con11b_pro_balance(h)..
902         phi_pro_load * d(h)
903         =E=
904         sum( res , G_RES_PRO(res,h)) + sum( sto , STO_OUT_PRO2PRO(sto,h) + S»
905         TO_OUT_M2PRO(sto,h) ) + G_MARKET_M2PRO(h)
906 ;

```

```

903
904 conl1c_pro_selfcon..
905      sum( (res,h) , G_RES_PRO(res,h) ) + sum( (h,sto) , STO_OUT_PRO2PRO(s»
to,h) )
906      =g=
907      phi_pro_self * sum( h , phi_pro_load * d(h))
908 ;
909
910 conl1d_pro_stolev_PRO2PRO(sto,h)$( (ord(h)>1) )..
911      STO_L_PRO2PRO(sto,h) =E= STO_L_PRO2PRO(sto,h-1) + sum( res , STO_IN_»
PRO2PRO(res,sto,h))*(1+eta_sto(sto))/2 - STO_OUT_PRO2PRO(sto,h)/(1+eta_sto(st»
o))*2
912 ;
913
914 conl1e_pro_stolev_PRO2M(sto,h)$( (ord(h)>1) )..
915      STO_L_PRO2M(sto,h) =E= STO_L_PRO2M(sto,h-1) + sum( res , STO_IN_PRO2»
M(res,sto,h))*(1+eta_sto(sto))/2 - STO_OUT_PRO2M(sto,h)/(1+eta_sto(sto))*2
916 ;
917
918 conl1f_pro_stolev_M2PRO(sto,h)$( (ord(h)>1) )..
919      STO_L_M2PRO(sto,h) =E= STO_L_M2PRO(sto,h-1) + STO_IN_M2PRO(sto,h)*(1»
+eta_sto(sto))/2 - STO_OUT_M2PRO(sto,h)/(1+eta_sto(sto))*2
920 ;
921
922 conl1g_pro_stolev_M2M(sto,h)$( (ord(h)>1) )..
923      STO_L_M2M(sto,h) =E= STO_L_M2M(sto,h-1) + STO_IN_M2M(sto,h)*(1+eta_s»
to(sto))/2 - STO_OUT_M2M(sto,h)/(1+eta_sto(sto))*2
924 ;
925
926 conl1h_1_pro_stolev_start_PRO2PRO(sto,'h1')..
927      STO_L_PRO2PRO(sto,'h1') =E= 0.25 * phi_sto_pro_ini(sto) * N_STO_E(sto»
) + sum( res , STO_IN_PRO2PRO(res,sto,'h1'))*(1+eta_sto(sto))/2 - STO_OUT_PRO»
2PRO(sto,'h1')/(1+eta_sto(sto))*2
928 ;
929
930 conl1h_2_pro_stolev_start_PRO2M(sto,'h1')..
931      STO_L_PRO2M(sto,'h1') =E= 0.25 * phi_sto_pro_ini(sto) * N_STO_E(sto) »
+ sum( res , STO_IN_PRO2M(res,sto,'h1'))*(1+eta_sto(sto))/2 - STO_OUT_PRO2M(s»
to,'h1')/(1+eta_sto(sto))*2
932 ;
933
934 conl1h_3_pro_stolev_start_M2PRO(sto,'h1')..
935      STO_L_M2PRO(sto,'h1') =E= 0.25 * phi_sto_pro_ini(sto) * N_STO_E(sto) »
+ STO_IN_M2PRO(sto,'h1')*(1+eta_sto(sto))/2 - STO_OUT_M2PRO(sto,'h1')/(1+eta_»
sto(sto))*2
936 ;
937
938 conl1h_4_pro_stolev_start_M2M(sto,'h1')..
939      STO_L_M2M(sto,'h1') =E= 0.25 * phi_sto_pro_ini(sto) * N_STO_E(sto) + »
STO_IN_M2M(sto,'h1')*(1+eta_sto(sto))/2 - STO_OUT_M2M(sto,'h1')/(1+eta_sto(st»
o))*2
940 ;
941
942 conl1i_pro_stolev(sto,h)$( (ord(h)>1) )..
943      STO_L_PRO(sto,h) =E= STO_L_PRO2PRO(sto,h) + STO_L_PRO2M(sto,h) + »
STO_L_M2PRO(sto,h) + STO_L_M2M(sto,h)
944 ;
945
946 conl1j_pro_stolev_max(sto,h)..
947      STO_L_PRO(sto,h) =L= N_STO_E_PRO(sto)
948 ;

```

```

949
950 con11k_pro_maxin_sto(sto,h)..
951      sum( res , STO_IN_PRO2PRO(res,sto,h) + STO_IN_PRO2M(res,sto,h) ) + ST»
O_IN_M2PRO(sto,h) + STO_IN_M2M(sto,h)
952      =L= N_STO_P_PRO(sto)
953 ;
954
955 con11l_pro_maxout_sto(sto,h)..
956      STO_OUT_PRO2PRO(sto,h) + STO_OUT_PRO2M(sto,h) + STO_OUT_M2PRO(sto,h) »
+ STO_OUT_M2M(sto,h)
957      =L= N_STO_P_PRO(sto)
958 ;
959
960 con11m_pro_maxout_lev(sto,h)..
961      ( STO_OUT_PRO2PRO(sto,h) + STO_OUT_M2PRO(sto,h) + STO_OUT_PRO2M(sto,h)»
) + STO_OUT_M2M(sto,h) ) / (1+eta_sto(sto))*2
962      =L= STO_L_PRO(sto,h-1)
963 ;
964
965 con11n_pro_maxin_lev(sto,h)..
966      ( sum( res , STO_IN_PRO2PRO(res,sto,h) + STO_IN_PRO2M(res,sto,h) ) + »
STO_IN_M2PRO(sto,h) + STO_IN_M2M(sto,h) ) * (1+eta_sto(sto))/2
967      =L= N_STO_E_PRO(sto) - STO_L_PRO(sto,h-1)
968 ;
969
970 con11o_pro_ending(sto,h)$( ord(h) = card(h) )..
971      STO_L_PRO(sto,h) =E= phi_sto_pro_ini(sto) * N_STO_E_PRO(sto)
972 ;
973
974 *****»
***
975 ***** MODEL *****
976 *****»
***
977
978 model DIETER /
979 obj
980
981 con1a_bal
982
983 con2a_loadlevel
984 con2b_loadlevelstart
985
986 con3a_maxprod_conv
987 %reserves%$ontext
988   con3b_minprod_conv
989   con3c_flex_reserves_spin
990   con3d_flex_reserves_nonspin
991 $ontext
992 $offtext
993 %ror_parameter%%ror_variable%$ontext
994   con3e_maxprod_ror
995 $ontext
996 $offtext
997 con3f_maxprod_res
998 %reserves%$ontext
999   con3g_minprod_res
1000 $ontext
1001 $offtext
1002
1003 con4a_stolev_start

```

```
1004 con4b_stolev
1005 con4c_stolev_max
1006 con4d_maxin_sto
1007 con4e_maxout_sto
1008 %reserves%$ontext
1009     con4f_resrv_sto
1010     con4g_resrv_sto
1011 $ontext
1012 $offtext
1013 con4h_maxout_lev
1014 con4i_maxin_lev
1015 con4j_ending
1016 con4k_PHS_EtoP
1017
1018 con5a_minRES
1019 con5b_maxBIO
1020
1021 %DSM%$ontext
1022 con6a_DSMcourt_duration_max
1023 con6b_DSMcourt_max
1024
1025 con7a_DSMShift_upanddown
1026 con7b_DSMShift_granular_max
1027 con7c_DSMS_distrib_up
1028 con7d_DSMS_distrib_do
1029 * con_7e_DSMShift_recovery
1030 $ontext
1031 $offtext
1032
1033 con8a_max_I_con
1034 con8b_max_I_res
1035 con8c_max_I_sto_e
1036 con8d_max_I_sto_p
1037 %DSM%$ontext
1038     con8e_max_I_dsm_cu
1039     con8f_max_I_dsm_shift_pos
1040 $ontext
1041 $offtext
1042
1043 %reserves%$ontext
1044 con9a_reserve_prov
1045 con9b_reserve_prov_PR
1046 $ontext
1047 $offtext
1048
1049 %EV%$ontext
1050 con10a_ev_ed
1051 %EV_EXOG% con10b_ev_chargelev_start
1052 con10c_ev_chargelev
1053 con10d_ev_chargelev_max
1054 %EV_EXOG% con10e_ev_maxin
1055 %EV_EXOG% con10f_ev_maxout
1056 %EV_EXOG% con10g_ev_chargelev_ending
1057 $ontext
1058 $offtext
1059 %EV%$ontext
1060 %reserves%$ontext
1061 %EV_EXOG% con10h_ev_minin
1062 %EV_EXOG% con10i_ev_maxin_lev
1063 %EV_EXOG% con10j_ev_minout
1064 %EV_EXOG% con10k_ev_maxout_lev
```

```
1065 $ontext
1066 $offtext
1067 %EV%$ontext
1068 %EV_EXOG%$ontext
1069 con10l_ev_exog
1070 $ontext
1071 $offtext
1072
1073 %prosumage%$ontext
1074 con8g_max_pro_res
1075 con8h_max_pro_sto_e
1076 con8i_max_sto_pro_p
1077 con11a_pro_distrib
1078 con11b_pro_balance
1079 con11c_pro_selfcon
1080 con11d_pro_stolev_PRO2PRO
1081 con11e_pro_stolev_PRO2M
1082 con11f_pro_stolev_M2PRO
1083 con11g_pro_stolev_M2M
1084 con11h_1_pro_stolev_start_PRO2PRO
1085 con11h_2_pro_stolev_start_PRO2M
1086 con11h_3_pro_stolev_start_M2PRO
1087 con11h_4_pro_stolev_start_M2M
1088 con11i_pro_stolev
1089 con11j_pro_stolev_max
1090 con11k_pro_maxin_sto
1091 con11l_pro_maxout_sto
1092 con11m_pro_maxout_lev
1093 con11n_pro_maxin_lev
1094 con11o_pro_ending
1095 $ontext
1096 $offtext
1097 /;
1098
1099 *****»
    ***
1100 ***** Options, fixings, report preparation *****
1101 *****»
    ***
1102
1103 * Solver options
1104 $onecho > cplex.opt
1105 lpmethod 4
1106 threads 4
1107 epgap 1e-3
1108 parallelmode -1
1109 $offecho
1110
1111 %no_crossover%$ontext
1112 $onecho > cplex.opt
1113 lpmethod 4
1114 threads 4
1115 epgap 1e-3
1116 parallelmode -1
1117 barcrossalg -1
1118 barepcomp 1e-8
1119 $offecho
1120 $ontext
1121 $offtext
1122
1123 dieter.OptFile = 1;
```

```

1124 dieter.holdFixed = 1 ;
1125
1126 * Parameters for default base year
1127 d(h) = d_y(%base_year%,h) ;
1128 phi_res(res,h) = phi_res_y(%base_year%,res,h) ;
1129 phi_reserves_call(reserves,h) = phi_reserves_call_y(%base_year%,reserves,h) ;
1130 phi_mean_reserves_call(reserves) = phi_mean_reserves_call_y(%base_year%,reser»
ves) ;
1131
1132
1133 *****»
***
1134 ***** Solve *****
1135 *****»
***
1136
1137 * Preparation of GUSS tool for scenario analysis
1138 phi_min_res = eps ;
1139 ev_quant = eps ;
1140 phi_pro_self = eps ;
1141
1142 $eval superscencount 1000
1143
1144 Set
1145 modelstats      model stats collection          /modelstat, solvesta»
t, resusd/
1146 superscen      Scenarios                      /scen1*scen%supersce»
ncount%/
1147 map(superscen,loop_res_share,loop_ev,loop_prosumage)    /#superscen:(#loop_re»
s_share.#loop_ev.#loop_prosumage)/
1148 ;
1149
1150 set
1151 scen(superscen);
1152 scen(superscen) = yes$( sum((loop_res_share,loop_ev,loop_prosumage) , map(sup»
erscen,loop_res_share,loop_ev,loop_prosumage)) )      ;
1153
1154 Parameters
1155 gussoptions      /Logoption 2, Optfile 1, Skipbasecas»
e 1/
1156 modstats(superscen, modelstats)
1157 min_res
1158 number_ev
1159 pro_selfcon
1160 ;
1161
1162 min_res(scen) = sum( (loop_res_share,loop_ev,loop_prosumage)$map(scen,loop_re»
s_share,loop_ev,loop_prosumage) , loop_res_share.val/100 ) ;
1163 number_ev(scen) = sum( (loop_res_share,loop_ev,loop_prosumage)$map(scen,loop_»
res_share,loop_ev,loop_prosumage) , loop_ev.val ) ;
1164 pro_selfcon(scen) = sum( (loop_res_share,loop_ev,loop_prosumage)$map(scen,loo»
p_res_share,loop_ev,loop_prosumage) , loop_prosumage.val/100 ) ;
1165
1166 Parameters
1167 marginal_con5a(superscen)
1168 marginal_con1a(superscen,h)
1169
1170 lev_Z(superscen)
1171 lev_G_L(superscen,ct,h)
1172 lev_G_UP(superscen,ct,h)
1173 lev_G_DO(superscen,ct,h)

```

```
1174 lev_G_RES(superscen,res,h)
1175 lev_CU(superscen,res,h)
1176 lev_STO_IN(superscen,sto,h)
1177 lev_STO_OUT(superscen,sto,h)
1178 lev_STO_L(superscen,sto,h)
1179 lev_N_CON(superscen,ct)
1180 lev_N_RES(superscen,res)
1181 lev_N_STO_E(superscen,sto)
1182 lev_N_STO_P(superscen,sto)
1183
1184 %EV%$ontext
1185 lev_EV_CHARGE(superscen,ev,h)
1186 lev_EV_DISCHARGE(superscen,ev,h)
1187 lev_EV_L(superscen,ev,h)
1188 lev_EV_PHEVFUEL(superscen,ev,h)
1189 lev_EV_GED(superscen,ev,h)
1190 $ontext
1191 $offtext
1192
1193 %DSM%$ontext
1194 lev_DSM_CU(superscen,dsm_curt,h)
1195 lev_DSM_UP(superscen,dsm_shift,h)
1196 lev_DSM_DO(superscen,dsm_shift,h,hh)
1197 lev_DSM_UP_DEMAND(superscen,dsm_shift,h)
1198 lev_DSM_DO_DEMAND(superscen,dsm_shift,h)
1199 lev_N_DSM_CU(superscen,dsm_curt)
1200 lev_N_DSM_SHIFT(superscen,dsm_shift)
1201 $ontext
1202 $offtext
1203
1204 %reserves%$ontext
1205 lev_RP_CON(superscen,reserves,ct,h)
1206 lev_RP_RES(superscen,reserves,res,h)
1207 lev_RP_STO_IN(superscen,reserves,sto,h)
1208 lev_RP_STO_OUT(superscen,reserves,sto,h)
1209 $ontext
1210 $offtext
1211
1212 %EV%$ontext
1213 %reserves%$ontext
1214 lev_RP_EV_V2G(superscen,reserves,ev,h)
1215 lev_RP_EV_G2V(superscen,reserves,ev,h)
1216 $ontext
1217 $offtext
1218
1219 %DSM%$ontext
1220 %reserves%$ontext
1221 lev_RP_DSM_CU(superscen,reserves,dsm_curt,h)
1222 lev_RP_DSM_SHIFT(superscen,reserves,dsm_shift,h)
1223 $ontext
1224 $offtext
1225
1226 %prosumage%$ontext
1227 lev_CU_PRO(superscen,res,h)
1228 lev_G_MARKET_PRO2M(superscen,res,h)
1229 lev_G_MARKET_M2PRO(superscen,h)
1230 lev_G_RES_PRO(superscen,res,h)
1231 lev_STO_IN_PRO2PRO(superscen,res,sto,h)
1232 lev_STO_IN_PRO2M(superscen,res,sto,h)
1233 lev_STO_IN_M2PRO(superscen,sto,h)
1234 lev_STO_IN_M2M(superscen,sto,h)
```



```

1235 lev_STO_OUT_PRO2PRO(superscen,sto,h)
1236 lev_STO_OUT_PRO2M(superscen,sto,h)
1237 lev_STO_OUT_M2PRO(superscen,sto,h)
1238 lev_STO_OUT_M2M(superscen,sto,h)
1239 lev_STO_L_PRO2PRO(superscen,sto,h)
1240 lev_STO_L_PRO2M(superscen,sto,h)
1241 lev_STO_L_M2PRO(superscen,sto,h)
1242 lev_STO_L_M2M(superscen,sto,h)
1243 lev_N_STO_E_PRO(superscen,sto)
1244 lev_N_STO_P_PRO(superscen,sto)
1245 lev_STO_L_PRO(superscen,sto,h)
1246 lev_N_RES_PRO(superscen,res)
1247 $ontext
1248 $offtext
1249 ;
1250
1251
1252 * Inclusion of scenario and fixing
1253 $include fix.gms
1254 $include scenario.gms
1255
1256
1257 * Definition of dictionary set for GUSS tool
1258 Set dict(*,*,*) /
1259 scen                .scenario          .''
1260 gussoptions         .opt                .modstats
1261
1262 phi_min_res         .param              .min_res
1263 %EV%$ontext
1264 ev_quant            .param              .number_ev
1265 $ontext
1266 $offtext
1267 %prosumage%$ontext
1268 phi_pro_self        .param              .pro_selfcon
1269 $ontext
1270 $offtext
1271
1272 con5a_minRES        .marginal            .marginal_con5a
1273 con1a_bal           .marginal            .marginal_con1a
1274
1275 Z                   .level              .lev_Z
1276 G_L                 .level              .lev_G_L
1277 G_DO                .level              .lev_G_DO
1278 G_RES               .level              .lev_G_RES
1279 CU                  .level              .lev_CU
1280 STO_IN              .level              .lev_STO_IN
1281 STO_OUT             .level              .lev_STO_OUT
1282 STO_L               .level              .lev_STO_L
1283 N_CON               .level              .lev_N_CON
1284 N_RES               .level              .lev_N_RES
1285 N_STO_E             .level              .lev_N_STO_E
1286 N_STO_P             .level              .lev_N_STO_P
1287
1288 %EV%$ontext
1289 EV_CHARGE           .level              .lev_EV_CHARGE
1290 EV_DISCHARGE        .level              .lev_EV_DISCHARGE
1291 EV_L                .level              .lev_EV_L
1292 EV_PHEVFUEL         .level              .lev_EV_PHEVFUEL
1293 EV_GED              .level              .lev_EV_GED
1294 $ontext
1295 $offtext

```

```

1296
1297 %DSM%$ontext
1298 DSM_CU .level .lev_DSM_CU
1299 DSM_UP .level .lev_DSM_UP
1300 DSM_DO .level .lev_DSM_DO
1301 DSM_UP_DEMAND .level .lev_DSM_UP_DEMAND
1302 DSM_DO_DEMAND .level .lev_DSM_DO_DEMAND
1303 N_DSM_CU .level .lev_N_DSM_CU
1304 N_DSM_SHIFT .level .lev_N_DSM_SHIFT
1305 $ontext
1306 $offtext
1307
1308 %reserves%$ontext
1309 RP_CON .level .lev_RP_CON
1310 RP_RES .level .lev_RP_RES
1311 RP_STO_IN .level .lev_RP_STO_IN
1312 RP_STO_OUT .level .lev_RP_STO_OUT
1313 $ontext
1314 $offtext
1315
1316 %reserves%$ontext
1317 %EV%$ontext
1318 %EV_EXOG% RP_EV_V2G .level .lev_RP_EV_V2G
1319 %EV_EXOG% RP_EV_G2V .level .lev_RP_EV_G2V
1320 $ontext
1321 $offtext
1322
1323 %reserves%$ontext
1324 %DSM%$ontext
1325 RP_DSM_CU .level .lev_RP_DSM_CU
1326 RP_DSM_SHIFT .level .lev_RP_DSM_SHIFT
1327 $ontext
1328 $offtext
1329
1330 %prosumage%$ontext
1331 CU_PRO .level .lev_CU_PRO
1332 G_MARKET_PRO2M .level .lev_G_MARKET_PRO2M
1333 G_MARKET_M2PRO .level .lev_G_MARKET_M2PRO
1334 G_RES_PRO .level .lev_G_RES_PRO
1335 STO_IN_PRO2PRO .level .lev_STO_IN_PRO2PRO
1336 STO_IN_PRO2M .level .lev_STO_IN_PRO2M
1337 STO_IN_M2PRO .level .lev_STO_IN_M2PRO
1338 STO_IN_M2M .level .lev_STO_IN_M2M
1339 STO_OUT_PRO2PRO .level .lev_STO_OUT_PRO2PRO
1340 STO_OUT_PRO2M .level .lev_STO_OUT_PRO2M
1341 STO_OUT_M2PRO .level .lev_STO_OUT_M2PRO
1342 STO_OUT_M2M .level .lev_STO_OUT_M2M
1343 STO_L_PRO .level .lev_STO_L_PRO
1344 STO_L_PRO2PRO .level .lev_STO_L_PRO2PRO
1345 STO_L_PRO2M .level .lev_STO_L_PRO2M
1346 STO_L_M2PRO .level .lev_STO_L_M2PRO
1347 STO_L_M2M .level .lev_STO_L_M2M
1348 N_STO_E_PRO .level .lev_N_STO_E_PRO
1349 N_STO_P_PRO .level .lev_N_STO_P_PRO
1350 N_RES_PRO .level .lev_N_RES_PRO
1351 $ontext
1352 $offtext
1353 /
1354 ;
1355
1356 solve DIETER using lp min Z scenario dict;

```

```
1357
1358 *$stop
1359 * Reporting
1360 $include report.gms
1361
1362 %reserves%%prosumage%execute_unload "results", report, report_tech, report_te»
    ch_hours, report_hours ;
1363
1364 %prosumage%$ontext
1365 %reserves%execute_unload "results", report, report_tech, report_tech_hours, r»
    eport_hours, report_prosumage, report_prosumage_tech, report_prosumage_tech_h»
    ours, report_market, report_market_tech, report_market_tech_hours ;
1366 $ontext
1367 $offtext
1368
1369 %reserves%$ontext
1370 execute_unload "results", report, report_tech, report_tech_hours, report_hour»
    s, report_reserves, report_reserves_tech, report_reserves_tech_hours ;
1371 $ontext
1372 $offtext
1373
1374
1375 * -----»
    - *
1376 * -----»
    - *
1377 * -----»
    - *
1378
```