

TIMES Early Retirement of Capacity Extension in ANSWER-TIMES

Introduction

The purpose of this note is to briefly describe how to invoke the TIMES Early Retirement of Capacity Extension in ANSWER-TIMES.

For an explanation of the TIMES Early Retirement of Capacity Extension see TIMES Version 3.2 User Note "TIMES Early Retirement of Capacity" (authors Antti Lehtila, Ken Noble), which will soon be downloadable from the ETSAP website as *TIMES-Early-Retirement-of-Capacity.pdf*.

For a concrete example demonstrating Run Model using the TIMES Retirement of Capacity Extension, open the database ***RetirementOfCapacityDemo.mdb*** (distributed with ANSWER-TIMES version 6.7.1 and higher), and consider in turn:

- The non-BASE scenario **CONTINU-RET** and the online Case **CONTINU-RET** that demonstrate ***Continuous*** Capacity Retirement; and
- The non-BASE scenario **DISCRET-RET** and the online Case **DISCRET-RET** that demonstrate ***Discrete (lumpy)*** Capacity Retirement.

For simplicity of explanation below, default Milestone Years in this demonstration database are the same as the Data Years. Understand that in general the values for the Capacity Retirement Data Parameters RCAP_BLK, RCAP_BND, NCAP_OLIFE (see the table below) in Milestone Years are interpolated/extrapolated from the values specified for the Data Years.

Retirement of Capacity Data Parameters in ANSWER-TIMES

The TIMES Retirement of Capacity Extension involves 5 new Data Parameters, as follows:

Retirement of Capacity Data Parameter	Description	Comment
PRC_RCAP(r,p)	Indicates process with early capacity retirement (Set)	Must be specified for each process p in region r for which early capacity retirement is desired.
RCAP_BLK(r,p,y)	Block size for discrete capacity retirement	Must be specified for each process p in region r for which discrete (lumpy) capacity retirement is desired in vintage year y that is a Data Year.
RCAP_BLKp(r,p,y)	Block size for discrete capacity retirement (past years)	Must be specified for each process p in region r for which discrete (lumpy) capacity retirement is desired in respect to capacity installed in vintage year y that is a Past Year (e.g. as specified by NCAP_PASTI).
RCAP_BND(r,p,lim,y)	Bound on capacity retirement	Optional limit lim (= LO/FX/UP/NB) on capacity retirement, for either continuous or discrete capacity retirement, for every vintage of process p in region r in year y .
NCAP_OLIFE(r,p,y)	Maximum full load operating lifetime of a process	Optional operating lifetime for process p in region r in year y .

Retirement of Capacity Results Parameters in ANSWER-TIMES

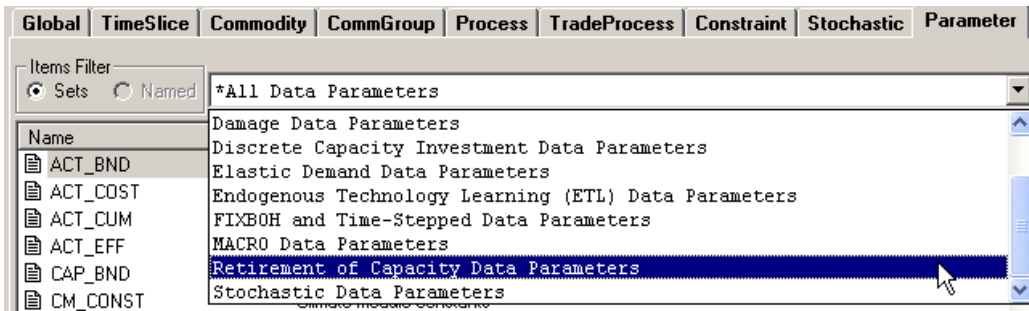
The TIMES Retirement of Capacity Extension involves three new Results Parameters, as follows:

Retirement of Capacity Results Parameter	Description	Comment – assuming for Run Model we have <input checked="" type="checkbox"/> Suppress Pure Zero Time Series Results
VAR_RCAPGv.L	Genuine Retirement of Process Capacity (vintaged)	Displayed for each process for which genuine capacity retirement (<u>excluding</u> forced retirements for PRC_RESID) occurs at a non-zero level.
VAR_RCAPv.L	Retirement of Process Capacity (vintaged)	Displayed for each process for which capacity retirement, <u>including</u> forced retirements for PRC_RESID, occurs at a non-zero level.
VAR_RCAPv.M	Retirement of Process Capacity (vintaged) - Marginal	Displayed for each process for which capacity retirement marginal is non-zero.

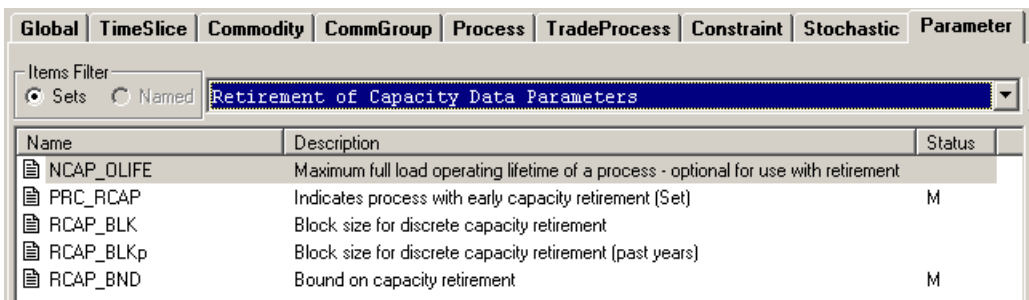
Specifying Capacity Retirement Data Parameters – Special Parameter Tab Setting

The Capacity Retirement Data Parameters are all Process Parameters and so may be specified on the Process tab. Or like all Data Parameters, they may be specified on the Parameter tab.

There is a special Parameter tab setting that provides a convenient way of adding / browsing / editing Capacity Retirement Data Parameters for multiple processes. On the Parameter tab, drop down the long combobox, and select the “Retirement of Capacity Data Parameters” setting:



This provides the convenience of displaying just those Data Parameters that are specific to the TIMES Retirement of Capacity Extension:



Select the Capacity Retirement Data Parameter that you want to add, and use the AddRow facility to specify instances of this Parameter (in the currently editable scenario).

Specifying the Type of Capacity Retirement TIMES Model Run to be carried out

The ANSWER-TIMES Model Variant and Objective Function Specification form (that is invoked from the Run Model form by clicking on the **Specify Model Variant...** button) has been enhanced to allow the user to select from the 3 Capacity Retirement options for a TIMES model run:

The screenshot shows a dialog box titled "Model Variant and Objective Function Specification" for the case "CONTINU-RET". The "Model Variants" section is circled in black, highlighting three radio button options: "No Capacity Retirement", "Continuous Capacity Retirement" (which is selected), and "Discrete Capacity Retirement". Other options in the dialog include "No Elastic Demand", "Save Base Prices for Elastic Demand", "Elastic Demand (Reading Base Prices)", "Climate", "No Damages in Objective", "Damages in Objective LP", "Damages in Objective NLP", "Discrete Capacity Investment", "Endogenous Technology Learning (ETL)", "MACRO", "No Stochastic/Tradeoff", "Stochastic", "Tradeoff/Sensitivity Analysis", "Fix Initial Periods (FIXBOH)", "Fix Up To", "Restart GD&X File", "Browse...", "Time-Stepped Solve", "TimeStep", "Overlap", "Objective Function Options", "OBJ Formulations", "Discounting", "Optimizer", and "Model Variant Description".

The 3 Capacity Retirement options are:

- No Capacity Retirement for any process (even if Capacity Retirement Data Parameter instances (such as PRC_RCAP, RCAP_BLK etc) are specified for a number of processes). No Capacity Retirement is the default.
- Continuous Capacity Retirement for those processes for which PRC_RCAP parameter instances are specified (but no Discrete Capacity Retirement for any process, even if RCAP_BLK and/or RCAP_BLKp parameter instances are specified for a number of processes). This Capacity Retirement option has been selected above.
- Discrete Capacity Retirement for those processes for which PRC_RCAP and RCAP_BLK and/or RCAP_BLKp parameter instances are specified, with Continuous Capacity Retirement for those processes for which PRC_RCAP but no RCAP_BLK or RCAP_BLKp parameter instances are specified.

Specifying a Continuous Capacity Retirement Model Run in ANSWER-TIMES: Overview

For a Continuous Capacity Retirement Model Run:

- Specify PRC_RCAP parameter instances for each process for which early capacity retirement is desired.
- Optionally specify RCAP_BND parameter instances to apply LO/FX/UP bounds to restrict the level at which early capacity retirement occurs.
- On the Run Model form click on the Specify Model Variant... button to bring up the Model Variant and Objective Function Specification form, and then select the “Continuous Capacity Retirement” option button:



- A Continuous Capacity Retirement Model Run requires only an LP optimizer (c.f. a Discrete Capacity Retirement Model Run that requires a MIP (Mixed Integer Programming) optimizer.
- Initiate the Model Run. ANSWER-TIMES automatically ensures that the control variable **RETIRE** is set to **LP** in the GEN file that controls the TIMES GAMS model run, by inserting:

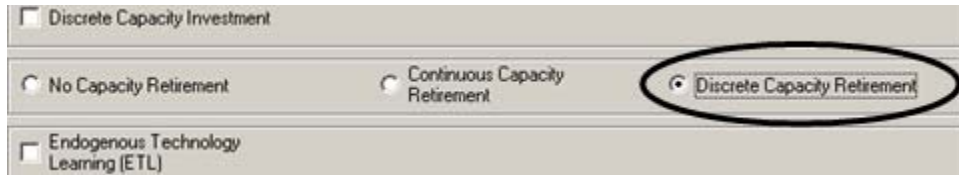
```
$SET RETIRE 'LP'
```

This can be seen by opening the file CONTINU-RET.GEN with a text editor.

Specifying a Discrete Capacity Retirement Model Run in ANSWER-TIMES: Overview

For a Discrete Capacity Retirement Model Run:

- Specify PRC_RCAP parameter instances for each process for which capacity retirement is desired. This must include processes for which discrete capacity retirement is desired, and may include other processes for which just continuous capacity retirement is desired.
- Specify RCAP_BLK and/or RCAP_BLKp parameter instances for each process for which discrete capacity retirement is desired. [How to do this is discussed in more detail below.](#)
- Optionally specify RCAP_BND parameter instances to apply LO/FX/UP bounds to restrict the level at which capacity retirement occurs.
- Optionally specify NCAP_OLIFE parameter instances.
- On the Run Model form click on the Specify Model Variant... button to bring up the Model Variant and Objective Function Specification form, and then select the “Discrete Capacity Retirement” option button:



- A Discrete Capacity Retirement Model Run requires a MIP (Mixed Integer Programming) optimizer.
- Initiate the Model Run. ANSWER-TIMES automatically ensures that the control variable **RETIRE** is set to **MIP** in the GEN file that controls the TIMES GAMS model run, by inserting:

\$SET RETIRE 'MIP'

This can be seen by opening the file DISCRET-RET.GEN with a text editor.

Demonstration Database RetirementOfCapacityDemo.mdb

The demonstration database **RetirementOfCapacityDemo.mdb** contains BASE scenario (with no Capacity Retirement Parameters) and two non-BASE scenarios **CONTINU-RET** and **DISCRET-RET** that specify Capacity Retirement Parameters for Continuous and Discrete Capacity Retirement respectively.

The two non-BASE scenarios specify Capacity Retirement Parameters for two Processes in the BASE scenario:

- Process E01-HICOST for which NCAP_PASTI parameter instances have been used to specify existing (Past Year) investment in capacity.
- Process TXD for which a PRC_RESID parameter instance has been used to specify existing (residual) investment in capacity.

Below some of the fine points of specifying Capacity Retirement Parameters for these two Processes (one with NCAP_PASTI and the other with PRC_RESID) are discussed, first in the context of Continuous Capacity Retirement, and then in the context of Discrete Capacity Retirement.

- ***In particular note that some care is needed in the Discrete Capacity Retirement case when specifying RCAP_BLK and/or RCAP_BLKp parameter instances: what is required depends on whether the process uses NCAP_PASTI or PRC_RESID to specify existing capacity.***

Continuous Capacity Retirement: Non-BASE Scenario and Case (Run) CONTINU-RET

1. On the Home Screen, make scenario **CONTINU-RET** the only Selected non-BASE scenario and make it the Editable scenario.

2. Move to the Process tab and select process E01-HICOST. You will see that the Capacity Retirement Parameters PRC_RCAP and RCAP_BND have already been specified for process E01-HICOST:

Items Filter: Sets Named *All Processes (PRC)

Name	Region	Description	Status
E01	REG	Coal Steam Electric	M
E01-HICOST	REG	Coal Steam Electric - High Cost	M
E21	REG	LWR Nuclear Plant	
E31	REG	Hydro-electric Plant	
E41	REG	Natural gas combined-cycle plant	
E51	REG	Pumped Storage Power Plant	
E70	REG	Oil Plant	
IMPDSL1	IMPEXP	Import of Diesel	
IMPDSL1	REG	Import of Diesel	
IMP GAS1	IMPEXP	Import of Uranium	

Item Management: Current Process: E01-HICOST

Subset Parameters: *C Process, Specific

Scenario	Parameter	Region	Process	Commo	Comm	Comm	Item5	Item6	I/E	1990	2000	2010	2020	2035
BASE	ACT_COST	?	REG	E01-HICOST	-	-	-	-	0	3.0000	3.0000	3.0000	3.0000	3.0000
BASE	ACT_EFF	?	REG	E01-HICOST	-	HCO	-	ANNUAL	-	0.3200	0.3200	0.3200	0.3200	0.3200
BASE	FLO_EMIS	?	REG	E01-HICOST	CO2	HCO	-	ANNUAL	-	89.0000	89.0000	89.0000	89.0000	89.0000
BASE	NCAP_AFA	?	REG	E01-HICOST	-	-	-	-	UP	0.8000	0.8000	0.8000	0.8000	0.8000
BASE	NCAP_COST	?	REG	E01-HICOST	-	-	-	-	0	14,000.0000	13,000.0000	12,000.0000	12,000.0000	12,000.0000
BASE	NCAP_FOM	?	REG	E01-HICOST	-	-	-	-	-	400.0000	700.0000	1,000.0000	1,000.0000	1,000.0000
BASE	NCAP_TLIFE	?	REG	E01-HICOST	-	-	-	-	0	40	40	40	40	40
M	CONTINU-RET	?	REG	E01-HICOST	-	-	-	-	UP	0.0500	0.0510	0.0520	0.0530	
Add	CONTINU-RET	?												

Scenario	Parameter	Region	Process	Commo	Item3	Year	Item5	Item6	Value
BASE	NCAP_PASTI	?	REG	E01-HICOST	-	-	-	1976	0.1800
BASE	NCAP_PASTI	?	REG	E01-HICOST	-	-	-	1986	0.1500
BASE	NCAP_TLIFE _p	?	REG	E01-HICOST	-	-	-	1976	40
BASE	NCAP_TLIFE _p	?	REG	E01-HICOST	-	-	-	1986	40
BASE	PRC_ACTUNT	?	REG	E01-HICOST	-	ELC	-	-	1
BASE	PRC_CAPACT	?	REG	E01-HICOST	-	-	-	-	31.5400
M	CONTINU-RET	?	REG	E01-HICOST	-	-	-	-	1
BASE	TOP-IN	?	REG	E01-HICOST	HCO	-	-	-	1
BASE	TOP-OUT	?	REG	E01-HICOST	CO2	-	-	-	1
BASE	TOP-OUT	?	REG	E01-HICOST	ELC	-	-	-	1
Add	CONTINU-RET	?							

Database: C:\AnswerTIMESv6\Answer_Databases\RetirementOfCapacityDemo.mdb Edit Scenario: CONTINU-RET

2a. We specify TID parameter PRC_RCAP to indicate that retirement applies to E01-HICOST.

2b. We specify TS parameter RCAP_BND to apply UPper limits of 0.0500, 0.5100, 0.5200, 0.5300 on the capacity retirement in each of years 1990, 2000, 2010, 2020. This is only to make the solution that we obtain more instructive in respect to the role played by RCAP_BND.

2c. After we carry out run CONTINU-RET, if we examine the Results for E01-HICOST and apply a TS Filter to restrict the display of Results Parameters to just VAR_RCAPGv.L (the Genuine Capacity Retirement Parameter) then we will find that:

- In each of the years 1990, 2000, 2010 the retirement of vintage 1976 is at the UPper limit specified by RCAP_BND, taking values 0.0500, 0.5100, 0.5200 respectively (by 2020 vintage 1976 capacity no longer exists since NCAP_TLIFE_p = 40); and
- In the years 1990 and 2000 the retirement of vintage 1986 is also at the UPper limit specified by RCAP_BND, taking values 0.0500, 0.5100 respectively. But in the year 2010, the retirement of vintage 1986 is 0.0490 falling short of the UPper limit of 0.0520 specified by RCAP_BND (this is because the 1986 NCAP_PASTI value is 0.1500):

Case	Parameter	Region	Process	Year	1990	2000	2010	2020	2035	2050	2065	2080
CONTINU-RET	VAR_RCAPGv.L	?	REG	E01-HICOST	1976	0.0500	0.0510	0.0520	0.0000	0.0000	0.0000	0.0000
CONTINU-RET	VAR_RCAPGv.L	?	REG	E01-HICOST	1986	0.0500	0.0510	0.0490	0.0000	0.0000	0.0000	0.0000

2d. If you repeat run CONTINU-RET (as run CONTINU-RET2) with no RCAP_BND specified for E01-HICOST, then you will find that the retirement in 1990 of the 1976 and 1986 vintages is 0.1800 and 0.1500 respectively:

Case	Parameter	Region	Process	Year	1990	2000	2010	2020	2035	2050	2065	2080
CONTINU-RET2	VAR_RCAPGv.L	REG	E01-HICOST	1976	0.1800	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
CONTINU-RET2	VAR_RCAPGv.L	REG	E01-HICOST	1986	0.1500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Discrete Capacity Retirement: Non-BASE Scenario and Case (Run) DISCRET-RET

1. On the Home Screen, make scenario DISCRET-RET the only Selected non-BASE scenario and make it the Editable scenario.
2. Move to the Process tab and select process E01-HICOST. You will see that the Capacity Retirement Parameters PRC_RCAP, RCAP_BLK, RCAP_BND and RCAP_BLKp have already been specified for process E01-HICOST:

Scenario	Parameter	Region	Process	Commo	Comm	Comm	Item5	Item6	I/E	1990	2000	2010	2020	2035
BASE	ACT_COST	REG	E01-HICOST	-	-	-	-	-	0	3.0000	3.0000	3.0000	3.0000	3.0000
BASE	ACT_EFF	REG	E01-HICOST	-	HCO	-	ANNUAL	-	0	0.3200	0.3200	0.3200	0.3200	0.3200
BASE	FLO_EMIS	REG	E01-HICOST	CO2	HCO	-	ANNUAL	-	0	89.0000	89.0000	89.0000	89.0000	89.0000
BASE	NCAP_AFA	REG	E01-HICOST	-	-	-	-	UP	0	0.8000	0.8000	0.8000	0.8000	0.8000
BASE	NCAP_COST	REG	E01-HICOST	-	-	-	-	-	0	14,000.0000	13,000.0000	12,000.0000	12,000.0000	12,000.0000
BASE	NCAP_FOM	REG	E01-HICOST	-	-	-	-	-	0	400.0000	700.0000	1,000.0000	1,000.0000	1,000.0000
BASE	NCAP_TLIFE	REG	E01-HICOST	-	-	-	-	-	0	40	40	40	40	40
M	DISCRET-RET	RCAP_BLK	REG	E01-HICOST	-	-	-	-	0	0.0000	0.0000	0.0000	0.0000	0.0000
M	DISCRET-RET	RCAP_BND	REG	E01-HICOST	-	-	-	UP	0	0.0500	0.0500	0.0500	0.0500	0.0500
Add	DISCRET-RET	RCAP	REG	E01-HICOST	-	-	-	-	0					

Scenario	Parameter	Region	Process	Commo	Item3	Year	Item5	Item6	Value
BASE	NCAP_PASTI	REG	E01-HICOST	-	-	-	-	1976	0.1800
BASE	NCAP_PASTI	REG	E01-HICOST	-	-	-	-	1986	0.1500
BASE	NCAP_TLIFEp	REG	E01-HICOST	-	-	-	-	1976	40
BASE	NCAP_TLIFEp	REG	E01-HICOST	-	-	-	-	1986	40
BASE	PRC_ACTUNT	REG	E01-HICOST	-	ELC	-	-	-	1
BASE	PRC_CAPACT	REG	E01-HICOST	-	-	-	-	-	31.5400
M	DISCRET-RET	PRC_RCAP	REG	E01-HICOST	-	-	-	-	1
M	DISCRET-RET	RCAP_BLKp	REG	E01-HICOST	-	-	-	1976	0.0450
M	DISCRET-RET	RCAP_BLKp	REG	E01-HICOST	-	-	-	1986	0.0375
BASE	TOP-IN	REG	E01-HICOST	HCO	-	-	-	-	1
BASE	TOP-OUT	REG	E01-HICOST	CO2	-	-	-	-	1
BASE	TOP-OUT	REG	E01-HICOST	ELC	-	-	-	-	1
Add	DISCRET-RET	RCAP	REG	E01-HICOST	-	-	-	-	

2a. We specify TID parameter PRC_RCAP to indicate that retirement applies to E01-HICOST.

2b. We specify RCAP_BLKp values for (past year) vintages 1976 and 1986 of 0.0450 and 0.0375 respectively to indicate that retirement of capacity for these vintages must be integer multiples of 0.0450 and 0.0375 respectively.

2c. We specify TS parameter RCAP_BLK with **explicit zeros** to indicate that **we do not wish any integer multiple restriction** to be applied to the retirement of capacity for the milestone year vintages.

- If we were to omit TS parameter RCAP_BLK with its explicit zeros, then we would find that the RCAP_BLKp values of 0.0450 and 0.0375 were extrapolated to provide RCAP_BLK values for milestone year vintages.

2d. If we **do wish integer multiple restrictions** to be applied to the retirement of capacity for the milestone year vintages, then we would specify appropriate non-zero RCAP_BLK datayear values (that would be interpolated/extrapolated to the milestone years for the model run).

2e. We specify TS parameter RCAP_BND to apply an UPper limit of 0.05 on the capacity retirement in each of years 1990, 2000, 2010, 2020. This is only to make the solution that we obtain more instructive in regard to the effects of the RCAP_BLKp parameter instances.

2f. After we carry out run DISCRET-RET, if we examine the Results for E01-HICOST and apply a TS Filter to restrict the display of Results Parameters to just VAR_RCAPGv.L (the Genuine Capacity Retirement Parameter) then we will find that:

- In each of the years 1990, 2000, 2010 the retirement of vintage 1976 is 0.0450 (by 2020 vintage 1976 capacity no longer exists since NCAP_TLIFEp = 40); and
- In each of the years 1990, 2000, 2010, 2020 the retirement of vintage 1986 is 0.0375:

Name	Region	Description	Status
E01	REG	Coal Steam Electric	
E01-HICOST	REG	Coal Steam Electric - High Cost	
E21	REG	LWR Nuclear Plant	
E31	REG	Hydro-electric Plant	
E41	REG	Natural gas combined-cycle plant	

Case	Parameter	Region	Process	Year	1990	2000	2010	2020	2035	2050	2065	2080
DISCRET-RET	VAR_RCAPGv.L	REG	E01-HICOST	1976	0.0450	0.0450	0.0450	0.0000	0.0000	0.0000	0.0000	0.0000
DISCRET-RET	VAR_RCAPGv.L	REG	E01-HICOST	1986	0.0375	0.0375	0.0375	0.0375	0.0000	0.0000	0.0000	0.0000

2g. If you repeat run DISCRET-RET (as run DISCRET-RET2) with no RCAP_BND specified for E01-HICOST, then you will find that the retirement in 1990 of the 1976 and 1986 vintages is 0.1800 (= 4 * 0.0450) and 0.1500 (= 4 * 0.0375) respectively:

Case	Parameter	Region	Process	Year	1990	2000	2010	2020	2035	2050	2065	2080
DISCRET-RET2	VAR_RCAPGv.L	REG	E01-HICOST	1976	0.1800	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DISCRET-RET2	VAR_RCAPGv.L	REG	E01-HICOST	1986	0.1500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

3. Now select process TXD. You will see that the Capacity Retirement Parameters PRC_RCAP, RCAP_BLK, RCAP_BND and RCAP_BLKp have already been specified for process TXD:

Scenario	Parameter	Region	Process	Commo	Comm	Comm	Item5	Item6	I/E	1990	2000	2010	2020	2035
BASE	ACT_EFF	?	REG TXD	-	DSL	-	ANNUAL	-	0	0.2310	0.2310	0.2310	0.2310	0.2310
BASE	FLD_EMIS	?	REG TXD	CO2	DSL	-	ANNUAL	-	0	75.0000	75.0000	75.0000	75.0000	75.0000
BASE	NCAP_AF	?	REG TXD	-	-	-	ANNUAL	UP	0	1.00000	1.00000	1.00000	1.00000	1.00000
BASE	NCAP_COST	?	REG TXD	-	-	-	-	-	0	1,044.0000	1,044.0000	1,044.0000	1,044.0000	1,044.0000
BASE	NCAP_FOM	?	REG TXD	-	-	-	-	-	0	52.00000	52.00000	52.00000	52.00000	52.00000
BASE	NCAP_TLIFE	?	REG TXD	-	-	-	-	-	0	20	20	20	20	20
BASE	PRC_RESID	?	REG TXD	-	-	-	-	-	0	3.0000	1.5000	0.0000		
M	DISCRET-RET	PRC_RESID	?	REG TXD	-	-	-	-	0	3.0000	1.0000	0.0000		
M	DISCRET-RET	RCAP_BLK	?	REG TXD	-	-	-	-	0	0.0000	0.0000	0.0000	0.0000	0.0000
M	DISCRET-RET	RCAP_BND	?	REG TXD	-	-	-	UP	0	1.5000				
Add	DISCRET-RET		?											

Scenario	Parameter	Region	Process	Commo	Item3	Year	Item5	Item6	Value
BASE	PRC_ACTUNT	?	REG TXD	-	TX	-	-	-	1
BASE	PRC_CAPACT	?	REG TXD	-	-	-	-	-	1.0000
M	DISCRET-RET	PRC_RCAP	?	REG TXD	-	-	-	-	1
M	DISCRET-RET	RCAP_BLKp	?	REG TXD	-	-	-	1985	0.5000
BASE	TOP-IN	?	REG TXD	DSL	-	-	-	-	1
BASE	TOP-OUT	?	REG TXD	CO2	-	-	-	-	1
BASE	TOP-OUT	?	REG TXD	TX	-	-	-	-	1
Add	DISCRET-RET		?						

3a. We specify TID parameter PRC_RCAP to indicate that retirement applies to TXD.

3b. We specify RCAP_BLKp values for the PRC_RESID vintage in **1985** of 0.5000 to indicate that retirement of capacity for this vintages must be an integer multiple of 0.5000.

- Why do we use **1985** as the PRC_RESID vintage? The generic rule used in TIMES is that the PRC_RESID vintage is **B(1) – 1**, where B(1) is the Beginning Year corresponding to the first Milestone Year. For this database, B(1) = 1986 and hence the PRC_RESID vintage is 1985:

Milestone Years, Beginning Years, Ending Years									
Default Milestone Years, B and E stored in Database are displayed in Edit mode.									
Checkboxes that are checked specify which Results Periods will comprise Milestone Years for Run Model.									
	1990	2000	2010	2020	2035	2050	2065	2080	
Milestone Years (M)	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Beginning Year (B)	1986	1996	2006	2016	2026	2043	2058	2073	
Allowable Milestone Years	1990	2000	2010	2020	2035	2050	2065	2080	
Ending Year (E)	1995	2005	2015	2025	2042	2057	2072	2087	

3c. Again we specify TS parameter RCAP_BLK with **explicit zeros** to indicate that **we do not wish any integer multiple restriction** to be applied to the retirement of capacity for the milestone year vintages.

3d. Of course if we **do wish integer multiple restrictions** to be applied to the retirement of capacity for the milestone year vintages, then we would specify appropriate non-zero RCAP_BLK datayear values (that would be interpolated/extrapolated to the milestone years for the model run).

3e. We specify TS parameter RCAP_BND to apply an UPper limit of 1.5 on the capacity retirement in year 1990.

3f. After we carry out run DISCRET-RET, if we examine the Results for TXD and apply a TS Filter to restrict the display of Results Parameters to just VAR_RCAPGv.L (the Genuine Capacity Retirement Parameter) then we will find that:

- In year 1990 the retirement of vintage 1985 is 1.5000 (= 3 * 0.5000). Although vintage 1985 is still available for (early) retirement in 2000 (since NCAP_TLIFE = 20) this does not occur in the optimal solution.

TXD		REG		Diesel Car									
Subset Parameters:		* Process, Specific				TS data							
Case	Parameter	Region	Process	Year	1990	2000	2010	2020	2035	2050	2065	2080	
DISCRET-RET	VAR_RCAPGv.L	?	REG	TXD	1985	1.5000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	

3g. If you repeat run DISCRET-RET (as run DISCRET-RET2) with no RCAP_BND specified for TXD, then you will find that the retirement in 1990 of the PRC_RESID vintage is 2.0000 (= 4 * 0.5000):

TXD		REG		Diesel Car									
Subset Parameters:		* Process, Specific				TS data							
Case	Parameter	Region	Process	Year	1990	2000	2010	2020	2035	2050	2065	2080	
DISCRET-RET2	VAR_RCAPGv.L	?	REG	TXD	1985	2.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	

“Run Model” considerations for a Discrete Capacity Retirement MIP Run

The “Run Model” outline given above ignores important considerations that apply when carrying out any MIP Run for a MIP problem that has a large number of integer/binary variables.

One such consideration is to specify a value for the GAMS OPTCR parameter that controls a mixed integer programming run. The OPTCR parameter is a relative termination tolerance, meaning that the MIP solver will stop and report the first integer solution found that is within 100*OPTCR % of the best possible solution. That is, if OPTCR is set at 0.01, the MIP solver will stop when it obtains an integer solution that is within 1% of the best possible solution.

- If OPTCR is set at 0.0, the MIP solver will continue until it has found the optimal integer solution, and verified that this integer solution is indeed optimal. This may involve a prohibitive amount of time for a MIP problem that has a large number of integer/binary variables.

For additional details, see the GAMS Users Guide, and the documentation that is specific to the MIP optimizer that you are running.

Setting a Value for the OPTCR parameter in ANSWER-TIMES

In ANSWER-TIMES, you can set a value for the OPTCR parameter by intervening in the *.GEN file that controls your MIP run. Near the bottom of the GEN file are the following 2 lines:

```
* Unasterisk the line below to set MIP optimality tolerance for an
ETL/Discrete Investment/Discrete Retirement run.
*OPTION OPTCR = 0.1;
```

All that you need to do is remove the asterisk from the second line and replace the value of 0.1 by your desired optimality tolerance, so for example to specify a value for OPTCR of 0.01 you would change the second line to become:

```
OPTION OPTCR = 0.01;
```

- If you want to do a succession of MIP runs with a particular value for OPTCR, then invoke menu option “Run, Edit GEN File Template” to make this change to your Template.GEN file. This will have the effect that the *.GEN file for all subsequent model runs will specify this particular value for OPTCR. (For details of this facility, see section 6.1.5.1 ‘Run, Edit GEN File Template’ facility in the *ANSWERv6-TIMES User Manual.pdf*.)
- If you want to vary the value for OPTCR on a run by run basis, then before you click on the [OK] button on the Run Model form, you should check the Edit GAMS Control File checkbox at the bottom left of the Run Model form:

The image shows a dialog box with several checkboxes. The checkbox labeled 'Edit GAMS Control File' is checked and circled in black. Other checkboxes include 'Generate Files, Do Not Run', 'Regenerate Base DD File', 'Regenerate Non-Base DDS Files', 'Regenerate Rule-based DDSs', 'Create Results For Import into ANSWER', 'Suppress Pure Zero Time Series Results', 'Import Results Automatically', and 'Automatic Repair & Compact after Import'. There are 'OK' and 'Cancel' buttons at the bottom right.

You will then be provided with the opportunity to edit the *.GEN file for your current run, and hence to specify the value for OPTCR that you wish to apply for your current run. (For details see section 6.1.4.1 Run Model ‘Edit GAMS Control File’ checkbox option in the *ANSWERv6-TIMES User Manual.pdf*.)

- For the tiny Discrete Capacity Retirement MIP problem **DISCRET-RET** above, a value for OPTCR of 0.0 was specified, so that the optimal integer solution was obtained.