

TIMES Discrete Capacity Investment Extension in ANSWER-TIMES

Introduction

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

For an explanation of the TIMES Discrete Capacity Investment Extension see:

- Chapter 7 of “Documentation for the TIMES Model – Part I” (authors Richard Loulou, Uwe Remme, Amit Kanudia, Antti Lehtila, Gary Goldstein), which can be downloaded from the ETSAP website as *TIMESDoc-Intro.pdf*, and
- “Documentation for the TIMES Model – Part II” (authors Richard Loulou, Uwe Remme, Amit Kanudia, Antti Lehtila, Gary Goldstein), which can be downloaded from the ETSAP website as *TIMESDoc-Details.pdf*.

For a concrete example demonstrating Run Model using the TIMES Discrete Capacity Investment Extension, see the non-BASE scenario **DISCRETE-INV** and the online Case **DISCRETE-INV** in database Example4-v661.mdb (distributed with ANSWER-TIMES version 6.6.1 and higher).

Specification of Discrete Capacity Investment Extension Data Parameters in ANSWER-TIMES

The TIMES Discrete Capacity Investment Extension involves 2 Data Parameters, as follows:

Discrete Capacity Investment Data Parameter	Description
NCAP_DISC	Unit size of discrete capacity addition
PRC_DSCNCAP	Indicates process with discrete capacity additions (Set)

Discrete Capacity Investment Data Parameters may be specified on either the Process tab, or on the Parameter tab.

Process Tab

On the Process tab, specify that additions to capacity for a particular Process are discrete (lumpy) by selecting that Process and using the AddRow in the Time Series spread to add parameter NCAP_DISC, and the AddRow in the TID spread to add parameter PRC_DSCNCAP.

- For the demonstration database Example4-v661.mdb, if you make the non-BASE scenario **DISCRETE-INV** the editable scenario, move to the Process tab and select process E70 (Oil Plant), you will see that the Discrete Capacity Investment Parameters NCAP_DISC and PRC_DSCNCAP have already been specified for process E70. See the screen snapshot on the following page.
- Note that three NCAP_DISC parameter instances have been specified for process E70, for unit sizes U001, U002, U003 of 0.25, 0.50, 0.75 respectively (with these unit sizes applying in each time period). When you carry out Run Model invoking the TIMES Discrete Capacity Investment Extension, you will expect investment in new capacity for process E70 in a period to be one of the three unit sizes of 0.25, 0.50, 0.75, or to be 0.

Global	TimeSlice	Commodity	CommGroup	Process	TradeProcess	Constraint	Stochastic	Parameter						
Items Filter: <input checked="" type="radio"/> Sets <input type="radio"/> Named *All Processes (PRC)														
Name	Region	Description		Status										
E31	REG	Hydro-electric Plant												
E41	REG	Natural gas combined-cycle plant												
E51	REG	Pumped Storage Power Plant												
E70	REG	Oil Plant		M										
IMPDSL1	IMPEXP	Import of Diesel												
Subset Parameters: *C Process, Specific														
Scenario	Parameter	Region	Process	Commo	CommG	Comm	Item5	Item6	I/E	1990	2000	2010	2015	2020
BASE	NCAP_COST	REG	E70	-	-	-	-	-	0	1,000.0000	1,000.0000	1,000.0000	1,000.0000	1,000.0000
M	DISCRETE-INV	REG	E70	-	-	-	-	U001	0	0.25	0.25	0.25	0.25	
M	DISCRETE-INV	REG	E70	-	-	-	-	U002	0	0.50	0.50	0.50	0.50	
M	DISCRETE-INV	REG	E70	-	-	-	-	U003	0	0.75	0.75	0.75	0.75	
BASE	NCAP_FDM	REG	E70	-	-	-	-	-	0	30.0000	30.0000	30.0000	30.0000	30.0000
Scenario	Parameter	Region	Process	Commo	Item3	Year	Item5	Item6	Value					
BASE	PRC_ACTUNT	REG	E70	-	ELC	-	-	-	1					
BASE	PRC_CAPACT	REG	E70	-	-	-	-	-	31.5400					
M	DISCRETE-INV	REG	E70	-	-	-	-	-	1					
BASE	TOP-IN	REG	E70	DSL	-	-	-	-	1					
BASE	TOP-OUT	REG	E70	CO2	-	-	-	-	1					
BASE	TOP-OUT	REG	E70	ELC	-	-	-	-	1					

Database: C:\AnswerTIMESv6\Answer_Databases\Example4-v661.mdb Edit Scenario: DISCRETE-INV

- Note that the NCAP_DISC Data Parameter has as one of its arguments UnitSize (this argument appears above in the Item6 column of the TS spread for each of the NCAP_DISC parameter instances), where the members of UnitSize are as follows:

Add Row UnitSize Item Selection	
U001	Unit Size 1 for Discrete Capacity Addition
U002	Unit Size 2 for Discrete Capacity Addition
U003	Unit Size 3 for Discrete Capacity Addition
U004	Unit Size 4 for Discrete Capacity Addition
U005	Unit Size 5 for Discrete Capacity Addition
U006	Unit Size 6 for Discrete Capacity Addition
U007	Unit Size 7 for Discrete Capacity Addition
U008	Unit Size 8 for Discrete Capacity Addition
U009	Unit Size 9 for Discrete Capacity Addition
U010	Unit Size 10 for Discrete Capacity Addition

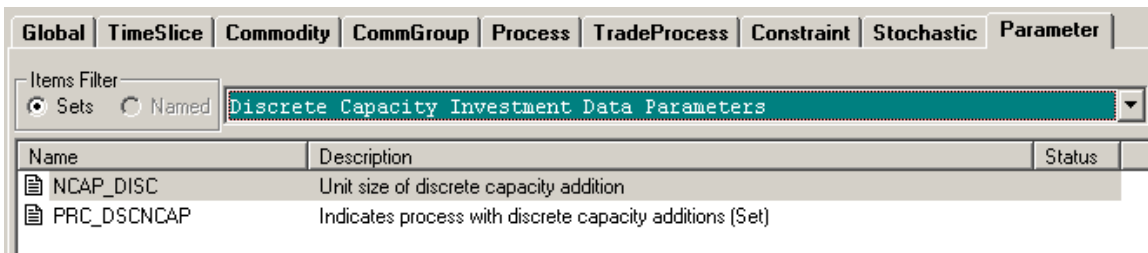
OK Cancel

Parameter Tab

The Parameter tab offers the convenience of being able to see all instances of parameters NCAP_DISC and PRC_DSCNCAP in the database (for the currently selected scenarios) and also provides a convenient way of adding these parameters for multiple Processes. On the Parameter tab, drop down the long combobox, and select the Discrete Capacity Investment Data Parameters setting:

Global	TimeSlice	Commodity	CommGroup	Process	TradeProcess	Constraint	Stochastic	Parameter
Items Filter: <input checked="" type="radio"/> Sets <input type="radio"/> Named *All Data Parameters								
Name	*All Data Parameters							
	Climate Data Parameters							
	Damage Data Parameters							
	Discrete Capacity Investment Data Parameters							
	Elastic Demand Data Parameters							
	Endogenous Technology Learning (ETL) Data Parameters							
	FIXBOH and Time-Stepped Data Parameters							
	Macro Data Parameters							
ACT_BND								
ACT_COST								
ACT_CUM								
ACT_EFF								
CAP_BND								
CM CONST								

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

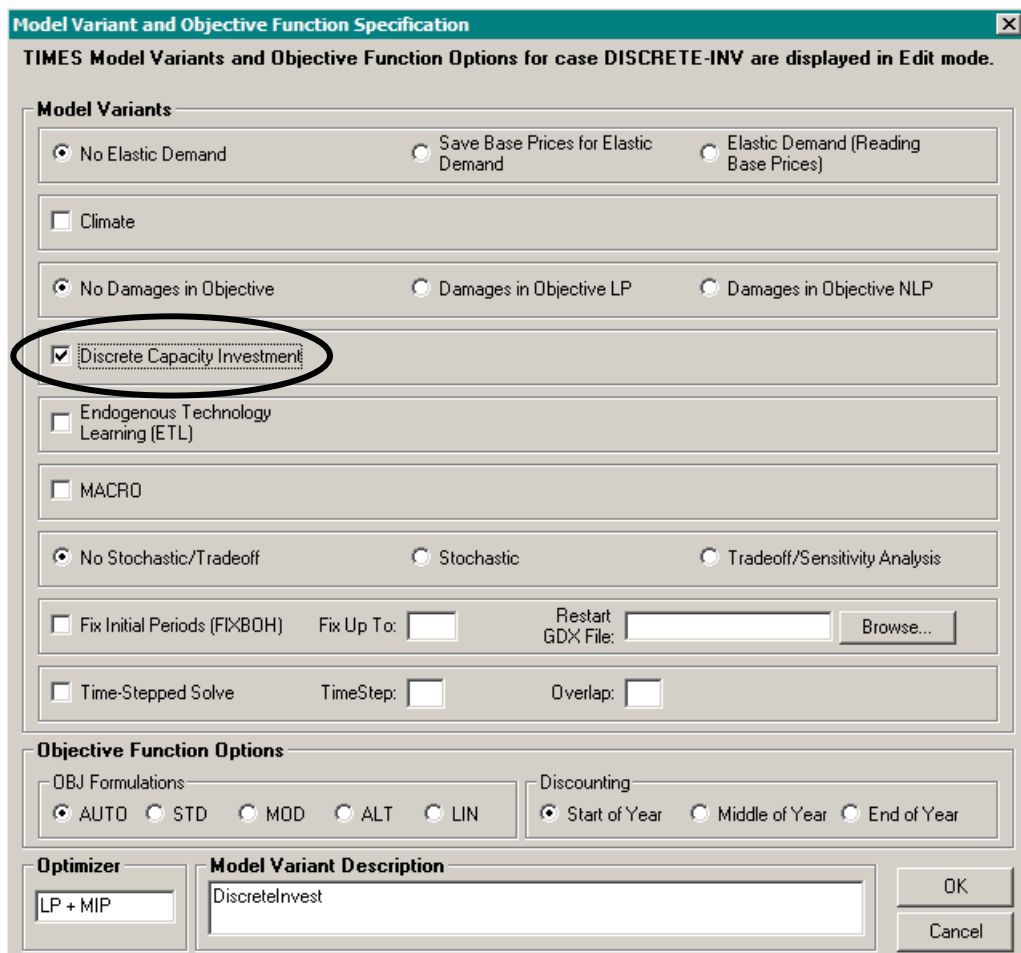


Now use the AddRow facility to specify Discrete Capacity Investment Data Parameter instances.

Specifying a Discrete Capacity Investment Extension Model Run in ANSWER-TIMES

To specify in ANSWER-TIMES that a TIMES model run uses the Discrete Capacity Investment Extension, click on the **Specify Model Variant...** button on the Run Model form, and then check the Discrete Capacity Investment checkbox.

- For Run **DISCRETE-INV** as the current run on the Run Model form, this displays:



- Click on the [OK] button on the Model Variant Specification form to return to the Run Model form, and click on the [OK] button of the Run Model form to carry out Run Model using the Discrete Capacity Investment Extension. Note that a MIP (Mixed Integer Programming) optimizer is needed to carry out a Discrete Capacity Investment model run.
- ANSWER-TIMES then ensures that the control variable **DSC** is set to **YES** in the GEN file that controls the TIMES GAMS model run, by inserting:

\$\$SET DSC 'YES'

This can be seen by opening the file DISCRETE-INV.GEN with a text editor.

- Run Model Results for Case DISCRETE-INV
The screen snapshot below compares the investment in new capacity (VAR_NCAP.L) for process E70 for the two Cases EX4-7PER (7 period run of the BASE scenario for standard TIMES) and DISCRETE-INV (7 period run of the BASE scenario, but with Discrete Capacity Investment applying to process E70):

Case	Parameter	Region	Process	Commo	TimeSlic	1990	2000	2010	2020	2035	2050	2065	2080
DISCRETE-INV	VAR_FLO-IN.M	?	REG	E70	DSL	SUN	8.19	7.61	7.61	7.61	7.61	7.61	7.61
DISCRETE-INV	VAR_FLO-IN.M	?	REG	E70	DSL	WID	7.44	6.64	10.12	6.65	8.19	9.14	10.12
DISCRETE-INV	VAR_FLO-IN.M	?	REG	E70	DSL	WIN	8.19	7.61	10.12	8.06	8.73	9.41	10.12
EX4-7PER	VAR_FLO-OUT.M	?	REG	E70	ELC	FAD	27.85	24.99	22.57	22.57	22.57	22.57	22.57
EX4-7PER	VAR_FLO-OUT.M	?	REG	E70	ELC	FAN	27.85	27.63	25.88	25.88	25.88	25.88	25.88
EX4-7PER	VAR_FLO-OUT.M	?	REG	E70	ELC	SPD	27.85	27.63	26.90	28.68	28.84	28.11	28.65
EX4-7PER	VAR_FLO-OUT.M	?	REG	E70	ELC	SPN	27.85	24.99	23.99	26.46	26.68	25.66	26.41
EX4-7PER	VAR_FLO-OUT.M	?	REG	E70	ELC	SUD	27.85	26.17	22.57	22.57	22.57	22.57	22.57
EX4-7PER	VAR_FLO-OUT.M	?	REG	E70	ELC	SUN	27.85	27.63	22.57	22.57	22.57	22.57	22.57
EX4-7PER	VAR_FLO-OUT.M	?	REG	E70	ELC	WID	24.54	24.99	29.00	27.72	27.53	27.91	27.69
EX4-7PER	VAR_FLO-OUT.M	?	REG	E70	ELC	WIN	27.30	27.63	31.35	30.40	30.28	30.54	30.40
DISCRETE-INV	VAR_NCAP.L	?	REG	E70	-	-	0.75	0.50	0.00	0.50	0.75	0.25	0.50
EX4-7PER	VAR_NCAP.L	?	REG	E70	-	-	0.80	0.39	0.18	0.38	0.77	0.36	0.51

Note that for Case DISCRETE-INV, the VAR_NCAP.L values in each time period are always one of the three unit sizes of 0.25, 0.50, 0.75, or are 0.

“Run Model” considerations for a (Discrete Capacity Investment) 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

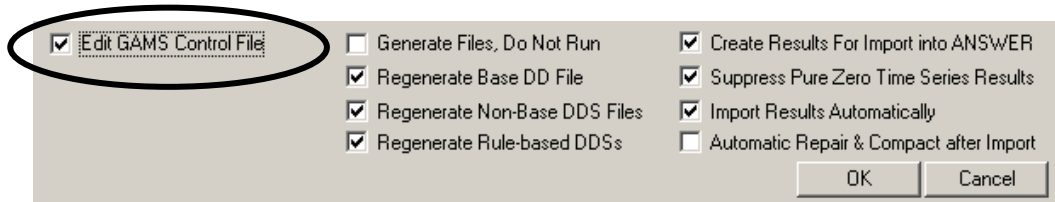
In ANSWER-TIMES, you can set a value for the OPTCR parameter by intervening in the *.GEN file that controls your MIP run. Near the bottom of the GEN file are the following 2 lines:

```
* Unasterisk the line below to set MIP optimality tolerance for an ETL/Lumpy
Investment 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:



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 Investment MIP problem **DISCRETE-INV** above, a value for OPTCR of 0.0 was specified, so that the optimal integer solution was obtained.