TIMES Elastic Demand Extension in ANSWER-TIMES (Revised Dec. 2011)

Introduction

The purpose of this note is to briefly describe how to invoke the TIMES Elastic Demand Extension in ANSWER-TIMES.
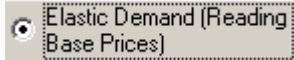
For an explanation of the TIMES Elastic Demand Extension see:

- Chapter 6 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

- Section 3.1 of TIMES Version 2.8 User Note "User Control Switches in TIMES" (author Antti Lehtila), which can be downloaded from the ETSAP website as *TIMES-Control-Switches.pdf.*

For a concrete example demonstrating how to carry out a TIMES Elastic Demand model run, see the online Case **EX4-7PERSVBP**, the non-BASE scenarios **ELAST-DM** and **CO2LIMIT**, and the online Cases **ELAST-DM** and **ELAST-DM-CO2** in demonstration database Example4-v672.mdb.

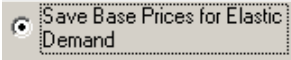## TIMES Elastic Demand Extension in ANSWER-TIMES - Overview

The essence of what is required to carry out a TIMES Elastic Demand model run is summarized in section 3.1 of *TIMES-Control-Switches.pdf*, though restated here in a slightly different way:

Baseline / Elastic Demand Model Run	ANSWER-TIMES Model Variant Specification Option Button Selected
Run a baseline scenario with $SET TIMESED 'NO' causing the TIMES model generator to save the base price levels from the baseline scenario run to file **com_bprice.gdx**.	Save Base Prices for Elastic Demand
Run an elastic demand policy scenario with $SET TIMESED YES that reads the base price levels in file **com_bprice.gdx** and uses these as reference prices for an Elastic Demand run.	Elastic Demand (Reading Base Prices)

That is, prior to undertaking an Elastic Demand model run, you must have previously used Run Model to carry out a run in which you saved the base prices that are to be used as reference prices to file **com_bprice.gdx**.

Carrying out an ANSWER-TIMES Model Run to Save Base Prices to file com_bprice.gdx

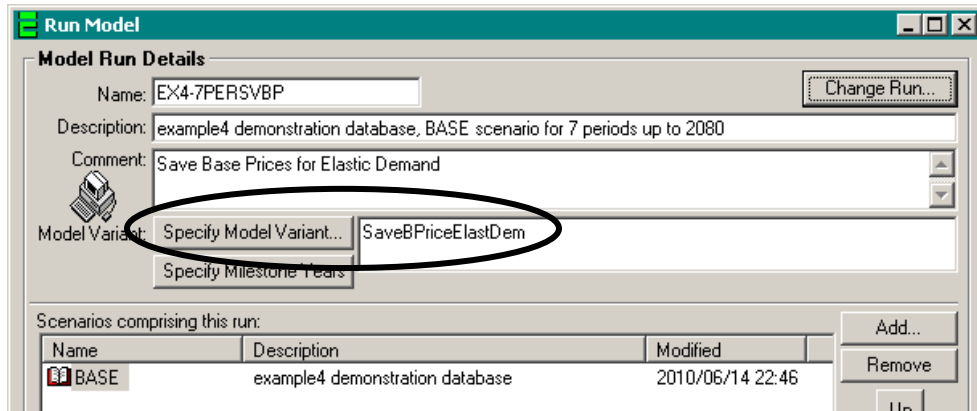To carry out an ANSWER-TIMES model run to save base prices to file **com_bprice.gdx**:

- Invoke Run Model to display the Run Model form, and select the desired Run (Case) to be used to generate the Base Prices.

- Click on the [Specify Model Variant...] button to display the Model Variant Specification form.

- On the Model Variant Specification form select the [Save Base Prices for Elastic Demand] option button.

- Click the [OK] button on the Model Variant Specification form to return to the Run Model form.

- Click the [OK] button on the Run Model form to initiate a model run that will save base prices to file **com_bprice.gdx** (from where they can subsequently be used as reference prices for an Elastic Demand run).

For the demonstration database Example4-v672.mdb, if you invoke Run Model and use the

[Change Run...] button on the Run Model form to select Run (Case) **EX4-7PERSVBP**, and then

click on the [Specify Model Variant...] button to display the Model Variant Specification form, you will see:

(Run (Case) **EX4-7PERSVBP** was created by first selecting Run **EX4-7PER** as the desired Run to be used to generate the Base Prices, and then for purpose of easing the explanation in this documentation, changing the Name on the Run Model form from **EX4-7PER** to **EX4-7PERSVBP** so that both of these Runs (Cases) are online in database Example4-v672.mdb.)

After clicking on the [OK] button on the Model Variant Specification form to return to the Run Model form, the top part of the Run Model form will appear as follows:

The textbox displaying **SaveBPriceElastDM** indicates in ANSWER-TIMES that the model run will save base prices to file **com_bprice.gdx**.

You should carry out Run Model for Case **EX4-7PERSVBP** *so that file* **com_bprice.gdx** *containing base prices (subsequently to be used as reference prices for Elastic Demand runs* **ELAST-DM** *and* **ELAST-DM-CO2***) is created in sub-folder Gams_WrkTI on your PC.* You might like to check that:

- ANSWER-TIMES has inserted the line **$SET TIMESED 'NO'** in the GEN file that controls the TIMES GAMS model run by opening the file EX4-7PERSVBP.GEN with a text editor; and

- File **com_bprice.gdx** has been created in sub-folder Gams_WrkTI on your computer.

Specification of Elastic Demand Extension Data Parameters in ANSWER-TIMES

The TIMES Elastic Demand Extension involves 4 Data Parameters, as follows:

Elastic Demand Data Parameter	Description
COM_ELAST	Elasticity of demand
COM_ELASTX	Elasticity shape of demand
COM_STEP	Step size for elastic demand
COM_VOC	Variance of elastic demand

(The Elastic Demand Data Parameter COM_ELASTX is for advanced users.)

Elastic Demand Data Parameters may be specified on either the Commodity tab, or on the Parameter tab.

Commodity Tab
On the Commodity tab, specify that Elastic Demand applies to particular Demand Commodities by selecting those Commodities and using the AddRow in the Time Series spread to add parameter instances for COM_ELAST and COM_VOC, and the AddRow in the TID spread to add parameter instances for COM_STEP.

- For the demonstration database Example4-v672.mdb, if you make the non-BASE scenario **ELAST-DM** the editable scenario, move to the Commodity tab and select demand commodity TX (Automobile Transportation), you will see that the above Elastic Demand Parameters – except for COM_ELASTX – have already been specified for commodity TX. See the screen snapshot on the following page.

- Similarly valued parameter instances have also been specified for the demand commodities RH (Residential Heating) and RL (Residential Lighting).

Parameter Tab

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

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

Now use the AddRow facility to specify Elastic Demand Data Parameter instances as required.

- For non-BASE scenario **ELAST-DM** as the editable scenario, if you move to the Parameter tab, select the Elastic Demand Data Parameters setting and click on the ⬛Select All Items button (and change the setting to ⬛TS,TID data ▾), you will see displayed all of the Elastic Demand Data Parameter instances:

This Parameter tab display indicates that Elastic Demand Data Parameter instances are specified for RH, RL and TX.

Specifying an Elastic Demand Model Run in ANSWER-TIMES – with no policy measure

It is good practice, <u>before</u> carrying out an Elastic Demand model run that also involves a "policy measure" (such as an emissions constraint or an emissions tax) and where some of those Demands that are Elastic might respond to the "policy measure", to first carry out an Elastic

Demand model run without any "policy measure" and check that this run lines up well with the business-as-usual run used to generate the Base Prices. This is the Run (Case) **ELAST-DM** in demonstration database Example4-v672.mdb.

To specify in ANSWER-TIMES that a TIMES model run uses the Elastic Demand Extension, click on the [Specify Model Variant...] button on the Run Model form, and then select the ⊙ Elastic Demand (Reading Base Prices) option button.

- For Run **ELAST-DM** 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, ensure that the scenarios comprising the run are **BASE** and **ELAST-DM**:

and click on the [OK] button of the Run Model form to carry out Run Model using the Elastic Demand Extension. As noted previously, an Elastic Demand run requires that a

preceding baseline model run has created file **com_bprice.gdx** (containing base prices to be used as reference prices for the Elastic Demand run).

- ANSWER-TIMES then ensures that the control variable **TIMESED** is set to **YES** by inserting the line **$SET TIMESED 'YES'** in the GEN file that controls the TIMES GAMS model run. This can be seen by opening the file ELAST-DM.GEN with a text editor.

Specifying an Elastic Demand Model Run in ANSWER-TIMES – <u>with</u> policy measure

Before carrying out an Elastic Demand model run that involves a "policy measure" (such as an emissions constraint or an emissions tax) and where some of those Demands that are Elastic might respond to the "policy measure", we first need to specify the "policy measure".

- In non-BASE scenario **CO2LIMIT**, the "policy measure" is provided by using the COM_BNDPRD data parameter to specify a *tight* CO_2 emissions constraint over the period 2000 to 2080. Thus with non-BASE scenario **CO2LIMIT** as the editable scenario, select the Commodity tab and make CO2 the selected commodity, then use the AddRow to specify COM_BNDPRD as follows:

- Now we are ready to carry out an Elastic Demand model run where some of those Demands that are Elastic might respond to this CO2 emissions constraint.

- Bring up the Run Model form and use it to specify model run **ELAST-DM-CO2** as per the screen snapshot on the following page. Be sure to ensure that the scenarios comprising the run are **BASE**, **ELAST-DM** and **CO2LIMIT**. Also, so that your screen snapshots mimick those in the remainder of this document, ensure that the checkbox
 is unchecked.
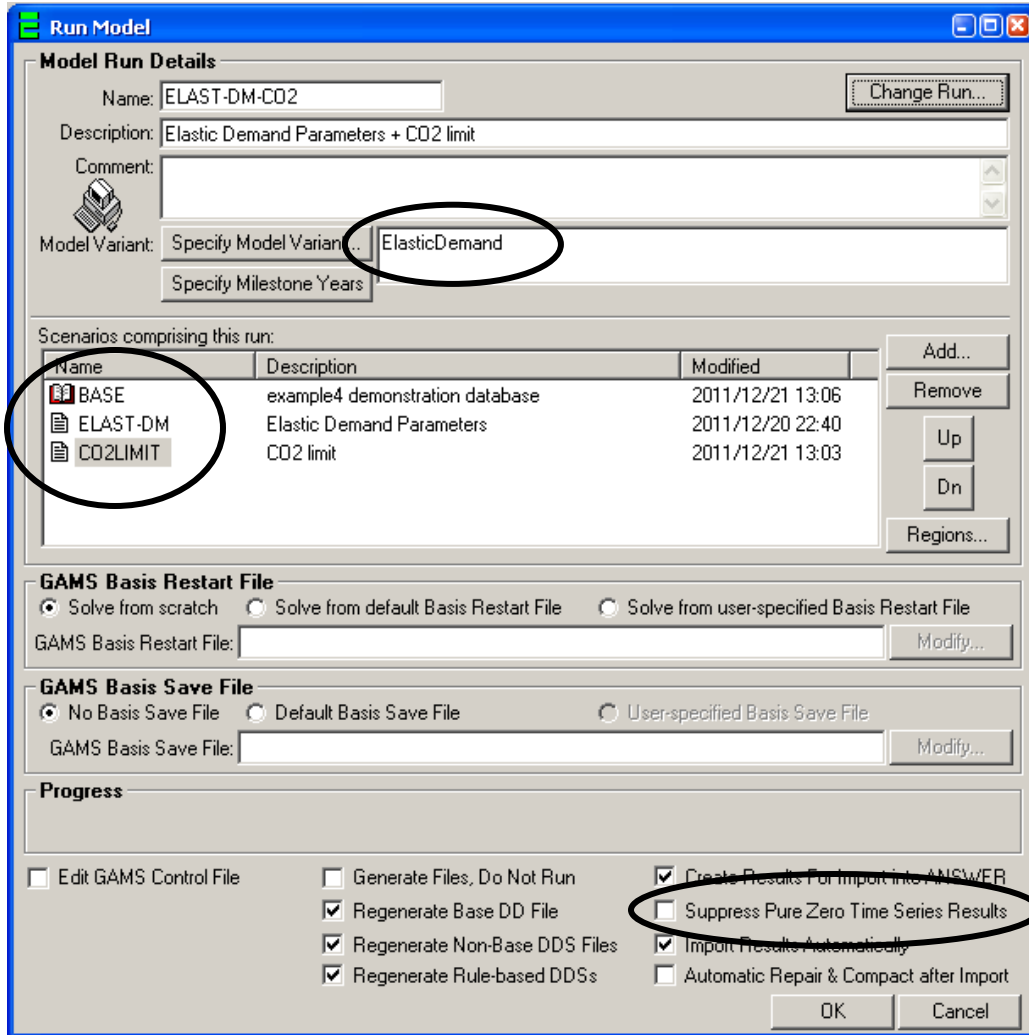
After carrying out run **ELAST-DM-CO2** and importing the results into ANSWER-TIMES, ensure that the Selected Cases listview (bottom RH quadrant of the Home Screen) has **ELAST-DM** and **ELAST-DM-CO2** as the only selected Cases:
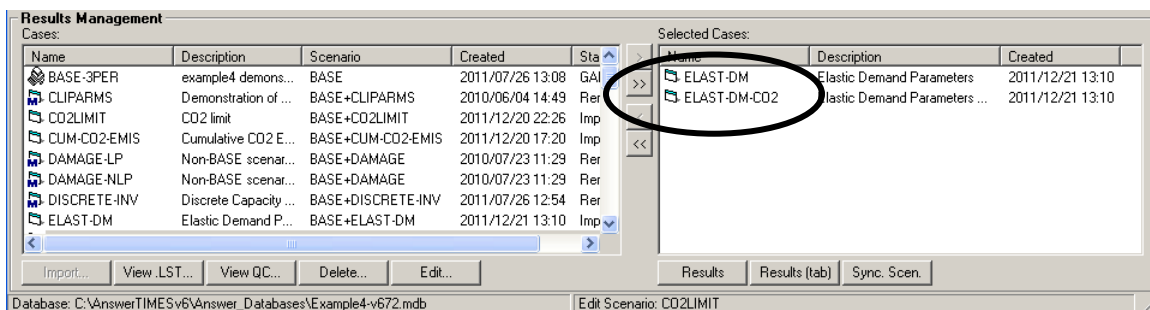
Click on the [Results] button below the Selected Cases listview, which will take you to the Parameter tab for Results, and note the following:

- If you select results parameter OBJz.L (Total Discounted System Cost) then the **ELAST-DM-CO2** Case is showing a considerably higher value than the **ELAST-DM** Case:

- If you multi-select results parameters VAR_COMNET.L, VAR_COMNET.M, VAR_COMPRD.L and VAR_COMPRD.M then the VAR_COMNET.L values for Case **ELAST-DM** show the CO_2 emissions levels for that Case, which are considerably higher than those for case **ELAST-DM-CO2** (which are at the upper limit of the CO_2 emissions constraint that we imposed). The VAR_COMPRD.M results show the marginals for the CO_2 emissions constraint in each of the time periods 2000 to 2080:

To confirm that demand TX (Automobile Transportation) has responded elastically to the CO_2 emissions constraint, proceed as follows:

- Bring up the TS and TID Filter form and specify a filter that selects all Processes that can produce demand TX, that is all Processes whose name begins with TX (Like "TX*"):

- Select results parameter **VAR_ACT.L** and click on the Case header in the spread so that the spread appears as follows:

Case	Parameter		Region	Process	TimeSlic	1990	2000	2010	2020	2035	2050	2065	2080
ELAST-DM	VAR_ACT.L	?	REG	TXD	ANNUAL		6.3000	11.6900	11.6900	11.6900	11.6900	11.6900	11.6900
ELAST-DM	VAR_ACT.L	?	REG	TXE	ANNUAL		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ELAST-DM	VAR_ACT.L	?	REG	TXG	ANNUAL		1.5000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ELAST-DM-CO2	VAR_ACT.L	?	REG	TXD	ANNUAL		5.5980	1.6427	0.0000	0.0000	0.0000	0.0000	0.0000
ELAST-DM-CO2	VAR_ACT.L	?	REG	TXE	ANNUAL		0.0000	7.9431	10.6379	10.6379	10.6379	10.6379	10.6379
ELAST-DM-CO2	VAR_ACT.L	?	REG	TXG	ANNUAL		1.5000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

- Use the mouse to multi-select all of the rows above, right-mouse click and select the "Analyze with Excel" menu option, and click OK on the little form that appears. An Excel spreadsheet whose first 7 rows are similar to what's displayed below (once the Item2, Item3, Item4 and Item6 columns have been deleted) will appear:

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Case	Parameter	Units	Region	Process	TimeSlice	1990	2000	2010	2020	2035	2050	2065	2080
2	ELAST-DM	VAR_ACT.L	PJ	REG	TXD	ANNUAL		6.3000	11.6900	11.6900	11.6900	11.6900	11.6900	11.6900
3	ELAST-DM	VAR_ACT.L	PJ	REG	TXE	ANNUAL		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4	ELAST-DM	VAR_ACT.L	PJ	REG	TXG	ANNUAL		1.5000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5	ELAST-DM-CO2	VAR_ACT.L	PJ	REG	TXD	ANNUAL		5.5980	1.6427	0.0000	0.0000	0.0000	0.0000	0.0000
6	ELAST-DM-CO2	VAR_ACT.L	PJ	REG	TXE	ANNUAL		0.0000	7.9431	10.6379	10.6379	10.6379	10.6379	10.6379
7	ELAST-DM-CO2	VAR_ACT.L	PJ	REG	TXG	ANNUAL		1.5000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
8														
9	sum over ELAST-DM							7.8000	11.6900	11.6900	11.6900	11.6900	11.6900	11.6900
10														
11	sum over ELAST-DM-CO2							7.0980	9.5858	10.6379	10.6379	10.6379	10.6379	10.6379
12														
13	difference between ELAST-DM sum and ELAST-DM-CO2 sum							0.7020	2.1042	1.0521	1.0521	1.0521	1.0521	1.0521
14														

- Note that the numeric values obtained by summing over the 3 **ELAST-DM** rows correspond to the COM_PROJ values for TX specified in the BASE scenario for 2000 through to 2080, whereas the numeric values obtained by summing over the 3 **ELAST-DM-CO2** rows are *smaller* than the COM_PROJ values for TX, indicating that demand TX has adjusted *downwards* in response to the CO_2 emissions constraint.

- Note also that from 2020 onwards, neither TXD (Diesel Car) nor TXG (Gasoline Car) – both of which have associated CO_2 emissions – are used, and the entire (reduced) automobile transportation task is handled by TXE (Electric Car).

If you examine the GAMS LST file for case **ELAST-DM-CO2**, and search for "VAR VAR_ELAST" (Demand change due to price elasticity) and then scroll down until you encounter the first non-zero level for a VAR_ELAST variable, then you will see that this is for TX in 2000:

```
REG.2000.RL.SPD    .10.UP        .            .            0.0907       2616.1515
REG.2000.TX.ANNUAL.1 .LO         .            0.7020       0.7020       -266.3493
REG.2000.TX.ANNUAL.2 .LO         .            .            0.7020       608.5260
```

Note that the numeric value of 0.7020 corresponds to the value of 0.7020 in 2000 for the "difference between ELAST-DM sum and ELAST-DM-CO2 sum" in the spreadsheet snapshot above. Likewise the next non-zero levels for a VAR_ELAST variable occur for TX in 2010, and their sum of 2.1042 corresponds to the value of 2.1042 in 2010 for the "difference between ELAST-DM sum and ELAST-DM-CO2 sum" in the spreadsheet snapshot above.

```
REG.2010.RL.SPD    .10.UP        .            .            0.1361       1310.4792
REG.2010.TX.ANNUAL.1 .LO         .            1.0521       1.0521       -658.2003
REG.2010.TX.ANNUAL.2 .LO         .            1.0521       1.0521       -101.0621
REG.2010.TX.ANNUAL.3 .LO         .            .            1.0521       775.7332
```