TIMES-Starter Model Guidelines for Use

Prepared for the International Energy Agency's

Energy Technology Systems Analysis Program (IEA-ETSAP)

by DecisionWare Group

August 2016

Table of Contents

List of Figures

List of Tables

1 Introduction

This report describes the accompanying TIMES[1] Starter model (TIMES-Starter). The underlying premise of the TIMES-Starter model is to provide new users with a well thought out TIMES model structure employing best practices that is built from solid documented data sources. It provides all the basic building blocks, tools and techniques that need to be employed as part of assembling and applying a TIMES model.

The model data is assembled in flexible Excel workbooks (templates) that collectively comprise a viable starting point for development of a TIMES model - both with respect to designing a Reference Energy System (RES) and the depiction of the commodities and technologies underlying that RES. The templates are designed to be driven by the energy balance for any particular area of study (national, regional, municipal), and they are customizable to facilitate more rapid assembly of an initial model by new TIMES users. The intent is to provide a framework and roadmap that enables new users to assemble a high-quality initial model that is tailored as needed to reflect local conditions in a much more expeditious and organized manner.

The TIMES-Starter database is largely derived from the US Environmental Protection Agency Office of Research and Development (EPA-ORD) Nine-Region US MARKAL model (US9r) database[2], which is a peer-reviewed compilation of data from EPA, US Department of Energy (DOE) Annual Energy Outlook (AEO)[3]. Where the EPA database did not provide technologies seen as important (e.g., district heat (HPL) and Coupled Heat & Power (CHP) plants) other credible data sources were turned to, most notably the Danish Energy Agency's[4]. In a few cases, separately referenced, the technology characteristics in the database were updated or expanded, to plug holes or utilize better data. Modeling practices and parameters have been adjusted as needed to move the model data from the MARKAL to the TIMES framework, but the original EPA datasheets are provided to enable (easy) updating when new releases of US9r are made general available. [Full details with respect to the original USDOE AEO source data can be found in the US9r documentation (footnote 2) or by obtaining the full set of templates embodying the model.]

[1] The Integrated MARKAL/EFOM System, see www.iea-etsap.org.

[2] EPA U.S. Nine-region MARKAL Database, EPA 600/B-13/203, September 2013, http://nepis.epa.gov/Exe/ZyNET.exe/P100I4RX.TXT?ZyActionD=ZyDocument&Client=EPA&Index=2011+Thru+2015&Docs=&Query=&Time=&EndTime=&SearchMethod=1&TocRestrict=n&Toc=&TocEntry=&QField=&QFieldYear=&QFieldMonth=&QFieldDay=&IntQFieldOp=0&ExtQFieldOp=0&XmlQuery=&File=D%3A%5Czyfiles%5CIndex%20Data%5C11thru15%5CTxt%5C00000009%5CP100I4RX.txt&User=ANONYMOUS&Password=anonymous&SortMethod=h%7C-&MaximumDocuments=1&FuzzyDegree=0&ImageQuality=r75g8/r75g8/x150y150g16/i425&Display=p%7Cf&DefSeekPage=x&SearchBack=ZyActionL&Back=ZyActionS&BackDesc=Results%20page&MaximumPages=1&ZyEntry=1&SeekPage=x&ZyPURL. For access to the US9r templates and database contact Carol Lenox - Lenox.Carol@epa.gov.

[3] Most of the data support the publication by the US Energy Information Administration of the Annual Energy Outlook, http://www.eia.gov/forecasts/aeo/index.cfm).

[4] Link to the main English index for the supply technologies - http://www.ens.dk/en/info/facts-figures/scenarios-analyses-models/technology-data, heating device are only in Dutch at Heat Generation and Datablad for individuelle varmeanlæg og energitransport 2013.

This report serves as a "guidebook" explaining the basic organization, components and functionality of this Starter model, and provides guidelines of how to go about transforming the Starter model into a beginning model for a new application of TIMES. Therefore, the report describes:

- the basics of the approach taken;
- the underlying RES and naming conventions employed;
- each of the TIMES-Starter components;
- additional templates needed to complete the Starter model;
- using the TIMES-Starter model under ANSWER/VEDA/AnalyticsXLS, and
- how to go about adapting the Starter model.

In addition, some examples of common policy questions that the model might be used to explore (e.g., CO_2 emission limits or price, renewable and energy efficiency targets) are provided to complete the initial picture of what building and applying a TIMES model entails.

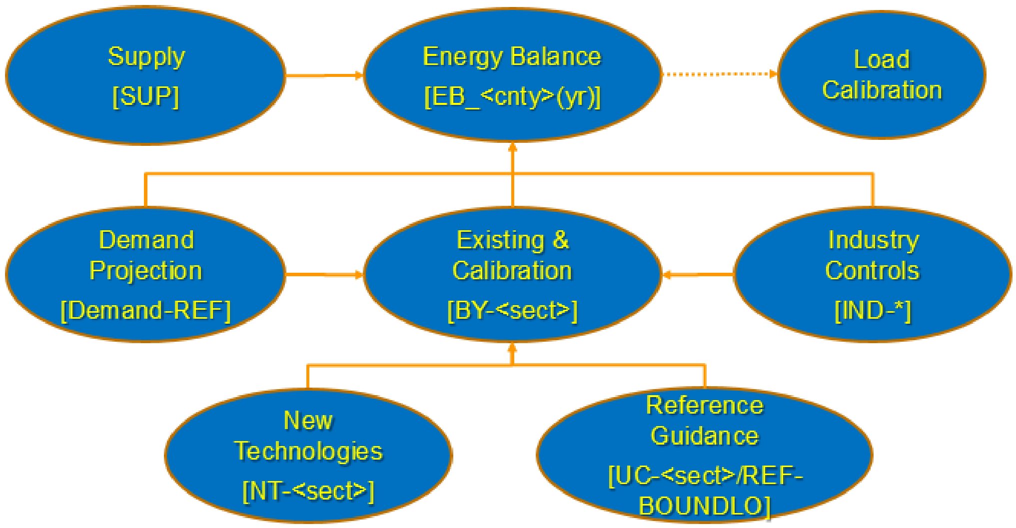
2 Organization of the Model Templates

2.1 Model Folder Orientation

The complete TIMES-Starter model is assembled in a single sub-folder sitting under the folder AnswerTIMESv6\Databases and named TIMES-Starter(vXX), where XX corresponds to a version number to make it easier to keep track of particular instances of the Starter (or later your own) model, currently v1.0. In this folder are a host of Excel ANSWER "Smart" workbooks that have been organized along the lines depicted in Figure 1, for the Reference or Business-as-Usual (BAU) scenario.

Note that these templates are linked, so that data contained in one workbook can be consistently shared across other dependent templates. The schematic in Figure 1 also shows the inter-dependency between the workbooks, that is where a child links to its parent. When a parent is updated all the dependent children MUST be updated as well (though it may be the case that the actual change does not affect a particular dependent workbook. These relationships are kept in the Dependency Table workbook which can be checked by ANSWER to ensure consistency (of dates), as noted in Section 7.3.

Figure 1: Schematic of Starter Templates Dependencies



* All workbooks to be loaded into ANSWER start with ATx_<country>*, with x="" for ver1 and "2" for ver2 ANSWER "Smart" XLS format

These workbooks fall into the following categories:

- EB – Energy Balance for the 1st year of the model and current load curve;
- SUP – Resource supply and imports;
- BY – Base year existing technologies and calibration procedure;
- NT – New technology options;
- Demand – Demand drivers and projections;
- IND – Industry configuration, and
- UC - Reference guidance user controls.

Where sector (<sect>) is noted in Figure 1 these correspond to:

- Electric generation technologies [PP];
- Agriculture demand devices [AGR];
- Commercial demand devices and conservation measures [COM];
- Industrial structure and processes, including refineries [IND] *{pending}*;
- Residential demand devices and conservation measures [RSD], and
- Transportation vehicle by mode [TRN].

In addition there are additional workbooks to assist with calibration of the electricity load duration curve (LoadCalibration) and check how the base year results compare to the energy balance (CalibrationCheck_REF) discussed in Section 6. There are also scenario templates (S_<scenario) for setting up alternate scenarios, and the Analytics graph comparison workbook for comparing run results (TIMES-Starter_AXLS) discussed in Section 13.

The naming conventions employed for the templates are explained a bit later in this section.

2.2 Template Components

The model data is assembled in ANSWER-TIMES "Smart" Excel workbooks[5] consisting of several worksheets as generally described in Table 1. The list in table does not cover all the sheets in all the workbooks, rather covers mainly the EB, BY and NT core technology templates. The sheets of the more specialized templates, including Supply, Demand, and Reference guidance (UCs and INDs) may have some other special sheets only relevant to them, and will be covered in their respective sections.

The Supply, UC, IND, and some scenario files use Version-1 (v1) of the Smart workbooks, while the majority of the templates use the newer Version 2 (v2), the latter being very similar in layout and functionality to their MARKAL US9r counterparts.

Table 1: Structure of ANSWER-TIMES Smart Workbooks

Worksheet	Description
ANSv1-692-Home, ANSv2-692-Home	ANSWER-TIMES template sheet that is used to add new ANSWER-TIMES smart sheet to the current workbook, or turn an existing XLS/XLSM into a "smart" workbook. [Note that the v1 workbooks all begin with AT_ and the v2 workbooks with AT2_.]
SETUP	Mapping of EPA-US9r/other names to TIMES TIMES-Starter names and removal of unwanted items, emission factors, and USD price conversion factors. The Setup sheet links to the EB workbook for the list of commodities and emission rates.
EB	Information for the Energy Balance workbook for the sector. [BYs only]
Regions	Description of Regions for the Database where this instance of the New Techs will be used. [Only active on Supply template.]
Calibration	The calculation sheet where the energy balance is apportioned and the initial year technology stock established for each sector. [BYs only]
Commodities[6]	Energy carriers, emissions, materials are defined by their name, description, units and set memberships to be used in the rest of the sheets. In V1 templates commodity groups may also be declared. These are in turn controlled by the SETUP sheet, in most cases. [Some v1 templates have an ITEMS sheet that contains both commodity and process declarations.]
Processes	Process technologies are defined by their name, description, units and set memberships to be used in the rest of the sheets. These are in turn controlled by the SETUP sheet, in most cases. [Some V1 templates have an ITEMS sheet that contains both commodity and process declarations.]
CommData	A sheet with the data for commodities in the sector (mostly used for mapping sector emissions to overall emissions and providing demand levels and load timings.
ProcData_<sect> or <nature-of-the-data>[7]	One or more sheets with the data for all technologies in the sector. [Note that the V1 templates have separate TID & TS sheets.]

[5] See *ANSWERv6-TIMES Smart Excel Workbook Manual* for details on working with / operating the templates.
[6] For v1 templates the Commodities, Process and UC declarations are provided on the ITEMS sheet.

Worksheet	Description
EPA/DEA/PIEM/EC currently (IEA/ETSAP/other_ <sheet>)	Declaration and data sheets from the EPA-US9r/Danish Energy Agency/ Pak-IEM/Energy Community-EE databases (and perhaps other sources including but not limited to IEA, ETSAP eTech-DS, etc.) providing the source values for the technology options.

All of the Starter workbooks employ the ANSWER-TIMES "Smart" functionality, and have an ANSv1-692or ANSv2-692-Home sheet, and most have an EB and SETUP sheet to enable easy inclusion/exclusion of commodities (based initially on the EB) and technologies (according to the active commodities and defined process components). Explicitly excluding a commodity or technology/process is handled by putting a "*" in Col-A. The Commodity/Process declaration and Comm/ProcData data sheets then carry along the "*" to have them ignored by ANSWER during the import process. If a commodity that does not appear in the current energy balance is needed in the future (for a new technology option), then it needs to be "activated" on the BY EB sheet by deleting the 0 carried from the EB.

The TIMES-Starter has a wide range of commodities and process for almost every situation. However, as every country has some unique features, the addition of a new commodity or process may be required. See Section 14.2.2 for a discussion of the process for adding new commodities or processes.

The ANSWER BASE scenario is manually loaded with the Global parameters related to discounting (year and global rate), and annual timeslices. With regard to the latter, the model is setup for four (4) seasons and three (3) divisions of the day for a total of twelve (12) timeslices. These timeslices are established in the LoadCurve workbook, but also found in the EB workbook where each BY and the Demand Projection workbooks link to them. The values in the TimePeriods & FRs tab of the EB_Starter(2013) template are laid out so that they can be directly copied and pasted into ANSWER if they need to be changed. Section 6 discusses how to adjust the LoadCurve workbook. Note that adjusting the number of timeslices or the inter-relationships between timeslices is certainly doable, but this would need to be done with care as there are lots of interdependencies and recalibration will be necessary along with modifying the LoadCurve calculation workbook. *Therefore, changing the number of timeslice is beyond the scope of the initial Starter model and will instead be discussed at a later time in a planned Intermediate Guide for the TIMES-Starter model.*

2.3 Connecting with the EPA US9r Data

The technology characterization data comprising the ANSWER-TIMES (ProcData) load sheets links directly to a copy of the equivalent US9r ANSWER-MARKAL (or other) load sheets, unless otherwise stated. The Excel VLOOKUP function is used to grab the data by mapping the EPA process name to the corresponding Starter process names as assembled on the SETUP sheet. This is accomplished by means of the entry in Col-H of the ProcData sheets, which in turn is grabbed from Col-D on SETUP based upon the Starter process name in Col-B of the same row.

---

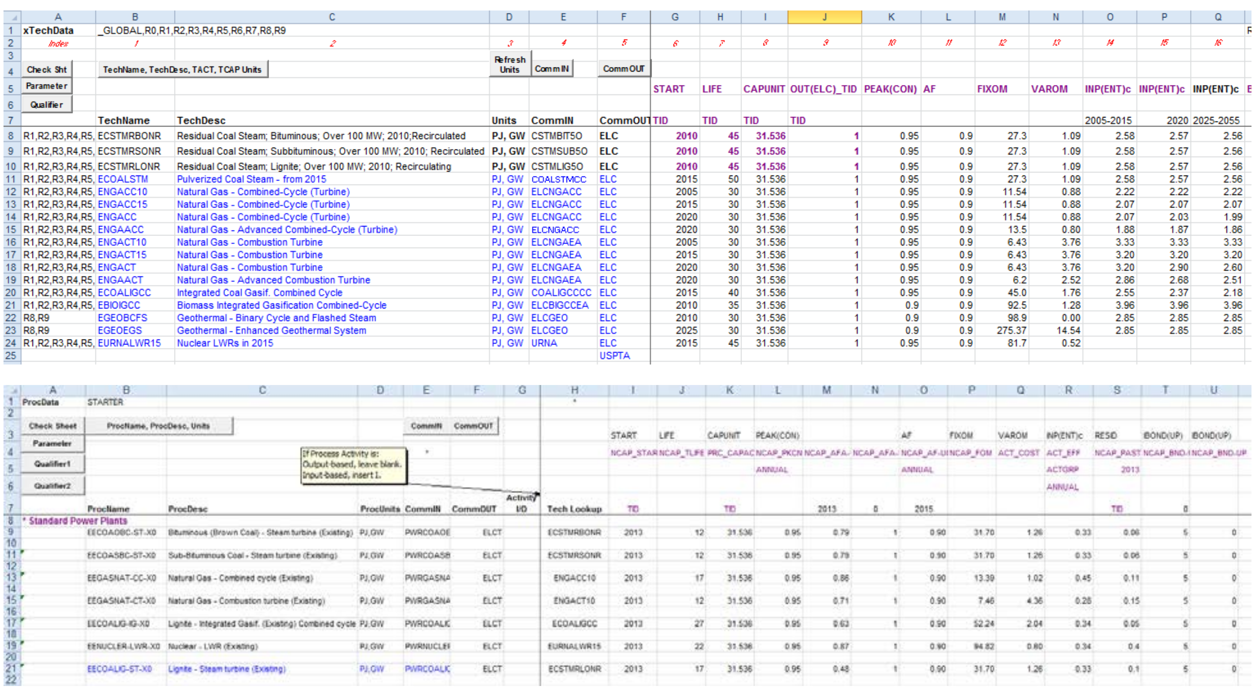
[7] For the v1 templates data is loaded from the TS&TID Data sheet for standard processes and UCs, and from separate TOP/TID/TS_Data sheets for Supply. [Nature-of-the-data refers to power plant or vehicle type when there are numerous types for a sector.]

There is a rather extensive set of technologies in the full US9r database (workbook), including multiple wind classes with different price points, old and future power plants of various types, retrofit and new FGD options, and much more. The user is encouraged to obtain the full US9r documentation (see Footnote #2).

On each ProcData sheet above the TIMES Parameter (in row 4), the corresponding MARKAL parameter name is provided for reference. This also then establishes the column on the source data sheet where the information is to come from. The VLOOKUP function then references that column in the EPA data sheet and the look-up range is set to cover the entire data set, which ensures capturing the correct value. Also, note that the model periods come from the Setup sheet, which is linked to the EB sheet and thus the user should carefully ensure that the correct column is grabbed from the US9r data there. This is done as part of the VLOOKUP by means of the displacement count parameter, which is thus sensitive to any changes in the column order on the EPA source data sheet.

In addition, there are some transformations performed on the source data when and where needed. The most notable is for all costs, where the SETUP monetary conversion factor is set to bring all costs to 2013 US dollars.   Others include converting from miles to kilometers for transport, and in the case of power plants inverting the input value (MARKAL) to efficiency (TIMES). We can see this in Figure 2 showing the MARKAL/TIMES templates (top/bottom) where Start=NCAP_START, LIFE=NCAP_LIFE, etc. as reflected in rows 3-4 of the latter, then for the most part the columns run across the worksheet in the same order, with some columns skipped over (hidden below).

Figure 2: Aligning TIMES-Starter & MARKAL US9r Parameters/Data



xTechData _GLOBAL,R0,R1,R2,R3,R4,R5,R6,R7,R8,R9

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
2	Index	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
4	Check Sht		TechName, TechDesc, TACT, TCAP Units	Refresh Units	Comm IN	Comm OUT											
5	Parameter						START	LIFE	CAPUNIT	OUT(ELC)_TID	PEAK(CON)	AF	FIXOM	VAROM	INP(ENT)c	INP(ENT)c	INP(ENT)c
6	Qualifier																
7		TechName	TechDesc	Units	CommIN	CommOUT	TID	TID	TID	TID					2005-2015	2020	2025-2055
8	R1,R2,R3,R4,R5,	ECSTMRBONR	Residual Coal Steam; Bituminous; Over 100 MW; 2010;Recirculated	PJ, GW	CSTMBIT5O	ELC	2010	45	31.536	1	0.95	0.9	27.3	1.09	2.58	2.57	2.56
9	R1,R2,R3,R4,R5,	ECSTMRSONR	Residual Coal Steam; Subbituminous; Over 100 MW; 2010; Recirculated	PJ, GW	CSTMSUB5O	ELC	2010	45	31.536	1	0.95	0.9	27.3	1.09	2.58	2.57	2.56
10	R1,R2,R3,R4,R5,	ECSTMRLONR	Residual Coal Steam; Lignite; Over 100 MW; 2010; Recirculating	PJ, GW	CSTMLIG5O	ELC	2010	45	31.536	1	0.95	0.9	27.3	1.09	2.58	2.57	2.56
11	R1,R2,R3,R4,R5,	ECOALSTM	Pulverized Coal Steam - from 2015	PJ, GW	COALSTMCC	ELC	2015	50	31.536	1	0.95	0.9	27.3	1.09	2.58	2.57	2.56
12	R1,R2,R3,R4,R5,	ENGACC10	Natural Gas - Combined-Cycle (Turbine)	PJ, GW	ELCNGACC	ELC	2005	30	31.536	1	0.95	0.9	11.54	0.88	2.22	2.22	2.22
13	R1,R2,R3,R4,R5,	ENGACC15	Natural Gas - Combined-Cycle (Turbine)	PJ, GW	ELCNGACC	ELC	2015	30	31.536	1	0.95	0.9	11.54	0.88	2.07	2.07	2.07
14	R1,R2,R3,R4,R5,	ENGACC	Natural Gas - Combined-Cycle (Turbine)	PJ, GW	ELCNGACC	ELC	2020	30	31.536	1	0.95	0.9	11.54	0.88	2.07	2.03	1.99
15	R1,R2,R3,R4,R5,	ENGAACC	Natural Gas - Advanced Combined-Cycle (Turbine)	PJ, GW	ELCNGACC	ELC	2020	30	31.536	1	0.95	0.9	13.5	0.80	1.88	1.87	1.86
16	R1,R2,R3,R4,R5,	ENGACT10	Natural Gas - Combustion Turbine	PJ, GW	ELCNGAEA	ELC	2005	30	31.536	1	0.95	0.9	6.43	3.76	3.33	3.33	3.33
17	R1,R2,R3,R4,R5,	ENGACT15	Natural Gas - Combustion Turbine	PJ, GW	ELCNGAEA	ELC	2015	30	31.536	1	0.95	0.9	6.43	3.76	3.20	3.20	3.20
18	R1,R2,R3,R4,R5,	ENGACT	Natural Gas - Combustion Turbine	PJ, GW	ELCNGAEA	ELC	2020	30	31.536	1	0.95	0.9	6.43	3.76	3.20	2.90	2.60
19	R1,R2,R3,R4,R5,	ENGAACT	Natural Gas - Advanced Combustion Turbine	PJ, GW	ELCNGAEA	ELC	2020	30	31.536	1	0.95	0.9	6.2	2.52	2.86	2.68	2.51
20	R1,R2,R3,R4,R5,	ECOALIGCC	Integrated Coal Gasif. Combined Cycle	PJ, GW	COALIGCCCC	ELC	2015	40	31.536	1	0.95	0.9	45.0	1.76	2.55	2.37	2.18
21	R1,R2,R3,R4,R5,	EBIOIGCC	Biomass Integrated Gasification Combined-Cycle	PJ, GW	ELCBIGCCEA	ELC	2010	35	31.536	1	0.9	0.9	92.5	1.28	3.96	3.96	3.96
22	R8,R9	EGEOBCFS	Geothermal - Binary Cycle and Flashed Steam	PJ, GW	ELCGEO	ELC	2010	30	31.536	1	0.9	0.9	98.9	0.00	2.85	2.85	2.85
23	R8,R9	EGEOEGS	Geothermal - Enhanced Geothermal System	PJ, GW	ELCGEO	ELC	2025	30	31.536	1	0.9	0.9	275.37	14.54	2.85	2.85	2.85
24	R1,R2,R3,R4,R5,	EURNALWR15	Nuclear LWRs in 2015	PJ, GW	URNA	ELC	2015	45	31.536	1	0.95	0.9	81.7	0.52			
25						USPTA											

ProcData STARTER

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
3	Check Sheet	ProcName, ProcDesc, Units			CommIN	CommOUT			START	LIFE	CAPUNIT	PEAK(CON)			AF	FIXOM	VAROM	INP(ENT)c	RESID	BOND(UP)	BOND(UP)
4	Parameter				*				NCAP_STAR	NCAP_TLIFE	PRC_CAPAC	NCAP_PKCN	NCAP_AFA-	NCAP_AFA-	NCAP_AF-U	NCAP_FOM	ACT_COST	ACT_EFF	NCAP_PAST	NCAP_BND-I	NCAP_BND-UP
5	Qualifier1		If Process Activity is: Output-based, leave blank. Input-based, insert I.									ANNUAL			ANNUAL			ACTGRP	2013		
6	Qualifier2																	ANNUAL			
7		ProcName	ProcDesc	ProcUnits	CommIN	CommOUT	Activity I/O	Tech Lookup	TID		TID		2013	0	2015				TID	0	
8	* Standard Power Plants																				
9		EECOAOBC-ST-X0	Bituminous (Brown Coal) - Steam turbine (Existing)	PJ,GW	PWRCOAOE	ELCT		ECSTMRBONR	2013	12	31.536	0.95	0.79	1	0.90	31.70	1.26	0.33	0.06	5	0
11		EECOASBC-ST-X0	Sub-Bituminous Coal - Steam turbine (Existing)	PJ,GW	PWRCOASB	ELCT		ECSTMRSONR	2013	12	31.536	0.95	0.79	1	0.90	31.70	1.26	0.33	0.06	5	0
13		EEGASNAT-CC-X0	Natural Gas - Combined cycle (Existing)	PJ,GW	PWRGASNA	ELCT		ENGACC10	2013	17	31.536	0.95	0.86	1	0.90	13.39	1.02	0.45	0.11	5	0
15		EEGASNAT-CT-X0	Natural Gas - Combustion turbine (Existing)	PJ,GW	PWRGASNA	ELCT		ENGACT10	2013	12	31.536	0.95	0.71	1	0.90	7.46	4.36	0.28	0.15	5	0
17		EECOALIG-IG-X0	Lignite - Integrated Gasif. (Existing) Combined cycle	PJ,GW	PWRCOALIC	ELCT		ECOALIGCC	2013	27	31.536	0.95	0.63	1	0.90	52.24	2.04	0.34	0.05	5	0
19		EENUCLER-LWR-X0	Nuclear - LWR (Existing)	PJ,GW	PWRNUCLEI	ELCT		EURNALWR15	2013	22	31.536	0.95	0.87	1	0.90	94.82	0.80	0.34	0.4	5	0
21		EECOALIG-ST-X0	Lignite - Steam turbine (Existing)	PJ,GW	PWRCOALIC	ELCT		ECSTMRLONR	2013	17	31.536	0.95	0.48	1	0.90	31.70	1.26	0.33	0.1	5	0

Note that US9r source data sheets mix existing and new technologies. However, for TIMES-Starter the existing technologies and new technologies are maintained in separate templates, so the original US9r source data sheet will appear in both workbooks, for each sector. But with respect to the existing processes modelers need to compare the characteristics of their existing set of technologies against those of the new standard new technologies to ensure that any impacts of local conditions are factored into the data. For example, the plant conversion efficiency might be adjusted lower due to higher ambient temperatures, or the investment cost increased because a dry-cooling water system is required.

The TIMES-Starter workbooks also detect changes in efficiency over time, and as necessary set the TIMES Vintage flag, so that said efficiencies are tied to the processes according to the year of investment rather than current model period.

In October 2016, the USEPA-ORD will release the first update to the US9r model following the creation of the TIMES-Starter model. In discussion with USEPA-ORD they have agreed to provide a clear summary of every STRUCTURAL change to their templates, particularly with respect to the column order. Knowing this, what is envisioned for updating the TIMES-Starter is that the updated US9r MARKAL data load sheets will be able to be copied (using Copy/PasteValues) over the existing corresponding TIMES-Starter worksheet, updating all the numbers. The VLOOKUP functions will need to be modified for any column changes, and the VLOOKUP range expanded as needed to capture any new processes added to US9r data set. These new processes and any new commodities they require will need to be added to the SETUP/Commodity/Process/ProcData tabs as necessary. A discussion on adding new processes can be found in Section 14.

2.4 Template Naming Conventions

The templates employ a simple naming convention consisting of AT(2)_<country>_<nature>-<sector>, where all load templates start with AT (for ANSWER-TIMES) and

- (2) indicates those templates employing the newer version 2 (v2) smart templates, as opposed to AT_ for the original version 1 (v1) templates;
- <country> is currently STARTER, but should be replaced by the country or region name;
- <nature> indicates the type of template, e.g., BY=base year, NT=New Tech, etc., and
- <sector> indicates the specific energy or demand sector

Supply, IND, UC and some scenario files use the v1 format, but the majority of the templates are in the v2 format. The ANSWER-TIMESver2-692.xlsm file is an empty template that may be used to create new v2 templates (ANSWER-TIMESver1-692 for v1), but more likely changes will involve modifying an existing TIMES-Starter templates or copying them to make new ones. The list of current templates is shown in Table 2.

Note that some workbooks are linked to others and should be handled as a pair (that is opening both together) when making changes or renaming the parent (linked to) template. However, it is recommended that one does not change workbook template names, rather make new folders and make your changes there so that the inter-dependencies are consistent, and the ANSWER Import Scenario remembering the template(s) for each scenario remains intact. [Every once and a while when opening a workbook it's a good idea to check "Data/Edit Links" to make sure the folder/files are pointing to the correct instance of the parent/grandparent.]

To help ensure that the workbooks are properly synchronized (that is all children have a last saved date newer than that of all their ancestors) ANSWER supports a Workbook Dependency Check facility at Import time. These dependencies are reflected in Figure 1 and Table 2. It is recommended that after importing changed (dependent) templates into ANSWER the user resave the DependencyXLS – so that when sorted by date it serves as a reminder of those changed since last import. Also, if the user therefore does choose to change of the name of a template they are strongly encouraged to also remember to change the Dependency table. There is a bi-directional dependency between the LoadCalibration and EB_Starter workbooks, though neither is actually loaded into ANSWER. As such only a change in the LoadCalibration is monitored. When updating many templates the easiest way to proceed in terms of meeting the dependency criterial is to make the changes in the order listed in the Child Templates column of the table below.

Table 2: ANSWER Templates Dependency Table

TIMES-Starter Template Dependencies	
Linked Child Templates	**Parent/GrandParent Template**
EB_Starter(2013).xlsm	Starter_LoadCalibration.xls
AT_Starter_SUP.xlsm	EB_Starter(2013).xlsm
AT2_Starter_BY-AGR.xlsm	EB_Starter(2013).xlsm
AT2_Starter_BY-COM.xlsm	EB_Starter(2013).xlsm
AT2_Starter_BY-IND.xlsm	EB_Starter(2013).xlsm
AT2_Starter_BY-PP.xlsm	EB_Starter(2013).xlsm
AT2_Starter_BY-RSD.xlsm	EB_Starter(2013).xlsm
AT2_Starter_BY-TRN.xlsm	EB_Starter(2013).xlsm
AT2_Starter_Demand-REF.xlsm	EB_Starter(2013).xlsm
	AT2_Starter_BY-AGR.xlsm
	AT2_Starter_BY-COM.xlsm
	AT2_Starter_BY-IND.xlsm
	AT2_Starter_BY-RSD.xlsm
	AT2_Starter_BY-TRN.xlsm
AT2_Starter_NT-AGR.xlsm	AT2_Starter_BY-AGR.xlsm
AT2_Starter_NT-COM.xlsm	AT2_Starter_BY-COM.xlsm
AT2_Starter_NT-PP.xlsm	AT2_Starter_BY-PP.xlsm
AT2_Starter_NT-RSD.xlsm	AT2_Starter_BY-RSD.xlsm
AT2_Starter_NT-TRN.xlsm	AT2_Starter_BY-TRN.xlsm
AT_Starter_UC-COM.xlsm	AT2_Starter_BY-COM.xlsm
AT_Starter_UC-COM-50.xlsm	AT2_Starter_BY-COM.xlsm
AT_Starter_UC-COM-90.xlsm	AT2_Starter_BY-COM.xlsm
AT_Starter_UC-RSD.xlsm	AT2_Starter_BY-RSD.xlsm
AT_Starter_UC-RSD-50.xlsm	AT2_Starter_BY-RSD.xlsm
AT_Starter_UC-RSD-90.xlsm	AT2_Starter_BY-RSD.xlsm
AT_Starter_UC-TRN.xlsm	AT2_Starter_BY-TRN.xlsm
AT_Starter_UC-TRN-50.xlsm	AT2_Starter_BY-TRN.xlsm
AT_Starter_UC-TRN-90.xlsm	AT2_Starter_BY-TRN.xlsm
REF_BOUNDLO.xlsm	AT2_Starter_BY-PP.xlsm
REF_BOUNDLO-RED.xlsm	AT2_Starter_BY-PP.xlsm
AT_Starter_ZZDMY.xlsm	AT_Starter_SUP.xlsm
	AT2_Starter_Demand-REF.xlsm

* Global data needs to be manually copied into BASE if changed from EB template

The templates are managed and loaded into the ANSWER-TIMES database as discussed in Section 7.

Note that if one encounters a problem with an ANSWER "Smart" XLS not functioning properly, saving the current templates as an XLSX (that is, workbook without macros) and then using the ANSWER-TIMES template “Master” to update this XLSX to an XLSM is a strategy that should overcome problematic XLSM functionality.

3 RES Component Naming Conventions and Units

Good practice for TIMES models is to employ strict naming conventions for both energy carrier and technology names encompassing the Reference Energy System (RES). Table 3 provides the three components of each energy carrier name. Each energy carriers has a core three-character identifiers (e.g., OIL, COA, RNW). In the database, these core names are preceded by a three-character sector identifier that indicates which sector the energy carrier is being supplied from (SUP) or to (all others), and may include a qualifier identifying a subset of the core energy carrier group (e.g., hard coal, diesel oil, etc.) it is associated with. For example, supply of hard/brown coal to all sectors is SUPCOAHRD/BRO, while coal for electric generation is PWRCOAHRD/BRO, and COMELC is electricity supplied to the commercial sector. Where it is not necessary to qualify the "root" it can be omitted (e.g., electricity). Rigorously employing such naming conventions, and being strict to include unique key words the description (e.g., "existing" for all technologies in place today) is critical to ensuring the correct functioning of the current process and commodity sets in the Starter model that enable the power of VEDA_Back-End (VBE) and the ANSWER Named Filters to be fully exploited.

Table 3: Commodity Naming Conventions

Energy Carrier Root	Description		Energy Carrier Qualifier[8]	Description
BIO	Biomass		ANT	Anthracite
COA	Coal		PSF	Biomass (primary solid fuel)
GAS	Natural Gas		BIT	Bituminous
NUC	Nuclear		BRI	Briquettes
OIL	Oil and Oil Products		CCO	Coke
RNW	Renewables		COI	Crude
Other	Will be added as needed		DSL	Diesel
			FOI	Fuel Oil
Energy Sector	**Description**		GEO	Geothermal
AGR	To Agriculture sector		GSL	Gasoline
COM	To Commercial sector		HYD	Hydro
IND	To Industrial sector		JET	Jet Fuel
PWR	To Electric Generation		KER	Kerosene
RSD	To Residential sector		LFG	Landfill Gas
SUP	Supply & Imports/Exports		LIG	Lignite
TRN	To Transportation sector		LNG	Liquefied Natural Gas
			LPG	Liquefied Petroleum Gas
			MSW	Municipal Solid Waste
			NAT	Natural Gas
			PET	Peat
			RFO	Residual Fuel Oil
			SOL	Solar
			WAS	Waste
			WIN	Wind
			URN	Uranium
			Others	Will be added as needed

[8] Note that some Energy Carriers in the IEA energy balance are not listed in this table.

Similarly, naming conventions for technologies look to identify aspects of the sector or demand service (perhaps by type (e.g., rural/urban households, public/private buildings)), and nature of the technology (e.g., power plant or device type, fuel consumed, kind of demand device, and quality of the device). For example, the residential heating devices in Figure 3 have their names built as:

- Sector: R - Residential
- Service: H - Heating
- Building Type: B - Households [could have >1 type]
- Fuel: GASNAT – Natural Gas
- Device Type F/HA/R - Furnace/Air Heat Pump/Radiant
- Device Quality ST/IM/BE/AD - Standard/Improved/Best/Advanced for conventional to most efficient

Figure 3: Demand Device Naming Example - Residential Household Heating Devices

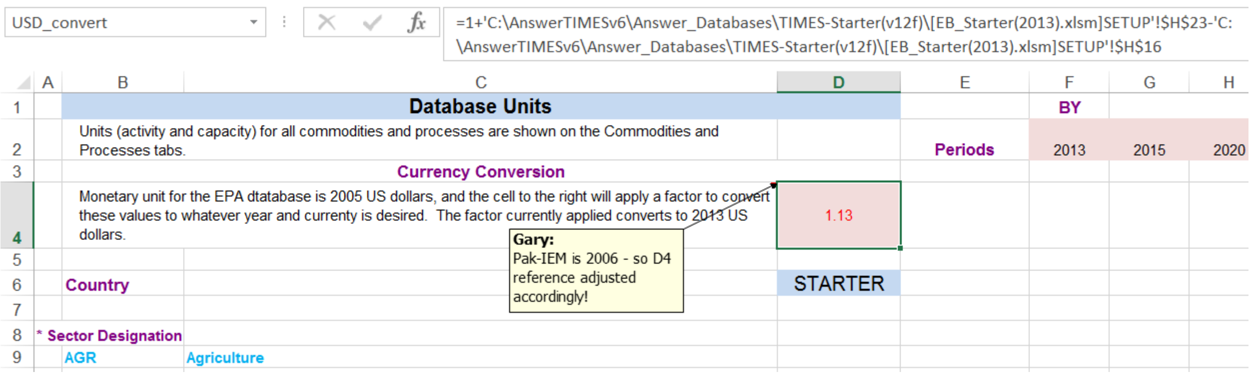
TIMES	Description	EPA
* Building Type		
* Space Heating		
* Electric Radiant		
RHBELC-R-ST	Residential Heating: Electricity Radiant-Standard	RSHERDV110
* Electric Heat Pump		
RHBELC-HA-ST	Residential Heating: Electricity Heat Pump-Standard	RSHEHPV110
RHBELC-HA-IM	Residential Heating: Electricity Heat Pump-Improved	RSHEHPV210
RHBELC-HA-BE	Residential Heating: Electricity Heat Pump-Best	RSHEHPV310
RHBELC-HA-AD	Residential Heating: Electricity Heat Pump-Advanced	RSHEHPV410
* Natural Gas Furnace		
RHBGASNAT-F-ST	Residential Heating: Natural Gas Furnace-Standard	RSHNFRV210
RHBGASNAT-F-IM	Residential Heating: Natural Gas Furnace-Improved	RSHNFRV310
RHBGASNAT-F-BE	Residential Heating: Natural Gas Furnace-Best	RSHNFRV410
RHBGASNAT-F-AD	Residential Heating: Natural Gas Furnace-Advanced	RSHNFRV510
* Natural Gas Radiant		
RHBGASNAT-R-ST	Residential Heating: Natural Gas Radiant-Standard	RSHNRDV110
RHBGASNAT-R-IM	Residential Heating: Natural Gas Radiant-Improved	RSHNRDV210
RHBGASNAT-R-BE	Residential Heating: Natural Gas Radiant-Best	RSHNRDV310
* Kerosene Furnace		
RHBOILKER-F-ST	Residential Heating: Kerosene Furnace-Standard	RSHKFRV110
RHBOILKER-F-IM	Residential Heating: Kerosene Furnace-Improved	RSHKFRV210

In the sector sections that follow the approach, components and some examples of each technology group are given.

In terms of units, in the US9r database all costs are expressed in 2005 US dollars, and the workbooks have all been designed with a conversion factor on the SETUP sheet (cell D4 as USD_Convert) to allow conversion to other years and currencies. The current conversion factor is set to calculate cost parameters in 2013 US dollars, which corresponds to the first year of the model. However, the

Agriculture data, not available from US9r, is in 2006 US$ so the USD_Convert needs be adjusted by referring to the EB USD conversion table, as should below. Note that in the case of the DEA data a different approach was taken were work was done on the source data sheet to convert from Euros to Dollars, where it so happens the costs are in 2005Euros so not inflating/deflating is necessary.

Figure 4: Setting USD_Convert for a Particular Sector (Agriculture)



In terms of the commodity and technology attribute units:

- Energy - Petajoules (PJ);
- Capacity - Gigawatts (GW) for power sector, Petajoules/annum (PJa) for most others, and kilometer index for transportation;
- Demand - most are Petajoules, with some transportation in passenger/freight kilometers and lighting in lumens, and
- Emissions - Million/Thousand Tons (Mt/Kt).

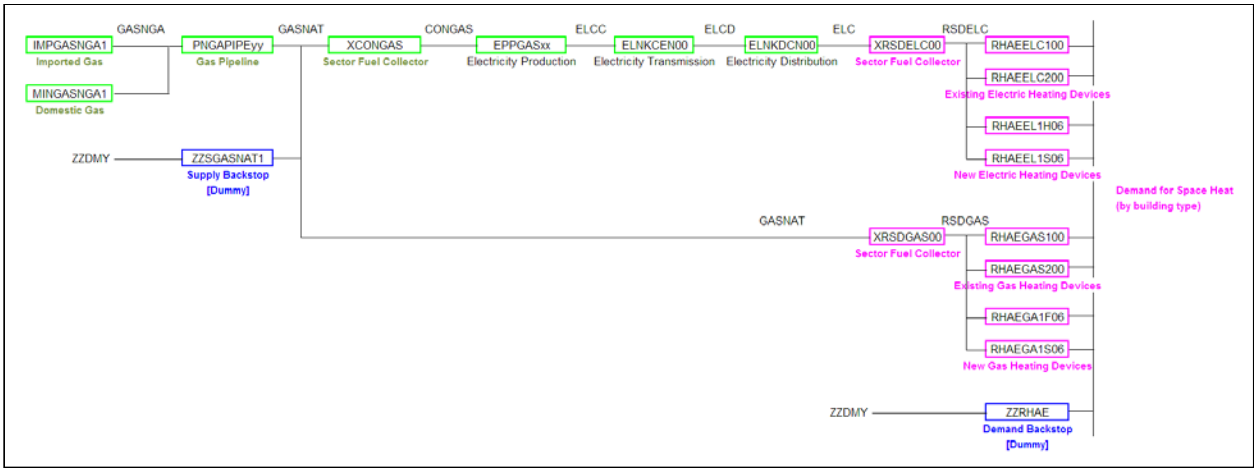
Note that some of the transportation demands are in terms of Billion Vehicle Miles (bvm) in US9r which are then converted to Billion Vehicle Kilometers (bvk) for the TIMES-Starter.

4 Organization of the TIMES-Starter RES

All TIMES models are organized around the principles of the Reference Energy System (RES) network. The RES connects processes (e.g., resource supply, power plants, refineries, pipelines, demand devices) that produce/consume commodities (energy, materials, emissions) by means of identifying the flow of the commodities from / into the processes. This network then manages the underlying energy system to ensure the flows balance and that each of the process is properly characterized in terms of where it "fits" in the energy system. The key to this simple approach is the requirement that the name of each commodity changes when exiting a process, where, as discussed in the next sections, employing strict naming conventions make it easy to identify each process and commodity within the RES.

Figure 5, while not from the Starter model, shows the basic approach to organizing the RES. Resources are imported/mined, in this case natural gas, then moved via a pipeline to either the power or demand sectors (here Residential), where a "dummy" sector exchange process (beginning with "X") converts the name of the upstream gas supply to that of the corresponding sector (retaining the word "GAS" in its name to facilitate set definition and filtering later). When the gas is consumed to generate electricity that commodity stream kicks in and centralized electricity is sent along the transmission lines to the distribution network, where consumption is then tracked by demand sector (retaining "ELC" in the commodity name throughout).

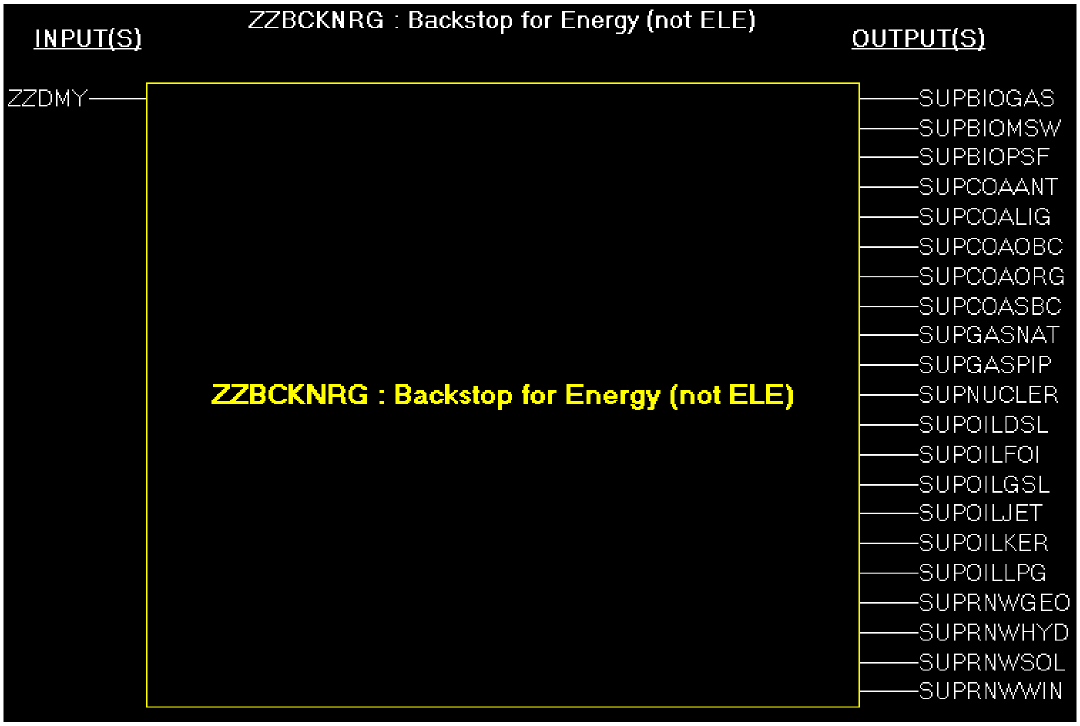
Figure 5: Basic RES Organization Principles



Thus, as part of employing good RES design principles, processes are often inserted at convenient points in the network for the purposes of facilitating tracking, collecting, and distinguishing aspects of the underlying energy system. One such convention employed is the use of X<sector><fuel> processes (see XCONGAS in Figure 5) to channel commodities between upstream sources and the various sectors modeled, where the processes' main purpose is to change the name of the commodity to its sector counterpart. These may also serve as an appropriate place to track sector emissions (by fuel), apply sector delivery charges, reflect losses in the distribution system, and reflect limits/cost of expanding infrastructure.

Another good TIMES modeling practice that greatly aids in model debugging is to employ "backstop" processes that can produce the main commodities in the energy system by consuming a dummy commodity at an extremely high cost. These backstop processes (typically named ZZBCK<type>) are setup to produce all conventional energy carriers, electricity, and demand services that are currently used in the model to help avoid infeasibilities that may arise due to a production shortfall or RES connectivity problem --- the most common cause of infeasibilities (along with inconsistent bounds). A typical ZZBCKNRG process for energy is shown in Figure 6, where a ZZBCKELC (operating at the timeslice level) and ZZBCKDEM are also created to supply unmet electricity or service demand(s). If a ZZBCK process is called upon, it can be readily identified in the solution because the impact of its high cost will increase the objective function value dramatically.

Figure 6: Backstop Process to Avoid (Most) Infeasible Solutions



5 A Look at the Input Data Workbooks

This section describes by sector the nature of the various input data sheets found in the main templates that comprise the model. The type of sheets found in the workbooks were discussed in Section 2.2, while here the content with respect to the model data is the focus.

Here all the examples shown, with the exception of Supply, present the New Technology (NT) templates to get across the nature of the information needed, and where and how it is organized in the template. How to go about augmenting the information found in the templates, most notably adding/removing commodities and processes, and/or making entire new sub-sectors (e.g., splitting households into urban and rural) or new regions, is discussed in Section 14.

Before going through the templates a critical aspect of how TIMES handles input data with respect to interpolation / extrapolation is warranted in terms of what is most commonly used in the Starter model. The interpoltion rules are explained in the ETSAP TIMES documentation (http://www.iea-etsap.org/web/Documentation.asp). In the input templates whenever the Period=0 for any paramter the value provided corresponds to the override of the default interpolation rule. In the Starter (and most TIMES models) the I/E override is employed for:

- Restricting investment in existing processes and devices via i/e=12 for NCAP_BND (setting it to eps for all periods);

- Keeping shares in place over the modeling horizon with i/e=5 for FLO_SHARE/MARK (interpolate and extend constant), and
- Extending the RHS=0 for UCs via i/e=5 (interpolate and extend constant).

There may of course be other instances where the I/E default is overridden, but these are used the most common ones. The rest of the parameters are usually interpolated with extrapolation constant, as their default. The table from the TIMES documentation is shown below.

Table 2. Option Codes for the control of data interpolation

Action	Option code	Applies to
Default interpolation/extrapolation (see above)	0 (or none)	All
No interpolation/extrapolation	< 0	All
Interpolation but no extrapolation	1	All
Interpolation, but extrapolation with EPS	2	All
Full interpolation and extrapolation	3	All
Interpolation and backward extrapolation	4	All
Interpolation and forward extrapolation	5	All
Migrated interpolation/extrapolation within periods	10	Bounds, RHS
Interpolation migrated at end-points, no extrapolation	11	Bounds, RHS
Interpolation migrated at ends, extrapolation with EPS	12	Bounds, RHS
Interpolation migrated at end, backward extrapolation	14	Bounds, RHS
Interpolation migrated at start, forward extrapolation	15	Bounds, RHS
Log-linear interpolation beyond YEAR	YEAR (≥1000)	All

5.1 Energy Balance

The process of depicting the energy system for a TIMES model starts from the complete first year energy balance. For the TIMES-Starter a typical energy balance for 2013 is used. Thus the first step in adapting the TIMES-Starter for another energy system is to properly enter the associated energy balance. The layout of the TIMES-Starter Energy Balance worksheet corresponds to that published by the IEA. Because many of the other templates are driven by the Energy Balance, its layout, as seen in Figure 7, should be considered rigid and should not be changed. [If a fuel is missing for your energy system you can (carefully) take over one of the other fuels (columns) that you don't need, as long as you follow the naming conventions discussed earlier.]

Figure 7: Energy Balance Sheet

Country (Region) Name	OILLPG	OILGSL	OILJET	OILKER	OILDSL	OILFOI	OILNAP	OILLUB	OILBIT	OILPCO	OILNSO	GASNAT	BIOIWA	BIOMSW	BIOPSF	BIOGAS
PJ	LPG	Gasoline	Jet Fuel	Kerosene	Diesel	Fuel Oil	Naphtha	Lubricants	Bitumen	Petroleum Coke	Non-specified Oil Products	Natural Gas	Industrial Waste	Municipal Waste	Primary Solid Biofuels	Biogases
Main activity producer electricity plants	-	-	-	-			-	-	-	-	-	15.00	-	3.00	15.00	3.00
Autoproducer electricity plants	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Main activity producer CHP plants	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Autoproducer CHP plants	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Main activity producer heat plants	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Autoproducer heat plants	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat pumps	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Electric boilers	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chemical heat for electricity production	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gas works	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oil refineries	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Coal transformation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Liquefaction plants	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Non-specified (transformation)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Energy industry own use	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Losses	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Final consumption	**0.75**	**16.47**	**0.03**	**0.01**	**17.48**	**0.18**	-	-	-	-	-	**32.61**	-	-	**20.14**	-
Industry	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Iron and steel	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chemical and petrochemical	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Non-ferrous metals	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Non-metallic minerals	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Transport equipment	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Machinery	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mining and quarrying	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Food and tobacco	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Paper, pulp and print	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Wood and wood products	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Construction	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Textile and leather	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Non-specified (industry)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Transport	**0.09**	**16.43**	**0.03**	-	**17.13**	-	-	-	-	-	-	**1.97**	-	-	-	-
Road	0.09	16.43	-	-	16.68	-	-	-	-	-	-	1.97	-	-	-	-
Domestic aviation	-	-	0.03	-	-	-	-	-	-	-	-	-	-	-	-	-
Rail	-	-	-	-	0.39	-	-	-	-	-	-	-	-	-	-	-
Pipeline transport	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Domestic navigation	-	-	-	-	0.06	-	-	-	-	-	-	-	-	-	-	-
Non-specified (transport)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Other	**0.65**	**0.04**	-	**0.01**	**0.35**	**0.18**	-	-	-	-	-	**30.65**	-	-	**20.14**	-
Residential	0.64	-	-	0.01	-	-	-	-	-	-	-	27.72	-	-	19.80	-
Commercial	0.01	-	-	-	-	0.18	-	-	-	-	-	2.87	-	-	0.34	-
Agriculture	-	0.04	-	-	0.35	-	-	-	-	-	-	0.06	-	-	0.0018	-
Fishing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Non-specified (other)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Non-energy use	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

As indicated in Figure 1, virtually all the AT* templates rely on the information in the EB_<region>(year) (in this case EB_Starter(2013)) workbook including the

- country or region name;
- fuel names and descriptions;
- emissions names, descriptions and rates;
- years the model is to be setup for (noting that TIMES supports model year and data year independence, so the model can be run for other years than those for which data is provided), and
- timeslice definitions and fractions apportioning the year into 4-seasons and 3-day slices (for a total of 12 divisions of the year) to track the timing of the electricity and (seasonal) heat demands.

Note that the milestone years and timeslice values in the TimePeriods&FRs sheet come from the LoadCalibration workbook. Both the SUP and the BY sector templates link to this sheet to get the year and timeslice information. Also, if the LoadCalibration workbook is updated, the years and timeslice information **MUST** be manually changed and the TimePeriods&FRs sheet is structured to allow the updated values to be copied and pasted into the BASE scenario of ANSWER, as shown in Figure 8.

Figure 8: Years and Time Slice Data from the EB_Starter Workbook and in ANSWER

Start year	Milestone Years							
2013	2015	2020	2025	2030	2035	2040	2045	2050

Pat DeLaquil:
If these values are to be changed, copy/paste them into the BASE scenario.

Discount year (G_DYEAR)	2015
Global Discount rate (G_DRATE)	0.05

Annual Time Slices

	Spring	Spring Day	Spring night	Spring Peak	Summer	Summer Day	Summer Night	Summer Peak	Winter	Winter Day	Winter Night	Winter Peak	Fall	Fall Day	Fall Night	Fall Peak
TimeSlice	SP	SPD	SPN	SPP	SU	SUD	SUN	SUP	WI	WID	WIN	WIP	FA	FAD	FAN	FAP
Year fraction (G_YRFR)	0.251	0.147	0.084	0.021	0.251	0.147	0.084	0.021	0.246	0.143	0.082	0.021	0.251	0.148	0.083	0.021

Time slice inputs and sectoral FR inputs come from the Starter_Load Calibration template.

Pat DeLaquil:
If Load calcibration is adjusted or G_YRFR are changed, copy/paste these values into the BASE scenario.

TimeSlice	G_YRFR
FA	0.2515
FAD	0.1479
FAN	0.0829
FAP	0.0207
SP	0.2513
SPD	0.1466
SPN	0.0838
SPP	0.0209
SU	0.2513
SUD	0.1466
WI	0.2459
WID	0.1434
WIN	0.0820
WIP	0.0205

Sectoral Demand Load fractions (COM_FR)

Sector	SPD	SPN	SPP	SUD	SUN	SUP	WID	WIN	WIP	FAD	FAN	FAP	Check if 1
Agriculture	0.200	0.026	0.024	0.300	0.154	0.046	0.000	0.000	0.000	0.200	0.026	0.024	1.000
Industry	0.147	0.084	0.021	0.147	0.084	0.021	0.143	0.082	0.021	0.148	0.083	0.021	1.000
Transport	0.147	0.084	0.021	0.147	0.084	0.021	0.143	0.082	0.021	0.148	0.083	0.021	1.000
Commercial													
Heating	0.126	0.050	0.024	0.000	0.000	0.000	0.384	0.144	0.072	0.126	0.050	0.024	1.000
Hot Water	0.158	0.063	0.030	0.158	0.063	0.030	0.160	0.060	0.030	0.158	0.063	0.030	1.000
Space Cooling	0.158	0.063	0.030	0.315	0.125	0.060	0.000	0.000	0.000	0.158	0.063	0.030	1.000
Lighting	0.189	0.075	0.036	0.063	0.025	0.012	0.256	0.096	0.048	0.126	0.050	0.024	1.000
Other	0.158	0.063	0.030	0.158	0.063	0.030	0.192	0.072	0.036	0.126	0.050	0.024	1.000
Residential													
Heating	0.130	0.048	0.022	0.000	0.000	0.000	0.390	0.144	0.066	0.128	0.046	0.026	1.000
Hot Water	0.163	0.060	0.028	0.163	0.058	0.030	0.163	0.060	0.028	0.160	0.058	0.033	1.000
Space Cooling	0.160	0.060	0.030	0.325	0.115	0.060	0.000	0.000	0.000	0.160	0.058	0.033	1.000
Lighting	0.192	0.072	0.036	0.065	0.023	0.012	0.256	0.096	0.048	0.128	0.046	0.026	1.000
Other	0.160	0.060	0.030	0.163	0.058	0.030	0.192	0.072	0.036	0.128	0.046	0.026	1.000

SETUP | Energy Balance | Example IEA balance | TimePeriods & FRs | Definitions | Conversion factors ...

Scenario	Parameter		Region	Region2	Item1	Item2	Item3	Ite	Item5	Item	I/E	2013
BASE	G_DRATE	?	STARTER	-	-	_	-	-	-	-	0	0.0500

Scenario	Parameter		Region	Region2	Item1	Item2	Item3	Ite	Item5	Item	Value
BASE	G_DYEAR	?	_GLOBAL	-	-	_	-	-	-	-	2,015.00
BASE	G_YRFR	?	STARTER	-	-	_	-	-	FA	-	0.2515
BASE	G_YRFR	?	STARTER	-	-	_	-	-	FAD	-	0.1479
BASE	G_YRFR	?	STARTER	-	-	_	-	-	FAN	-	0.0829
BASE	G_YRFR	?	STARTER	-	-	_	-	-	FAP	-	0.0207
BASE	G_YRFR	?	STARTER	-	-	_	-	-	SP	-	0.2513
BASE	G_YRFR	?	STARTER	-	-	_	-	-	SPD	-	0.1466
BASE	G_YRFR	?	STARTER	-	-	_	-	-	SPN	-	0.0838
BASE	G_YRFR	?	STARTER	-	-	_	-	-	SPP	-	0.0209
BASE	G_YRFR	?	STARTER	-	-	_	-	-	SU	-	0.2513
BASE	G_YRFR	?	STARTER	-	-	_	-	-	SUD	-	0.1466
BASE	G_YRFR	?	STARTER	-	-	_	-	-	SUN	-	0.0838
BASE	G_YRFR	?	STARTER	-	-	_	-	-	SUP	-	0.0209
BASE	G_YRFR	?	STARTER	-	-	_	-	-	WI	-	0.2459
BASE	G_YRFR	?	STARTER	-	-	_	-	-	WID	-	0.1434
BASE	G_YRFR	?	STARTER	-	-	_	-	-	WIN	-	0.0820
BASE	G_YRFR	?	STARTER	-	-	_	-	-	WIP	-	0.0205

The information from the Energy Balance is collected on the EB sheet in the SUP and BY sector templates, which in turn controls the default commodities on the SETUP sheet according to what is currently used in the region to avoid loading those commodities not needed in the energy system.

> Note that when a commodity not in the initial year energy balance is needed in the future, simply **BLANK OUT** (not deleted/erased) the 0 found in sector EB sheet, as shown in Figure 8 for COM (D5) --- this then activates said commodity on the SETUP sheet and creates the associated X<sect><fuel> sector delivery processes. For SUP both the source (import/export/domestic) and the total need to be blanked out.

Figure 9: Sector EB and Commodity Control Sheet

Pat DeLaquil:
If a fuel is needed for new planned or envisioned technologies, delete the existing zero entry to allow the X process to be created.
The matching supply must be activated similarly in the SUP

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	start year	2013																
2																		
3			COAANT	COAOBC	COASBC	COALIG	COABKB	COAGWG	COAPEA	OILLPG	OILGSL	OILKER	OILDSL	OILFOI	OILNSO	GASNAT	BIOPSF	BIOGAS
4	PJ	Sector Name	Anthracite (Hard Coal)	Bituminous (Brown Coal)	Sub-Bituminous Coal	Lignite	Briquettes	Town (Coal) Gas	Peat	LPG	Gasoline	Kerosene	Diesel	Fuel Oil	Other Oil Products (excluding non-energy uses)	Natural Gas	Primary Solid Biofuels	Biogases
5	Commercial	COM	0.013	0	0	0.0053	0	0	0	0.0134	0	0	0	0.1794	0	2.8712	0.336	0
6																		
7	Split each by end-use																	
8	CH	Commercial Heating	100%			100%								50%		60%	100%	
9	CC	Commercial Cooling														1%		
10	CWH	Commercial Water Heating												40%		16%		
11	CCK	Commercial Cooking								100%						20%		
12	CLT	Commercial Lighting																
13	CRF	Commercial Refrigeration																
14	COF	Commercial Office Equipment																
15	CPL	Commercial Public Lighting																
16	CME	Commercial Misc Energy												10%		3%		
17		**Check 100%**	**100%**	**0%**	**0%**	**100%**	**0%**	**0%**	**0%**	**100%**	**0%**	**0%**	**0%**	**100%**	**0%**	**100%**	**100%**	**0%**
18																		
19																		
20	FEC by end-use																	
21	CH	Commercial Heating	0.013	0	0	0.0053	0	0	0	0	0	0	0	0.0897	0	1.72272	0.336	0
22	CC	Commercial Cooling	0	0	0	0	0	0	0	0	0	0	0	0	0	0.028712	0	0
23	CWH	Commercial Water Heating	0	0	0	0	0	0	0	0	0	0	0	0.07176	0	0.459392	0	0
24	CCK	Commercial Cooking	0	0	0	0	0	0	0	0.0134	0	0	0	0	0	0.57424	0	0
25	CLT	Commercial Lighting	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	CRF	Commercial Refrigeration	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	COF	Commercial Office Equipment	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	CPL	Commercial Public Lighting	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	CME	Commercial Misc Energy	0	0	0	0	0	0	0	0	0	0	0	0.01794	0	0.086136	0	0
30		**Total**	**0.013**	**0**	**0**	**0.0053**	**0**	**0**	**0**	**0.0134**	**0**	**0**	**0**	**0.1794**	**0**	**2.8712**	**0.336**	**0**
31		Check diff from FEC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

5.2 Supply

The Supply (SUP) sector of the TIMES-Starter has been setup with the basic imports, exports and domestic production for those energy carriers needed to supply the fuels currently consumed by the TIMES-Starter technologies in the database and in accordance with the first year Energy Balance. As mentioned in Section 5.1, the EB sheet in the SUP workbook connects to the EB workbook and is then used to control the fuels and supply options that are activated. If a new technology requires a fuel not in the current Energy Balance the 0 in rows 5 and 6-8 (as appropriate for domestic/imports/exports) of the SUP EB sheet should simply be deleted to activate said fuel for future use. The list of current energy carriers is shown in Figure 10.

Figure 10: Current Supply Energy Carriers[9]

Name	Region	Description
SUPBIOCHA	STARTER	Renewables - Charcoal
SUPBIODSL	STARTER	Renewables - Biodiesels
SUPBIOGAS	STARTER	Renewables - Biogases
SUPBIOGSL	STARTER	Renewables - Biogasoline
SUPBIOIWA	STARTER	Renewables - Industrial Waste
SUPBIOJKE	STARTER	Renewables - Bio Jet Kerosene
SUPBIOMSW	STARTER	Renewables - Municipal Waste
SUPBIOPSF	STARTER	Renewables - Primary Solid Biofuels
SUPCOAANT	STARTER	Coal - Anthracite
SUPCOABFG	STARTER	Coal - Blast Furnace Gas
SUPCOABKB	STARTER	Coal - Briquettes
SUPCOACCO	STARTER	Coal - Coking Coal
SUPCOACOG	STARTER	Coal - Coke Oven Gas
SUPCOAGCO	STARTER	Coal - Gas Coke
SUPCOAGWG	STARTER	Coal - Gas Works Gas
SUPCOALIG	STARTER	Coal - Lignite
SUPCOAOBC	STARTER	Coal - Other Bituminous Coal
SUPCOAORG	STARTER	Coal - Other Recovered Gases
SUPCOAPEA	STARTER	Coal - Peat
SUPCOASBC	STARTER	Coal - Sub-Bituminous Coal
SUPGASNAT	STARTER	Natural Gas: Supply
SUPGASPIP	STARTER	Natural Gas: Pipeline
SUPNUCLER	STARTER	Nuclear: Supply

Name	Region	Description
SUPOILASP	STARTER	Asphalt
SUPOILBIT	STARTER	Oil - Bitumen
SUPOILCOI	STARTER	Oil - Crude Oil
SUPOILDSL	STARTER	Oil - Diesel
SUPOILDST	STARTER	Distillate
SUPOILETH	STARTER	Oil - Ethane
SUPOILFOI	STARTER	Oil - Fuel Oil
SUPOILGSL	STARTER	Oil - Gasoline
SUPOILJET	STARTER	Oil - Jet Fuel
SUPOILJTF	STARTER	Jet Fuel
SUPOILKER	STARTER	Oil - Kerosene
SUPOILLPG	STARTER	Oil - LPG
SUPOILLUB	STARTER	Oil - Lubricants
SUPOILNAP	STARTER	Oil - Naphtha
SUPOILNGL	STARTER	Oil - Natural Gas Liquids
SUPOILNSO	STARTER	Oil - Non-specified Oil Products
SUPOILPCO	STARTER	Oil - Petroleum Coke
SUPOILPFS	STARTER	Petrochemical Feedstocks
SUPOILPTC	STARTER	Petroleum Coke
SUPOILRFE	STARTER	Oil - Refinery Feedstocks
SUPOILRFO	STARTER	Residual
SUPRNWETH	STARTER	Ethanol - Supply
SUPRNWGEO	STARTER	Renewables - Geothermal
SUPRNWH2	STARTER	Hydrogen - Supply
SUPRNWHYD	STARTER	Renewables - Hydro
SUPRNWSOL	STARTER	Renewables - Solar
SUPRNWTWO	STARTER	Renewables - Tide, Wave and Ocean
SUPRNWWIN	STARTER	Renewables - Wind

[9] This list encompasses all the energy forms listed in the standard IEA Energy Balance. However, currently there may not be technologies that produce/consume some of those listed.

For each SUP<core><type> fuel there needs to be a corresponding IMP-EXP/MIN<energy carrier> process that either takes imports from or sends exports to the IMPEXP region, or produces domestic resources from the MINRNW region respectively, with the current list of resource supply options listed in Figure 11.

Figure 11: Imports & Domestic Resources Supply Options

Name	Region	Description
EXPSUPCOASBC-1	STARTER	Export Coal - Sub-Bituminous Coal
IMPSUPCOAANT-1	STARTER	Import Coal - Anthracite
IMPSUPCOABKB-1	STARTER	Import Coal - Briquettes
IMPSUPCOACCO-1	STARTER	Import Coal - Coking Coal
IMPSUPCOALIG-1	STARTER	Import Coal - Lignite
IMPSUPCOASBC-1	STARTER	Import Coal - Sub-Bituminous Coal
IMPSUPGASNAT-1	STARTER	Import Natural Gas: Supply
IMPSUPNUCLER-1	STARTER	Import Nuclear: Supply
IMPSUPOILCOI-1	STARTER	Import Oil - Crude Oil
IMPSUPOILDSL-1	STARTER	Import Oil - Diesel
IMPSUPOILFOI-1	STARTER	Import Oil - Fuel Oil
IMPSUPOILGSL-1	STARTER	Import Oil - Gasoline
IMPSUPOILJET-1	STARTER	Import Oil - Jet Fuel
IMPSUPOILKER-1	STARTER	Import Oil - Kerosene
IMPSUPOILLPG-1	STARTER	Import Oil - LPG
IMPSUPOILNGL-1	STARTER	Import Oil - Natural Gas Liquids
MINSUPCOALIG-1	STARTER	Extraction Coal - Lignite
MINSUPCOASBC-1	STARTER	Extraction Coal - Sub-Bituminous Coal
MINSUPGASNAT-1	STARTER	Extraction Natural Gas: Supply
MINSUPOILCOI-1	STARTER	Extraction Oil - Crude Oil
RNWSUPBIODSL-1	STARTER	Renewables - Biodiesels
RNWSUPBIOGAS-1	STARTER	Renewables - Biogases
RNWSUPBIOGSL-1	STARTER	Renewables - Biogasoline
RNWSUPBIOIWA-1	STARTER	Renewables - Industrial Waste
RNWSUPBIOJKE-1	STARTER	Renewables - Bio Jet Kerosene
RNWSUPBIOMSW-1	STARTER	Renewables - Municipal Waste
RNWSUPBIOPSF-1	STARTER	Renewables - Primary Solid Biofuels
RNWSUPRNWGEO-1	STARTER	Renewables - Geothermal
RNWSUPRNWHYD-1	STARTER	Renewables - Hydro
RNWSUPRNWSOL-1	STARTER	Renewables - Solar
RNWSUPRNWTWO-1	STARTER	Renewables - Tide, Wave and Ocean
RNWSUPRNWWIN-1	STARTER	Renewables - Wind

The Supply template uses the earlier v1 of the ANSWER-TIMES templates, as the IRE parameters are not (yet) available in the newer v2, employed for most of the other templates, so it has a slightly different layout. The most important differences are:

- there is a single ITEMS sheet for commodities, processes, and user constraint declaration;
- there are different data load sheets depending upon the nature of the information to be handled;
- the parameters run down the rows rather than across the columns, and
- to the right of the I/E column the individual columns are taken in the order that the periods are handled in ANSWER *** Regardless of the header on Row-7 ***.

The SETUP sheet in the Supply template operates similarly to the other templates with one additional wrinkle. As shown in Figure 12 and discussed below, the user may provide factors that are applied to the assumed price for the various energy supply options and to the initial year supply to set the final period limit – linearly interpolated.

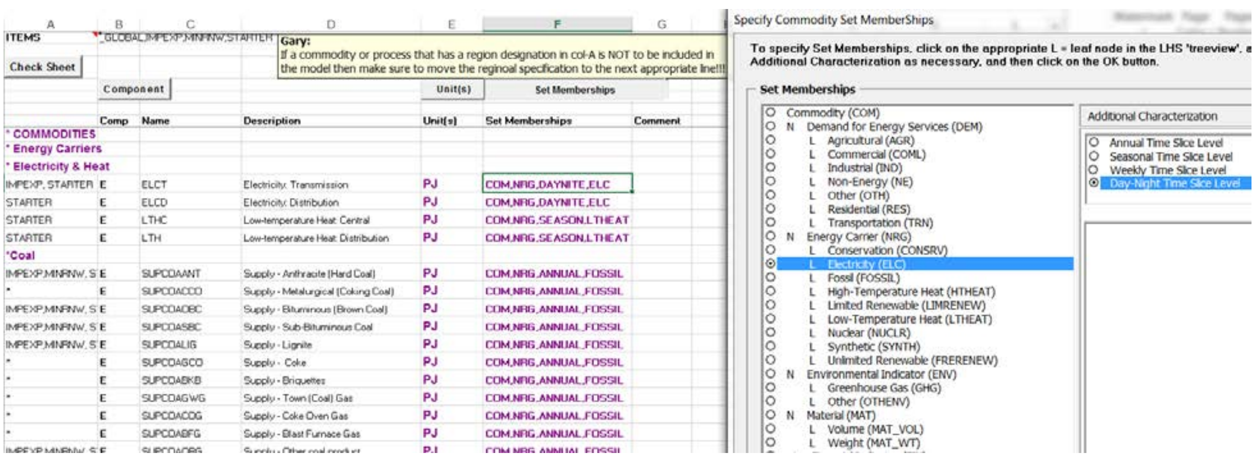
Figure 12: Supply Template SETUP Sheet Price/Bound Factors

A	B	C	D	E
	RNW	Renewable		
* Source / Price Step				
	-1			
	-2	new		
* Imports				
* Electricity & Heat			Price factor	Bound factor
	IMPELCT-1	Import Electricity: Transmission	1	1.2
	GRD-ELCD-1	Electricity: Distribution		1
	GRD-LTHC-1	Low-temperature Heat: Central		1
	GRD-ELCD-2	Electricity: Distribution - new		nolim
	GRD-LTHC-2	Low-temperature Heat: Central - new		nolim
*Coal				
	IMPSUPCOAANT-1	Import Supply - Anthracite (Hard Coal)	1	1.5
*	IMPSUPCOACCO-1	Import Supply - Metalurgical (Coking Coal)	1	1
	IMPSUPCOAOBC-1	Import Supply - Bituminous (Brown Coal)	1	nolim
	IMPSUPCOASBC-1	Import Supply - Sub-Bituminous Coal	1	1
	IMPSUPCOALIG-1	Import Supply - Lignite	0.85	1
*	IMPSUPCOAGCO-1	Import Supply - Coke	1	1
*	IMPSUPCOABKB-1	Import Supply - Briquettes	1.1	1
*	IMPSUPCOAGWG-1	Import Supply - Town (Coal) Gas	1	1
*	IMPSUPCOACOG-1	Import Supply - Coke Oven Gas	1	1
*	IMPSUPCOABFG-1	Import Supply - Blast Furnace Gas	1	1
	IMPSUPCOAORG-1	Import Supply - Other coal product	1	nolim
*	IMPSUPCOAPEA-1	Import Supply - Peat	1	1
* Oil			1	
*	IMPSUPOILCOI-1	Import Supply - Crude Oil	1.1	1
*	IMPSUPOILNGL-1	Import Supply - Natural Gas Liquids	1.1	1

Gary:
IRE multipler for EPA or other IRE (if blue) - if blank need to set price on SupplyPrice sheet manually.

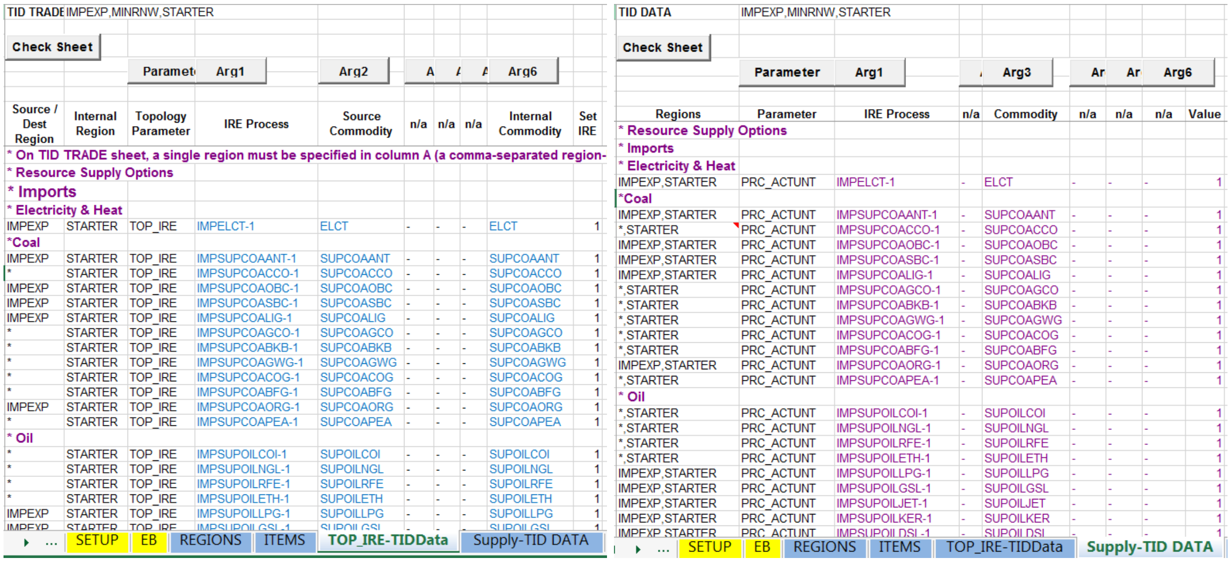
The commodity and process names, descriptions, units, and set memberships are entered on the ITEMS sheet, as in Figure 13. Note that the regions in Col-A need to align according to the nature of the possible supply sources.

Figure 13: Supply Items Declaration Sheet, and Set Membership Specification Form



After the commodities (energy carriers and emissions) are declared (on the ITEMS sheet according to SETUP), the topology information needs to be provided on the TOP-TIDData sheet (via TOP_IRE indicators), and the main commodity delivered identified on the CommSup-TID_Data sheet (via PRC_ACTUNT), as shown in Figure 14.

Figure 14: Supply Options Topology and Product



TID TRADE IMPEXP,MINRNW,STARTER

Check Sheet

Source / Dest Region	Internal Region	Topology Parameter	IRE Process	Source Commodity	n/a	n/a	n/a	Internal Commodity	Set IRE
		Paramet	Arg1	Arg2	A	A	A	Arg6	
* On TID TRADE sheet, a single region must be specified in column A (a comma-separated region-									
* Resource Supply Options									
* Imports									
* Electricity & Heat									
IMPEXP	STARTER	TOP_IRE	IMPELCT-1	ELCT	-	-	-	ELCT	1
*Coal									
IMPEXP	STARTER	TOP_IRE	IMPSUPCOAANT-1	SUPCOAANT	-	-	-	SUPCOAANT	1
*	STARTER	TOP_IRE	IMPSUPCOACCO-1	SUPCOACCO	-	-	-	SUPCOACCO	1
IMPEXP	STARTER	TOP_IRE	IMPSUPCOAOBC-1	SUPCOAOBC	-	-	-	SUPCOAOBC	1
IMPEXP	STARTER	TOP_IRE	IMPSUPCOASBC-1	SUPCOASBC	-	-	-	SUPCOASBC	1
IMPEXP	STARTER	TOP_IRE	IMPSUPCOALIG-1	SUPCOALIG	-	-	-	SUPCOALIG	1
*	STARTER	TOP_IRE	IMPSUPCOAGCO-1	SUPCOAGCO	-	-	-	SUPCOAGCO	1
*	STARTER	TOP_IRE	IMPSUPCOABKB-1	SUPCOABKB	-	-	-	SUPCOABKB	1
*	STARTER	TOP_IRE	IMPSUPCOAGWG-1	SUPCOAGWG	-	-	-	SUPCOAGWG	1
*	STARTER	TOP_IRE	IMPSUPCOACOG-1	SUPCOACOG	-	-	-	SUPCOACOG	1
*	STARTER	TOP_IRE	IMPSUPCOABFG-1	SUPCOABFG	-	-	-	SUPCOABFG	1
IMPEXP	STARTER	TOP_IRE	IMPSUPCOAORG-1	SUPCOAORG	-	-	-	SUPCOAORG	1
*	STARTER	TOP_IRE	IMPSUPCOAPEA-1	SUPCOAPEA	-	-	-	SUPCOAPEA	1
* Oil									
*	STARTER	TOP_IRE	IMPSUPOILCOI-1	SUPOILCOI	-	-	-	SUPOILCOI	1
*	STARTER	TOP_IRE	IMPSUPOILNGL-1	SUPOILNGL	-	-	-	SUPOILNGL	1
*	STARTER	TOP_IRE	IMPSUPOILRFE-1	SUPOILRFE	-	-	-	SUPOILRFE	1
*	STARTER	TOP_IRE	IMPSUPOILETH-1	SUPOILETH	-	-	-	SUPOILETH	1
IMPEXP	STARTER	TOP_IRE	IMPSUPOILLPG-1	SUPOILLPG	-	-	-	SUPOILLPG	1
IMPEXP	STARTER	TOP_IRE	IMPSUPOILGSL-1	SUPOILGSL	-	-	-	SUPOILGSL	1

… SETUP | EB | REGIONS | ITEMS | TOP_IRE-TIDData | Supply-TID DATA

TID DATA IMPEXP,MINRNW,STARTER

Check Sheet

Regions	Parameter	IRE Process	n/a	Commodity	n/a	n/a	n/a	Value
	Parameter	Arg1	A	Arg3	Ar	Ar	Arg6	
* Resource Supply Options								
* Imports								
* Electricity & Heat								
IMPEXP,STARTER	PRC_ACTUNT	IMPELCT-1	-	ELCT	-	-	-	1
*Coal								
IMPEXP,STARTER	PRC_ACTUNT	IMPSUPCOAANT-1	-	SUPCOAANT	-	-	-	1
*,STARTER	PRC_ACTUNT	IMPSUPCOACCO-1	-	SUPCOACCO	-	-	-	1
IMPEXP,STARTER	PRC_ACTUNT	IMPSUPCOAOBC-1	-	SUPCOAOBC	-	-	-	1
IMPEXP,STARTER	PRC_ACTUNT	IMPSUPCOASBC-1	-	SUPCOASBC	-	-	-	1
IMPEXP,STARTER	PRC_ACTUNT	IMPSUPCOALIG-1	-	SUPCOALIG	-	-	-	1
*,STARTER	PRC_ACTUNT	IMPSUPCOAGCO-1	-	SUPCOAGCO	-	-	-	1
*,STARTER	PRC_ACTUNT	IMPSUPCOABKB-1	-	SUPCOABKB	-	-	-	1
*,STARTER	PRC_ACTUNT	IMPSUPCOAGWG-1	-	SUPCOAGWG	-	-	-	1
*,STARTER	PRC_ACTUNT	IMPSUPCOACOG-1	-	SUPCOACOG	-	-	-	1
*,STARTER	PRC_ACTUNT	IMPSUPCOABFG-1	-	SUPCOABFG	-	-	-	1
IMPEXP,STARTER	PRC_ACTUNT	IMPSUPCOAORG-1	-	SUPCOAORG	-	-	-	1
*,STARTER	PRC_ACTUNT	IMPSUPCOAPEA-1	-	SUPCOAPEA	-	-	-	1
* Oil								
*,STARTER	PRC_ACTUNT	IMPSUPOILCOI-1	-	SUPOILCOI	-	-	-	1
*,STARTER	PRC_ACTUNT	IMPSUPOILNGL-1	-	SUPOILNGL	-	-	-	1
*,STARTER	PRC_ACTUNT	IMPSUPOILRFE-1	-	SUPOILRFE	-	-	-	1
*,STARTER	PRC_ACTUNT	IMPSUPOILETH-1	-	SUPOILETH	-	-	-	1
IMPEXP,STARTER	PRC_ACTUNT	IMPSUPOILLPG-1	-	SUPOILLPG	-	-	-	1
IMPEXP,STARTER	PRC_ACTUNT	IMPSUPOILGSL-1	-	SUPOILGSL	-	-	-	1
IMPEXP,STARTER	PRC_ACTUNT	IMPSUPOILJET-1	-	SUPOILJET	-	-	-	1
IMPEXP,STARTER	PRC_ACTUNT	IMPSUPOILKER-1	-	SUPOILKER	-	-	-	1
IMPEXP,STARTER	PRC_ACTUNT	IMPSUPOILDSL-1	-	SUPOILDSL	-	-	-	1

… SETUP | EB | REGIONS | ITEMS | TOP_IRE-TIDData | Supply-TID DATA

Data to be associated with the supply options is provided on Supply-TSData and Grid&Pipeline+BNDS sheet, most notably the resource supply costs and any limits (via IRE_PRICE/ACT_BND) for each supply step curve for each commodity, as appropriate. Figure 15 shows some sample prices. The prices are taken from the US-DOE EIA Annual Energy Outlook (AEO), with the user price factor from SETUP applied. Where the AEO does not provide data for a particular fuel, either adjustment factors from SETUP are applied to the price of a similar commodity or just placeholders provided where cells are colored according to:

- EPA = white or green, where green denotes the same EIA data used for >1 commodity;
- IRE = blue not in EIA price, but instead derived from another IRE;
- Other = yellow when pull from other sources, or
- Non-specified = red text, not yet setup - user to provide.

These prices are provided merely as a starting point to get the model running and behaving reasonably. The user needs to adjust the price information and update the potential limits over time for their situation. Furthermore, it may be the case that a particular commodity has more than one source (e.g., imports from different countries) and price (for example, less expensive open pit and more expensive mine coal). If this is the case then the entries for a similar supply option should be copied/inserted on the SETUP, Items, TOP_IRE, both Supply sheets as well as the BNDs sheet, incrementing the final character price index for each new supply source incremented (see rows 81-83 of the SETUP sheet). Note that with respect to both the price and bounds the user is free to drop the EIA-tied formulas and enter their data over the time horizon.

Figure 15: Supply Options Prices

TS TRADE | IMPEXP,MINRNW,STARTER

Check Sheet

Populate DataYears

Paramet Arg1 Arg2 Arg3 Arg5 Ar I/E Opt

Color Key:
SETUP(factor)*data, where data is:
- EPA = white or green, where green denotes the same EIA data use
- IRE = blue not in EIA price, but instead derived from another IRE
- Other = yellow when pull from other sources
- Non-specified = red text, not yet setup - user to provide

Internal Region	Source/ Dest Region	Price Parameter	IRE Process	Commodity	Time slice	n/a	Import/ Export	n/a	I/E Opt	2013	2015	2020	2025	2030	2035
* On TS TRADE sheet, a single region must be specified in column A (a comma-separated region-list is not allowed)															
* Resource Supply Options															
* Imports															
* Electricity & Heat															
STARTER	IMPEXP	IRE_PRICE	IMPELCT-1	ELCT	ANNUAL		IMP		0	36.04	36.30	37.13	37.07	38.18	39.34
*Coal															
STARTER	IMPEXP	IRE_PRICE	IMPSUPCOAANT-1	SUPCOAANT	ANNUAL		IMP		0	2.47	2.54	2.91	3.11	3.34	3.52
*		IRE_PRICE	IMPSUPCOACCO-1	SUPCOACCO	ANNUAL		IMP		0	3.44	4.67	5.47	6.53	7.53	8.64
STARTER	IMPEXP	IRE_PRICE	IMPSUPCOAOBC-1	SUPCOAOBC	ANNUAL		IMP		0	2.47	2.54	2.91	3.11	3.34	3.52
STARTER	IMPEXP	IRE_PRICE	IMPSUPCOASBC-1	SUPCOASBC	ANNUAL		IMP		0	2.47	2.54	2.91	3.11	3.34	3.52
STARTER	IMPEXP	IRE_PRICE	IMPSUPCOALIG-1	SUPCOALIG	ANNUAL		IMP		0	2.44	2.50	2.87	3.07	3.29	3.47
*		IRE_PRICE	IMPSUPCOAGCO-1	SUPCOAGCO	ANNUAL		IMP		0	11.60					
*		IRE_PRICE	IMPSUPCOABKB-1	SUPCOABKB	ANNUAL		IMP		0	3.16	3.24	3.72	3.97	4.26	4.50
*		IRE_PRICE	IMPSUPCOAGWG-1	SUPCOAGWG	ANNUAL		IMP		0	11.60					
*		IRE_PRICE	IMPSUPCOACOG-1	SUPCOACOG	ANNUAL		IMP		0	11.60					
*		IRE_PRICE	IMPSUPCOABFG-1	SUPCOABFG	ANNUAL		IMP		0	11.60					
STARTER	IMPEXP	IRE_PRICE	IMPSUPCOAORG-1	SUPCOAORG	ANNUAL		IMP		0	11.60	11.60	11.60	11.60	11.60	11.60
*		IRE_PRICE	IMPSUPCOAPEA-1	SUPCOAPEA	ANNUAL		IMP		0	11.60					
* Oil															
*		IRE_PRICE	IMPSUPOILCOI-1	SUPOILCOI	ANNUAL		IMP		0	8.52	7.41	7.37	8.32	9.08	9.90
*		IRE_PRICE	IMPSUPOILNGL-1	SUPOILNGL	ANNUAL		IMP		0	8.58	10.35	11.30	12.31	13.54	14.88
*		IRE_PRICE	IMPSUPOILRFE-1	SUPOILRFE	ANNUAL		IMP		0	11.60					
*		IRE_PRICE	IMPSUPOILETH-1	SUPOILETH	ANNUAL		IMP		0	11.60					
STARTER	IMPEXP	IRE_PRICE	IMPSUPOILLPG-1	SUPOILLPG	ANNUAL		IMP		0	8.60	10.37	11.33	12.34	13.57	14.91
STARTER	IMPEXP	IRE_PRICE	IMPSUPOILGSL-1	SUPOILGSL	ANNUAL		IMP		0	38.03	32.99	31.96	34.19	35.64	37.98
STARTER	IMPEXP	IRE_PRICE	IMPSUPOILJET-1	SUPOILJET	ANNUAL		IMP		0	28.72	23.81	24.32	27.43	29.62	32.27

... SETUP | EB | REGIONS | ITEMS | TOP_IRE-TIDData | Supply-TID DATA | SupplyPrice-TSData | Grid&Pipelin ...

It is expected that all fuels can be found in the IEA energy balance needed for a country. However, if you do need to add a fuel, use a column that's not needed on the Energy Balance sheet of the EB workbook, which should then cascade into the Supply (and the BY workbooks --- REMEMBER to open/save all said EB dependent workbooks when making changes to the energy balance specfication.)

Note that any emissions that are to be associated with the energy carriers also need to be provided and their emission rate specified on a CommData sheet drawn from the EB workbook. The current template contains sector wide emissions accounting for fuel-based CO_2, CH4, and N2O. Provision for handling $SO_2$and NOx for other sectors and PM10 for the electric sector emissions could also be extracted from the US9r database, though is beyond the scope of the Starter model (currently).

Also, note that since the TIMES-Starter is (currently) a single region model there is no internal bi-lateral trade depicted.

5.3 Power Sector

5.3.1 Organization of the Power Sector Workbooks

This portion of the database resides in the BY/NT-PP workbooks, which contain several power plant process data sheets, as summarized in Table 4, along with their corresponding EPA-US9r and DEA data sheets. In addition, though not listed, as discussed in the introduction to this Section, the BY template includes an EB sheet tied to the EB workbook, both have a SETUP and Commodity/Process declaration sheets. The SETUP tab in the NT template is linked directly to the corresponding BY sheet for the commodity and plant type names to help ensure consistency. The final sheet (ProcData_XPRCs) defines the sector fuel and emissions tracking processes (XPWR<fuel>) that link the supply commodities to the electric power sector, and is only found in the BY sheet. [If another new transmission line is needed it should be added to the SUP template with the appropriate start year (NCAP_START) and cost (NCAP_COST)].

The inclusion/exclusion and any adjustment to the names/descriptions of the technologies to be included in your TIMES model is fully controlled by the SETUP sheet for all the EPA/other plants from which data is taken. If you want to add additional plants, it is recommended that their names be built by copying/pasting a similar plant on SETUP, then adding a counter (or quality indicator) to the end of the name. The plant then needs to be added to Processes and the Non-EPA-PP (or other) ProcData loadsheets, either with data entered directly or by linking to a source data sheet (see the DEA plants/sheets for examples).

Table 4: Data Sheets in Electricity Generation Technologies Workbook

Spreadsheet Name	Description
ProcData_NewPP	New power plant technologies using coal, gas, nuclear, biomass and geothermal.
ProcData_LFG&MSW	New power plant that use landfill gas or municipal solid waste.
ProcData_CHP	New combined heat & power plants.
ProcData_CCS	New coal & gas power plants with carbon sequestration, as well as existing plant retrofit options, and a "sink" to receive the sequestered CO_2.
ProcData_Solar&Wind	New solar & wind power plants.
ProcData_XPRCs	Sector fuel processes to move energy carriers from SUPply to PoWeR sector. [BY only]

5.3.2 Electric Sector Naming Conventions and Units

In TIMES, electric generation technologies take in one or more fuels (energy carriers) and convert them to electricity for use by other processes and demand devices. Power plant capacity units are gigawatts (GW), and power plant investment and fixed operating and maintenance (O&M) costs are given in terms of monetary units per GW. Like all other energy carriers, the electricity produced is denominated in units of petajoules (PJ), and is related to the plant capacity through a conversion factor of 31.536 PJ/GW-yr. Variable O&M costs are thus expressed in monetary units per PJ.

The technologies represented in the power plant database range from fossil fuel conversion technologies to nuclear and renewable technologies, including combined heat and power plants, with options for (new) CO_2 capture and sequestration. The naming convention for electric generating technologies starts with ‘Ex’ where x=E for electricity and H for CHP or HP for heat-only plants, followed by a six-character identifier representing the fuel (energy carrier) type, and a two-character identifier representing the plant technology type as illustrated in Table 5, where “X0” for existing or “xx” for advanced and additional qualifiers where needed may be appended.

Table 5: Electricity Generating Plant Type and Qualifiers

* Plant Types		
	EE	Electricity Generation
	EH	Coupled Heat & Power
	HP	Heating Plant
* Technology Types		
	CC	Combined cycle
	CCS	CO2 Capture & Storage
	CP	CHP
	CT	Combustion turbine
	DM	Hydro (Dam)
	EN	Engine
	GT	Gas turbine
	IG	Integrated Gasif.
	LWR	LWR
	OF	Offshore
	ON	Onshore
*	PS	Hydro (Pumped Storage)
	PV	Photovoltaics
	RR	Hydro (Run-of-River)
	ST	Steam turbine
	TC	Thermal Central
	X0	Existing

Note that in terms of emission control no scrubber retrofits and only new CO_2 sequestration are implemented at this time.

5.3.3 Power Plant Technology Names and Descriptions

The EPA-US9r database is the primary source of data for the new electricity generation technologies, supplemented by the DEA CHP and HPL plants and low-temperature heat devices. This data will be augmented with data from other public sources over time, including but not limited to US DOE, IEA-ETSAP eTech-DS, IEA, and needed.

Table 6 lists the new electricity power plant options found in the database currently. Note that in the case of new hydroelectric plants they need to be characterized based upon local conditions, and therefore those in the NT template serve mainly as examples awaiting user input. Also, in US9r there are numerous instances of biomass, solar and wind, where data from a single region is used and only one wind class just now from the 1st instance encountered by the VLOOKUP --- but grabbing data from a US region more aligned with the country of study and/or adding additional wind classes can readily be done as desired. In general, the user needs to factor in local circumstance (e.g., land and labor costs) for all the power plant data provided.

Table 6: New Power Plant Technologies

* USDOE/EPA Technologies			
* Standard Power Plants			
	EECOAOBC-ST	Bituminous (Brown Coal) - Steam turbine	ECSTMRBONR
	EECOASBC-ST	Sub-Bituminous Coal - Steam turbine	ECSTMRSONR
	EECOALIG-ST	Lignite - Steam turbine	ECSTMRLONR
	EEGASNAT-CC	Natural Gas - Combined cycle	ENGACC15
	EEGASNAT-CCA	Natural Gas - Combined cycle (Advanced)	ENGAACC
	EEGASNAT-CT	Natural Gas - Combustion turbine	ENGACT15
	EEGASNAT-CTA	Natural Gas - Combustion turbine (Advanced)	ENGAACT
	EECOALIG-IG	Lignite - Integrated Gasif. Combined cycle	ECOALIGCC
	EENUCLER-LWR	Nuclear - LWR	EURNALWR15
* LFG&MSW Plants			
	EEBIOGAS-EN	Biogases - Engine	ELFGICE
	EEBIOGAS-GT	Biogases - Gas turbine	ELFGGT
	EEBIOGAS-ST	Biogases - Steam turbine	ELFGST
	EEBIOGAS-CC	Biogases - Combined cycle	ELFGGCC
	EEBIOMSW-ST	Municipal Waste - Steam turbine	EMSWSTM
* Renewables Plants			
	EEBIOPSF-IG	Primary Solid Biofuels - Integrated Gasif. Combined	EBIOIGCC
	EERNWGEO-ST	Geothermal - Steam turbine	EGEOBCFS
	EERNWGEO-A	Geothermal (Advanced)	EGEOEGS
	EERNWSOL-PV4E	Solar - Photovoltaics: Class/CostCat 4E	ESOLPVC4E
	EERNWSOL-TC1E	Solar - Thermal Central: Class/CostCat 1E	ESOLSTCN1E
	EERNWWIN-ON3A	Wind - Onshore: Class/CostCat 3A	EWNDON3A
	EERNWWIN-ON3B	Wind - Onshore: Class/CostCat 3B	EWNDON3B
	EERNWWIN-ON3C	Wind - Onshore: Class/CostCat 3C	EWNDON3C
	EERNWWIN-ON3D	Wind - Onshore: Class/CostCat 3D	EWNDON3D
	EERNWHYD-DM	Hydro (Dam)	
*	EERNWHYD-PS	Hydro (Pumped Storage)	
	EERNWHYD-RR	Hydro (Run-of-River)	
* Danish Energy Agency Technologies			
* CHP Plants			DEA_CHP
	EHBIOPSF-ST	Coupled Heat & Power Primary Solid Biofuels - Stear	direct link
	EHCOAANT-ST	Coupled Heat & Power Anthracite (Hard Coal) - Stean	direct link
	EHGASNAT-CC	Coupled Heat & Power Natural Gas - Combined cycle	direct link
	EHGASNAT-EN	Coupled Heat & Power Natural Gas - Engine	direct link
*	EHOILFOI-CP	Fuel Oil - CHP	ECHPOIL
* District Heating Plants			DEA_DHP

Also shown in Table 6 is the EPA technology name that is used for the VLOOKUP into the source data sheets, along with the reminder that the DEA data is linked directly into their associated source data sheets.

> **Warning**: be sure to adhere to the basic naming convention of the components (that is use the same approach and number of characters as for some other entry) or the ANSWER named TechFilters and VBE Sets may no longer operate properly!

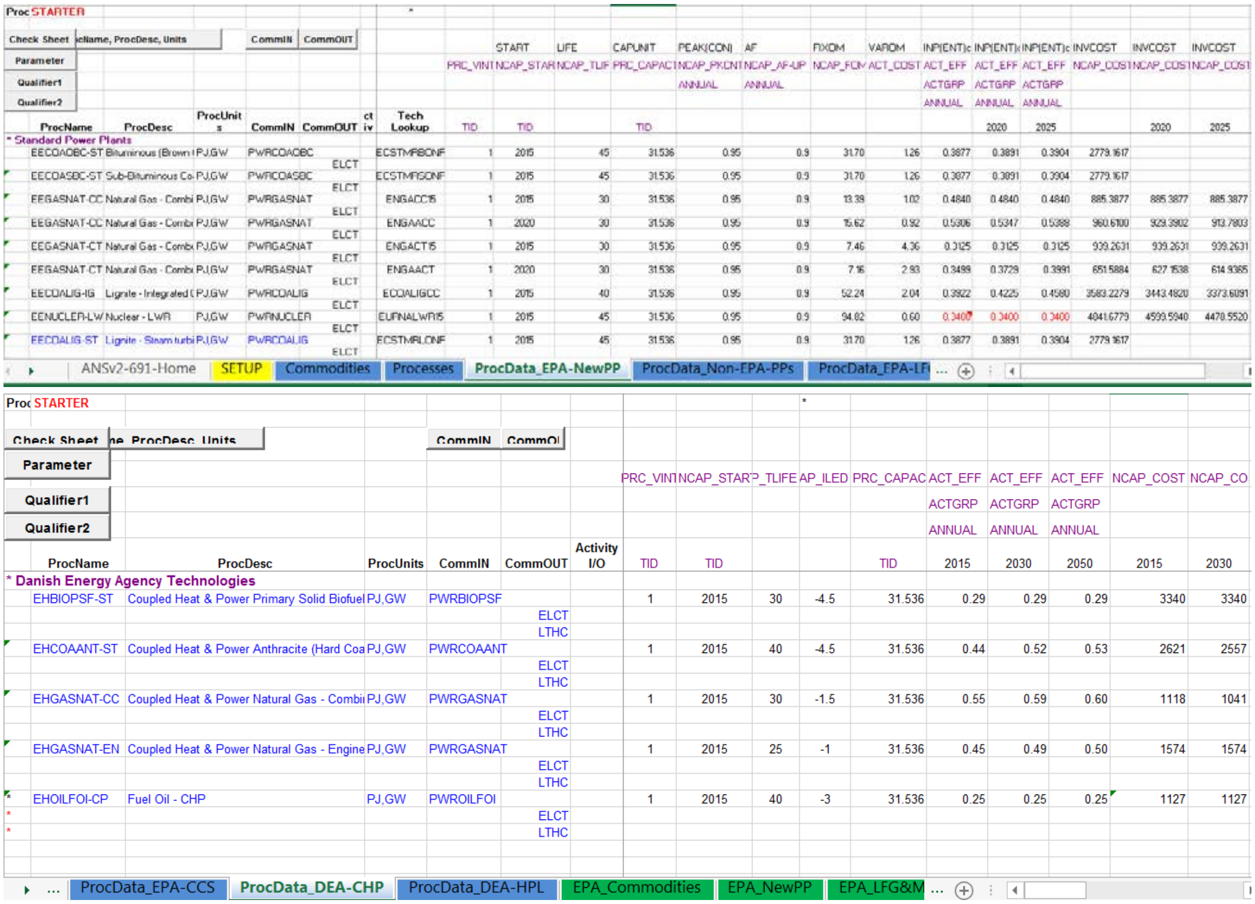
By default power plants are included if the commodity is part of the energy balance for the sector (including the removal of the base year 0 in the BY-PP EB sheet and needed in a later year, as discussed earlier) and the technology type is active (that is not "*" out explicitly by the user). Note that the plant and technology type in the BY template become the default in Col-A for inclusion/exclusion in the NT. Any power plant may be eliminated by entering "*"in Col-A on the SETUP sheet in either workbook. If there is a need to added a new power plant, do so by copying a similar type of plant's name on the SETUP and Process declaration sheets, and then the data blocks on the appropriate ProcData_* sheet. Most of the names are carefully built from $references to their components, so after copying only minor adjustments need to be done to say change a fuel or technology instance. However, if adding a new technology there will be no corresponding data on the source data sheets, so the appropriate numbers will need to be provided, or linked if you have your own source data sheet that is included in the workbook. Also, be sure when adding an existing plant not yet in the database that the plant also gets added to the Calibration sheet appropriately (by copy/inserting a similar plant in the same group).

5.3.4 Power Plant Technology Data

The power plants are split into five groups by EPA: general (NewPP), landfill gas and municipal solid waste (LFG&MSW), combined heat & power (CHPs), other renewables (Solar&Wind), and carbon capture & storage (CCS). For each of these there are EPA_ and corresponding ProcData_ sheets, where the latter links to the former for the actual data by means of VLOOKUPs. The original EPA plant name is replicated (from the SETUP sheet) for use in the VLOOKUP. For the most part parameters are aligned and run across the workbook in the same order on the ProcData sheet as their associated source data sheets. However, there are exceptions, and the EPA data sheets are indexed to allow easier identification of the proper column index to use in the VLOOKUP expression. In addition, the cost parameters are converted to the local currency based upon the factor entered on the SETUP sheet, and the input oriented MARKAL efficiency inverted for the TIMES default output normalized equivalent.

A snapshot of a power sector ProcData loadsheet is shown in Figure 16. In the case of the DEA sheet (below) note that there is no TechLookUp column, reinforcing the fact that a non-EPA source data sheet is referenced by means of direct links to the source data sheet, as opposed to employing VLOOKUP.

Figure 16: Power Sector New Plants Loadsheet



Proc STARTER

ProcName	ProcDesc	ProcUnits	CommIN	CommOUT	Act iv	Tech Lookup	PRC_VINT (TID)	START NCAP_START (TID)	LIFE NCAP_TLIFE	CAPUNIT PRC_CAPACT (TID)	PEAK(CON) NCAP_PKCNT ANNUAL	AF NCAP_AF-UP ANNUAL	FIXOM NCAP_FOM	VAROM ACT_COST	INP(ENT)c ACT_EFF ACTGRP ANNUAL	INP(ENT)c ACT_EFF ACTGRP ANNUAL 2020	INP(ENT)c ACT_EFF ACTGRP ANNUAL 2025	INVCOST NCAP_COST	INVCOST NCAP_COST 2020	INVCOST NCAP_COST 2025
* Standard Power Plants																				
EECOAOBC-ST	Bituminous (Brown	PJ,GW	PWRCOAOBC	ELCT		ECSTMRBONF	1	2015	45	31.536	0.95	0.9	31.70	1.26	0.3877	0.3891	0.3904	2779.1617		
EECOASBC-ST	Sub-Bituminous Co	PJ,GW	PWRCOASBC	ELCT		ECSTMRSONF	1	2015	45	31.536	0.95	0.9	31.70	1.26	0.3877	0.3891	0.3904	2779.1617		
EEGASNAT-CC	Natural Gas - Combi	PJ,GW	PWRGASNAT	ELCT		ENGACC15	1	2015	30	31.536	0.95	0.9	13.39	1.02	0.4840	0.4840	0.4840	885.3877	885.3877	885.3877
EEGASNAT-CC	Natural Gas - Combi	PJ,GW	PWRGASNAT	ELCT		ENGAACC	1	2020	30	31.536	0.95	0.9	15.62	0.92	0.5306	0.5347	0.5388	960.6100	929.3902	913.7803
EEGASNAT-CT	Natural Gas - Combu	PJ,GW	PWRGASNAT	ELCT		ENGACT15	1	2015	30	31.536	0.95	0.9	7.46	4.36	0.3125	0.3125	0.3125	939.2631	939.2631	939.2631
EEGASNAT-CT	Natural Gas - Combu	PJ,GW	PWRGASNAT	ELCT		ENGAACT	1	2020	30	31.536	0.95	0.9	7.16	2.93	0.3499	0.3729	0.3991	651.5884	627.1538	614.9365
EECOALIG-IG	Lignite - Integrated (	PJ,GW	PWRCOALIG	ELCT		ECOALIGCC	1	2015	40	31.536	0.95	0.9	52.24	2.04	0.3922	0.4225	0.4580	3583.2279	3443.4820	3373.6091
EENUCLER-LW	Nuclear - LWR	PJ,GW	PWRNUCLER	ELCT		EURNALWR15	1	2015	45	31.536	0.95	0.9	94.82	0.60	0.3400	0.3400	0.3400	4041.6779	4599.5940	4470.5520
EECOALIG-ST	Lignite - Steam turbi	PJ,GW	PWRCOALIG	ELCT		ECSTMRLONF	1	2015	45	31.536	0.95	0.9	31.70	1.26	0.3877	0.3891	0.3904	2779.1617		

ANSv2-691-Home | SETUP | Commodities | Processes | ProcData_EPA-NewPP | ProcData_Non-EPA-PPs | ProcData_EPA-LF ...

Proc STARTER

ProcName	ProcDesc	ProcUnits	CommIN	CommOUT	Activity I/O	PRC_VINT (TID)	NCAP_START (TID)	NCAP_TLIFE	NCAP_ILED	PRC_CAPACT (TID)	ACT_EFF ACTGRP ANNUAL 2015	ACT_EFF ACTGRP ANNUAL 2030	ACT_EFF ACTGRP ANNUAL 2050	NCAP_COST 2015	NCAP_COST 2030
* Danish Energy Agency Technologies															
EHBIOPSF-ST	Coupled Heat & Power Primary Solid Biofuel	PJ,GW	PWRBIOPSF			1	2015	30	-4.5	31.536	0.29	0.29	0.29	3340	3340
				ELCT											
				LTHC											
EHCOAANT-ST	Coupled Heat & Power Anthracite (Hard Coa	PJ,GW	PWRCOAANT			1	2015	40	-4.5	31.536	0.44	0.52	0.53	2621	2557
				ELCT											
				LTHC											
EHGASNAT-CC	Coupled Heat & Power Natural Gas - Combi	PJ,GW	PWRGASNAT			1	2015	30	-1.5	31.536	0.55	0.59	0.60	1118	1041
				ELCT											
				LTHC											
EHGASNAT-EN	Coupled Heat & Power Natural Gas - Engine	PJ,GW	PWRGASNAT			1	2015	25	-1	31.536	0.45	0.49	0.50	1574	1574
				ELCT											
				LTHC											
EHOILFOI-CP	Fuel Oil - CHP	PJ,GW	PWROILFOI			1	2015	40	-3	31.536	0.25	0.25	0.25	1127	1127
				ELCT											
				LTHC											

... ProcData_EPA-CCS | ProcData_DEA-CHP | ProcData_DEA-HPL | EPA_Commodities | EPA_NewPP | EPA_LFG&M ...

Note that the vintage flag is set automatically if more than 1 efficiency is provided for a plant, that is if its performance is expected to improve over time.

5.3.5 Calibration of the Initial Year

The power sector needs to properly reflect the first year fuel consumption and generation levels, as well as the proper amount of installed capacity for each plant type. To do this the EB energy balance sheet is automatically filled from the EB workbook, with the Calibration sheet, Figure 17, completed by providing relevant information for the yellow shaded cells related to retirement year, existing capacity, fuel consumed, electricity generated, with the maximum availability and general overal efficiency derived from that information which may be overwritten by the user if desired.

Figure 17: Power Sector Calibration Sheet

Calibration of power and heat generation	Fuel	Decomissioning year	Existing Capacity	Fuel consumption	Electricity Produced	Base Year Capacity factor	Availability for future years		Efficiency	
				Est/known	Est/known elc prod	Calc. from Elc and Cap	Max capacity factor AF	Based on elc:fuel ratio	Standard Estimate	Model input
er Plants			GW	PJ	PJ	%	%	%	%	%
Hydro (Dam) (Existing)	PWRRNWHYD	2040	0.120	1.500	1.500	39.6%	39.64%	100.0%	100.0%	100.0%
Hydro (Run-of-River) (Existing)	PWRRNWHYD	2050	0.050	0.50	0.500	31.7%	31.71%	100.0%	100.0%	100.0%
Hydro (Pumped Storage) (Existing)	PWRRNWHYD	2040				-	0.00%	-		-
	PWRELC									
Total			**0.170**	**2.000**	**2.000**					
Natural Gas - Combined cycle (Existing)	PWRGASNAT	2030	0.110	6.67	3.000	86.5%	90.0%	45.0%	48.4%	45.0%
Natural Gas - Combustion turbine (Existing)	PWRGASNAT	2025	0.150	11.98	3.355	70.9%	90.0%	28.0%	30.0%	28.0%
Total			**0.260**	**18.650**	**6.355**					
Bituminous (Brown Coal) - Steam turbine (Existing)	PWRCOAOBC	2025	0.060	4.59	1.500	79.3%	90.0%	32.7%	38.8%	32.7%
Sub-Bituminous Coal - Steam turbine (Existing)	PWRCOASBC	2025	0.060	4.50	1.500	79.3%	90.0%	33.3%	38.8%	33.3%
Lignite - Steam turbine (Existing)	PWRCOALIG	2030	0.200	13.64	4.500	71.3%	90.0%	33.0%	38.8%	33.0%
Lignite - Integrated Gasif. (Existing) Combined cycle	PWRCOALIG	2040	0.120	8.57	3.000	79.3%	90.0%	35.0%	39.2%	35.0%
Total			**0.440**	**31.300**	**10.500**					
Nuclear - LWR (Existing)	PWRNUCLER	2035	0.050	2.94	1.000	63.4%	90.0%	34.0%	34.0%	34.0%
Total			**0.050**	**2.940**	**1.000**					
Biogases - Engine (Existing)	PWRBIOGAS	2025	0.020	1.47	0.50	79.3%	90.0%	34.0%	36.0%	34.0%

... SETUP | EB | Calibration | Commodities | CommData | Processes | ProcData_EPA-StandardPP | ProcData_Non-EPA-PPs | ...

Note that if for any fuel group the fuel consumption total does not match the Energy Balance an error message will be displayed in the cell about that fuel group with the difference from the EB sheet shown.

As discussed in more detail in Section 6, the work on the Calibration sheets in each BY workbook is the starting point for the calibration process. The cycle involves running the model (for just the first period if desired) and using the VBE calibration check workbook to see how well the model is aligning with the energy balance, returning to the BY Calibration sheets to refine plant capacity, consumption and production (and derived efficiency) assumptions as needed.

5.4 Demand Sectors

There are five (5) demand sectors in the TIMES-Starter:

- Agriculture;
- Commercial;
- Industry;
- Residential, and
- Transportation.

Each sector is contained in a separate pair of workbooks (BY/NT-<sect>) that are loaded into their corresponding scenarios in the TIMES-Starter database. Within each workbook the standard set of worksheets introduced earlier in Table 1 can be found. Unless otherwise noted, the demand for energy services is in petajoules (PJ).

5.4.1 Agriculture

The US9r model does not explicitly breakout the Agriculture sector. However, the Asian Development Bank Pakistan Integrated Energy Model project (Pak-IEM)[10] did breakout the agriculture sector into four services (Tractors, Irrigation, Other), with associated devices as shown in Figure 18.

Figure 18: Agriculture New Processes[11]

* **End-Use Services**		
	AWP	Agriculture Water Pumping
	ATH	Agriculture Tractors - Hauling
*	ATF	Agriculture Tractors - Farm Op.
	AOE	Agriculture Other Use
* **Quality**		
	-I	-Improved
	-S	-Standard
* **Tractor type**		
	-B	>55hp
	-S	<55hp
	-C	Combine
* **TECHNOLOGIES**		
* **Agriculture Water Pumping**		
	AWPOILDSL-S	Agriculture Water Pumping: Diesel to Agriculture-Standard
	AWPOILDSL-I	Agriculture Water Pumping: Diesel to Agriculture-Improved
	AWPELC-S	Agriculture Water Pumping: Electricity to Agriculture-Standard
	AWPELC-I	Agriculture Water Pumping: Electricity to Agriculture-Improved
* **Agriculture Tractors - Hauling**		
	ATHOILDSL-B-S	Agriculture Tractors - Hauling: Diesel to Agriculture>55hp-Standard
	ATHOILDSL-S-S	Agriculture Tractors - Hauling: Diesel to Agriculture<55hp-Standard
	ATHOILDSL-C-S	Agriculture Tractors - Hauling: Diesel to AgricultureCombine-Standard
* **Agriculture Tractors - Farm Op.**		
* **Agriculture Other Use**		
	AOEELC-S	Agriculture Other Use: Electricity to Agriculture-Standard
	AOEOILDSL-S	Agriculture Other Use: Diesel to Agriculture-Standard
*	AOEOILFOI-S	Agriculture Other Use: Fuel Oil to Agriculture-Standard

Note that tractors are setup to be able to service separate demands for farm operations and haulage according to the FLO_SHARs, which may need to be adjusted for a particular country. However, only a single Tractors demand is currently specified in the Starter model. If the user wants to separate farm operation from hauling then the ATF end-use service simply has to be uncommented in Col-A of the SETUP sheet in the BY template , and the FLO_SHARs added on the ProcData sheet. Also, the demand projections will need to be provided for each of the two tractor demand services. A snapshot of the Agriculture load sheet is shown in Figure 19.

[10] http://www.decisionwaregroup.com/index.html - International page.

[11] Note that *Existing and *Vintage have been physically removed from the SETUP, Items and Data sheets to make them less cluttered and cleaner, though they are present on the US9r source data worksheets.

Figure 19: Agriculture New Options Loadsheet

ProcSTARTER

Check Sheet | Name, ProcDesc, Units | CommIN | CommOUT

Parameter				*			NCAP_START	NCAP_TLIFE	NCAP_COST	NCAP_FOM	ACT_COST	NCAP_AFA-UP	FLO_SHAR-FX	FLO_SHAR-FX	ACT_EFF	ACT_EFF	ACT_EFF
Qualifier1													ATH	ATF	ACTGRP	ACTGRP	ACTGRP
Qualifier2													ANNUAL	ANNUAL	ANNUAL	ANNUAL	ANNUAL
	ProcName	ProcDesc	Proc Units	CommIN	CommOUT	Activity I/O	TID									2015	2020
*					ADE												
* new																	
	AWPOILDSL-S	Agriculture Water Pumping: Diesel to Agriculture-Standar	PJ,PJa	AGROILDSL			2015	15	10.7116	0.111	0.0555	0.0636			0.0924	0.0946	0.0968
					AWP												
	AWPOILDSL-I	Agriculture Water Pumping: Diesel to Agriculture-Improve	PJ,PJa	AGRELC			2015	15	32.2552	0.1110	0.0555	0.0636			0.1694	0.1734	0.1775
					AWP												
	AWPELC-S	Agriculture Water Pumping: Electricity to Agriculture-Stan	PJ,PJa	AGRELC			2015	15	10.7116	0.111	0.0555	0.0636			0.3749	0.3838	0.3927
					AWP												
	AWPELC-I	Agriculture Water Pumping: Electricity to Agriculture-Impr	PJ,PJa	AGRELC			2015	15	18.6276	0.1110	0.0555	0.1124			0.4388	0.4493	0.4597
					AWP												
	ADEOILDSL-B-S	Agriculture Other Use: Diesel to Agriculture>55hp-Standar	PJ,PJa	AGROILDSL			2015	15	12.0084	0.111	0.0555	0.1124			0.2625	0.2688	0.2750
					ATH								0.1799				
*					ATF									0.8201			
	ADEOILDSL-S-S	Agriculture Other Use: Diesel to Agriculture<55hp-Standar	PJ,PJa	AGROILDSL			2015	15	32.2552	0.111	0.0555	0.0636			0.2100	0.2150	0.2200
					ATH								0.1799				
*					ATF									0.0201			
	ADEOILDSL-C-S	Agriculture Other Use: Diesel to AgricultureCombine-Stanc	PJ,PJa	AGROILDSL			2015	15	18.6276	0.111	0.0555	0.1124			0.1575	0.1613	0.1650
					ATH												
	ADEELC-S	Agriculture Other Use: Electricity to Agriculture-Standard	PJ,PJa	AGRELC			2015	15	36.2072	0.111	0.0555	0.1235			1.0500	1.0750	1.1000
					ADE												
	ADEOILDSL-S	Agriculture Other Use: Diesel to Agriculture-Standard	PJ,PJa	AGROILDSL			2015	15	43.4487	0.111	0.0555	0.1164			1.0500	1.0750	1.1000
					ADE												

ANSv2-691-Home | SETUP | REGIONS | Commodities | Processes | CommData | ProcData_AGR | PIEM_AGR-Existing | PIEM_/ ...

As already noted, the BY template includes an EB sheet tied to the EB workbook, both have a SETUP and Commodity/Process declaration sheets. The NT template SETUP tab is linked directly to the corresponding BY sheet for the commodity and device names to help ensure consistency. The final sheet (ProcData_XPRCs) defines the sector fuel and emissions tracking processes (XAGR<fuel>) that link the supply commodities to the Agriculture sector, and is only found in the BY sheet. If new commodities not found in the original first year energy balance are needed for future years, as discussed in Section 6, the 0 on row-5 of the BY-AGR EB sheet for said fuel should be deleted, activating the fuel and associated XAGR<fuel> process.

Any Agriculture component may be eliminated by entering "*" in Col-A on the SETUP sheet. If there is a need to add a new device type, do so by copying a similar type of devices' name on SETUP then Process data blocks on the appropriate ProcData_* sheets. Most of the names are carefully built from $references to their components, so after copying only minor adjustments need to be done to, say, change a fuel or technology instance. However, if adding a new technology there will be no corresponding data on the source data sheets, so the appropriate numbers will need to be provided. Also, be sure when adding an existing device not yet in the database that the device also gets added to the Calibration sheet appropriately (by copy/inserting a similar device in the same group).

> **Warning**: be sure to adhere to the basic naming convention of the components (that is use the same approach and number of characters as for some other entry) or the ANSWER named TechFilters and VBE Sets may no long operate properly!

5.4.1.1 Calibration of the Initial Year

The agriculture sector is rather simplified with only demands for tractors, irrigation and other. Once fuels have been apportioned to those energy serices on the EB sheet the only other action required is to split the tractor demand between small and large tractors (or combines), as seen in Figure 20. When entering any of these device splits, when there is more than one competing device consuming the same fuel, shares are requested for all but one of them, with the remaining share calculated to ensure the service/fuel total is respected.

Figure 20: Agriculture Calibration Sheet

Agriculture Water Pumping	EFF	CF	FEC share	energy (PJ)	Energy (PJ)	Capacity (PJ/a)
Agriculture Water Pumping: Diesel to Agriculture- Existing	0.09	0.06	1	0	0.0000	0.00
Agriculture Water Pumping: Electricity to Agriculture- Exis	0.36	0.11	1	0.1246	0.0445	0.40
				0.1246	0.0445	
			from EB	0.1246		
			check if zero	0.0000		
				Final	Useful	Installed
Agriculture Tractors	EFF	CF	FEC share	energy (PJ)	Energy (PJ)	Capacity (PJ/a)
Agriculture Tractors: Diesel to Agriculture>55hp- Existing	0.25	0.12	0.3	0.10587	0.0265	0.21
Agriculture Tractors: Diesel to Agriculture<55hp- Existing	0.20	0.12	0.3	0.10587	0.0212	0.18
Agriculture Tractors: Diesel to AgricultureCombine- Existi	0.15	0.08	0.4	0.14116	0.0212	0.26
				0.3529	0.0688	
			from EB	0.3529		
			check if zero	0.0000		
				Final	Useful	Installed
Agriculture Other Use	EFF	CF	FEC share	energy (PJ)	Energy (PJ)	Capacity (PJ/a)
Agriculture Other Use: Electricity to Agriculture- Existing 0	1.00	1.00	1	0	0.0000	0.00
Agriculture Other Use: Diesel to Agriculture- Existing 00	1.00	1.00	1	0	0.0000	0.00
Agriculture Other Use: Fuel Oil to Agriculture- Existing 00	1.00	1.00	1	0	0.0000	0.00
				0.0000	0.0000	
			from EB	0.0588		
			check if zero	0.0588		

As discussed in Section 6, the work on the Calibration sheets in each BY workbook is the starting point for the calibration process. The cycle involves running the model (for just the first period if desired) and using the VBE calibration check workbook to see how well the model is aligning with the energy balance, returning to the BY Calibration sheets to device share assumptions as needed.

5.4.2 Commercial

The US9r Commercial sector demands are specified for the end-use applications listed in Figure 21, with each of these applications serviced by multiple (sometimes many) devices. In the case of heating/cooling, the Building type is appended to the demand root so that if additional building types are added they are properly distinguished in all the device names. As shown in the figure, there are various types of lighting applications, including CFLs, halogen, incandescent, LED, etc., with different wattage and vintages (year in which they become available). The situation is similar for the other sectors as well. As discussed in Section 10, these various lighting options need to be apportioned by the user according to the general situation in the area of study, otherwise the single most cost-effective option will dominate the service demand. The multiple vintages of a technology in the EPA MARKAL model are replaced by a single technology option by using the vintage feature in TIMES.

The Commercial sector is designed the same as the rest of the EPA US9r referenced templates, in that the SETUP sheet controls what is/is not included for the sector, and the ProcData_COM sheet links directly to its EPA_COM counterpart by means of VLOOKUP based upon the EPA device name grabbed from SETUP in Col-H. In the case of costs, they are converted according to the factor specified in the SETUP tab (inherited from the EB workbook). The names and descriptions employed are assembled on the SETUP sheet according to the components in Figure 21 combined with the commodity consumed.

Figure 21: Commercial Sector End-use Applications & Lighting Technology Types

Building Type & End-Use Application

* Sector Components		
* Building Types		
	B	
* Energy Services		
	CH	Commercial Heating
	CC	Commercial Cooling
	CWH	Commercial Water Heating
	CCK	Commercial Cooking
	CLT	Commercial Lighting
	CRF	Commercial Refrigeration
	COF	Commercial Office Equipment
	CPL	Commercial Public Lighting
	CME	Commercial Misc Energy

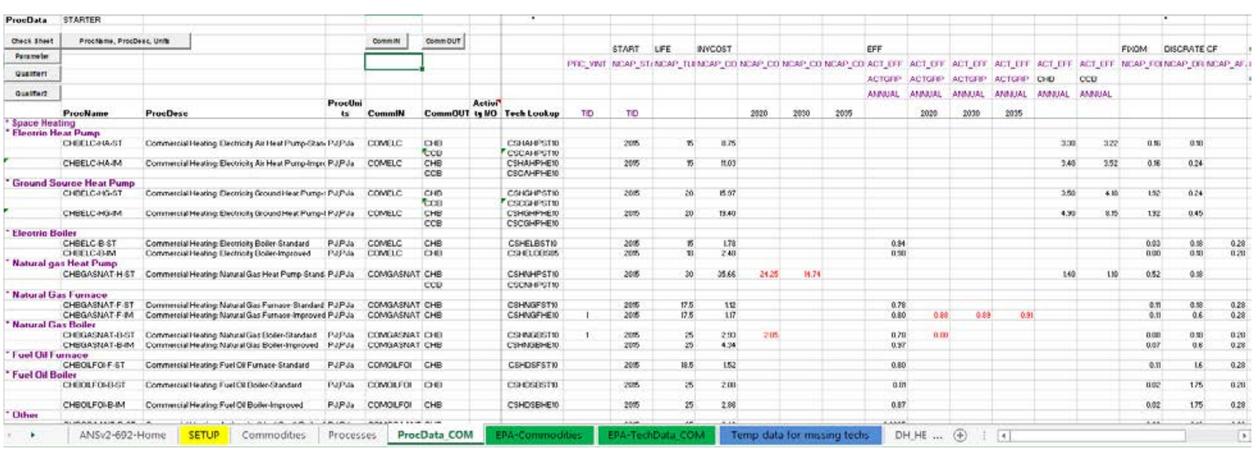
Lighting Technology Quality & Type

* Quality		
	AD	Advanced
	BE	Best
	IM	Improved
	ST	Standard
	X1	Existing1
* Lighting Type		
	-C-	CFL-
	-F-	Fluorescent-
	-H-	Halogen-
	-I-	Incandescent-
	-L-	LED-
	-D-	High Intensity Discharge-
	-R-	Reflector-

As discussed above, the BY template includes an EB sheet tied to the EB workbook, both the BY and NT templates have SETUP and Commodity/Process declaration sheets. The NT SETUP tab is linked directly to the corresponding BY sheet for the commodity and device names to help ensure consistency. The final sheet (ProcData_XPRCs) defines the sector fuel and emissions tracking processes (XCOM<fuel>) that link the supply commodities to the Commercial sector, and is only found in the BY sheet. If new commodities not found in the original first year energy balance are needed for future years, as discussed in Section 6, the 0 on row-5 of the BY-COM EB sheet for said fuel should be deleted, activating the fuel and associated XCOM<fuel> process.

One difference from MARKAL is that heat pumps are represented as a single device servicing both heating and cooling demands, with differing capacity factors and efficiencies. A snapshot of the Commercial load sheet, depicting the Lighting technology data, is shown in Figure 22. In the case of this example, using lighting, note that the units are in billion lumens (lbn-lum).

Figure 22: New Technology Commercial Loadsheet



Any Commercial component may be eliminated by entering "*" in Col-A on the SETUP sheet. If there is a need to add a new device type, do so by copying a similar type of devices' name on SETUP then Process data blocks on the appropriate ProcData_* sheets. Most of the names are carefully built from $references to their components, so after copying only minor adjustments need to be done to say change a fuel or technology instance. However, if adding a new technology there will be no corresponding data on the source data sheets, so the appropriate numbers will need to be provided. Also, be sure when adding an existing device not yet in the database that the device also gets added to the Calibration sheet appropriately (by copy/inserting a similar device in the same group).

> **Warning**: be sure to adhere to the basic naming convention of the components (that is use the same approach and number of characters as for some other entry) or the ANSWER named TechFilters and VBE Sets may no long operate properly!

5.4.2.1 Calibration of the Initial Year

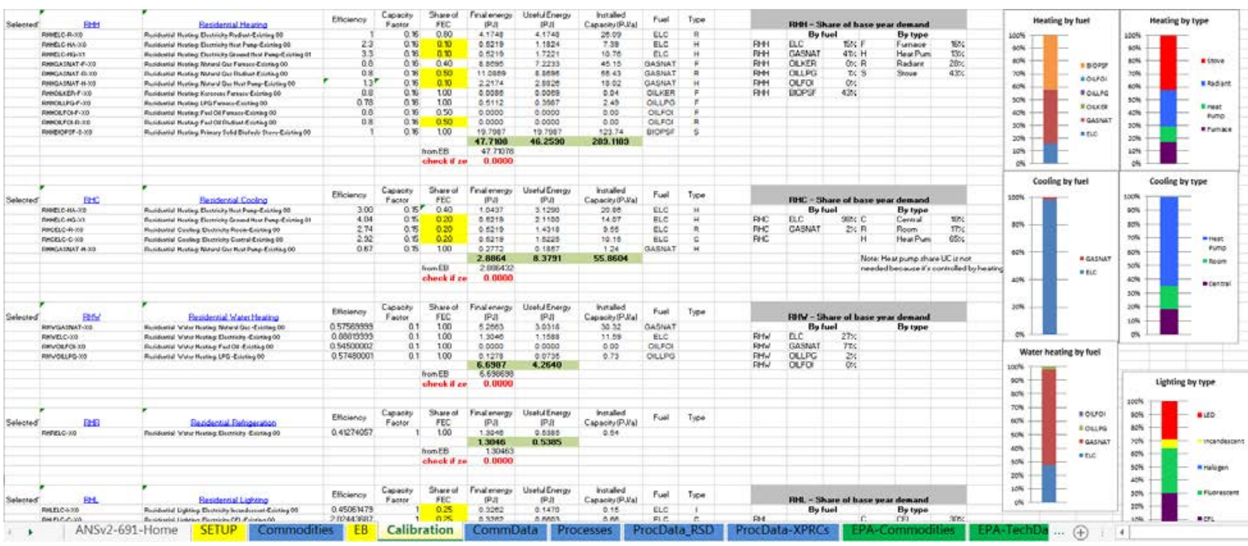
The Residential and Commerical sectors are very similar in terms of preparing and performing the calibration as for the most part they tend to have the same kinds energy services and devices types that meet them. Below in Figure 23 and Figure 24 the EB and Calibration sheets are shown, where the user input of the splits for the end-use services is done on the former and for the associated devices on the latter. When entering the device splits when there is more than one competing device consuming a fuel, shares are requested for all but one of them, with the remaining share calculated to ensure the service/fuel total is respected.

On the Calibration sheet, to the right of the calibration table, summary tables and graphs show the percentage of useful energy (end use service demand) provided by each fuel and/or device type. As these are end use service demand shares, they can be thought of in the Commercial/Residential sector as loosely the share of building type using each fuel/device type. As such, they can serve as feedback on the reasonableness of the fuel and device final energy shares the user has assigned. (For example, they may be compared with survey data on household energy/device use.) However, any changes needed in these service demand shares should be accomplished by adjusting the split of sector fuel consumption to the service demands on the EB or the final energy device shares in the Calibration table until the desired service demand shares are seen in the graphs/summary tables. These percentages also drive the Reference scenario guidance user constraints described in Section 10.

Figure 23: EB Sheet for Residential and Commercial

		COAANT	OILLPG	OILGSL	OILKER	OILDSL	OILFOI	GASNAT	BIOPSF	RNWGEO	RNWSOL	ELC	LTH	
PJ	Sector Name	Anthracite	LPG	Gasoline	Kerosene	Diesel	Fuel Oil	Natural Gas	Biomass	Geothermal	Solar	Electricity	Heat	Total of All Energy Sources
Residential	RSD	0	0.639	0	0.0086	0	0	27.7172	19.7987	0.208	0.0233	13.0463	0	61.4921
Split each by end-use														
RHH	Residential Heating		80%		100%			80%	100%			40%		
RHC	Residential Cooling							1%				20%		
RHW	Residential Water Heating		20%					19%				10%		
RHR	Residential Refrigeration											10%		
RHK	Residential Freezing													
RHL	Residential Lighting											10%		
RHO	Residential Other Appliances											10%		
	Residential Other Appliances - NGA													
	Residential Other Appliances - LPG													
	Check 100%	**0%**	**100%**	**0%**	**100%**	**0%**	**0%**	**100%**	**100%**	**0%**	**0%**	**100%**	**0%**	
FEC by end-use														
RHH	Residential Heating	0	0.5112	0	0.0086	0	0	22.17376	19.7987	0	0	5.21852	0	**47.71078**
RHC	Residential Cooling	0	0	0	0	0	0	0.277172	0	0	0	2.60926	0	**2.886432**
RHW	Residential Water Heating	0	0.1278	0	0	0	0	5.266268	0	0	0	1.30463	0	**6.698698**
RHR	Residential Refrigeration	0	0	0	0	0	0	0	0	0	0	1.30463	0	**1.30463**
RHK	Residential Freezing	0	0	0	0	0	0	0	0	0	0	0	0	**0**
RHL	Residential Lighting	0	0	0	0	0	0	0	0	0	0	1.30463	0	**1.30463**
RHO	Residential Other Appliances	0	0	0	0	0	0	0	0	0	0	1.30463	0	**1.30463**
	Residential Other Appliances - NGA	0	0	0	0	0	0	0	0	0	0	0	0	**0**
	Residential Other Appliances - LPG	0	0	0	0	0	0	0	0	0	0	0	0	**0**
	Total	**0**	**0.639**	**0**	**0.0086**	**0**	**0**	**27.7172**	**19.7987**	**0**	**0**	**13.0463**	**0**	**61.2098**
	Check diff from FEC	0	0	0	0	0	0	0	0	0.208	0.0233	0	0	0.2823

Figure 24: Calibration Sheet for Residential and Commercial



As discussed in Section 6, the work on the Calibration sheets in each BY workbook is the starting point for the calibration process. The cycle involves running the model (for just the first period if desired) and using the VBE calibration check workbook to see how well the model is aligning with the energy balance, returning to the BY Calibration sheets to devices shares assumptions as needed.

5.4.3 Industry and Oil Refinery

5.4.3.1 Overview

Because the Industrial sector is comprised of sub-sectors that are much more unique than the common residential and commercial end-use services, a generalized industry sector cannot be pre-assembled in the Starter model. Instead, what is provided is a process for assembling a country-specific industry sector from a combination of EPA and local sources of data.

The approach to modeling the Industrial sector is based on the EPA approach where each industry sub-sector has a single demand, which corresponds to that sub-sector's activity (output), and a single demand device, which requires specific end-use services, such as process heat, machine drive, etc., to produce a unit of industrial output.

The Starter model energy balance structure is based upon the IEA energy balance categories for Non-OECD countries, which as shown in Table 7 has 13 entries. However, the EPA database contains end-use service shares and technology characterizations for 19 industry sub-sectors, and the overlap between these is illustrated in Table 7 under the EPA header. For example, where EPA has Primary and Secondary steel, IEA has only Iron and Steel. Therefore, the process for building an industry sector in the Starter model begins with identification and mapping of the country's industry sub-sectors, as defined in their national energy balance, to the EPA sub-sectors. Local industry sub-sector experts will need to be consulted to ensure accurate characterization of their particular sub-sector.

The following examples are provided to help illustrate mapping decisions.

1. The energy balance has one entry for Iron and steel: If a primary steel industry exists, look for data on the activity split between primary and secondary (e.g., recycled steel for rebar) production. If no primary steel industry exists, use the Secondary steel end-use service shares and technology characterizations.
2. A similar approach can be taken with Non-ferrous metals. If primary aluminum production exists, look for data on the activity split between primary and secondary production and other metals (e.g., copper, nickel, tin) if they exist. Use the end-use service shares and technology characterizations for each of the sub-sector processes that have activity.
3. Similarly for Non-metallic minerals, if a Glass industry exists, look for activity data on glass and cement (which will exist in most countries) to determine their share of total Non-metallic minerals activity. Use the end-use service shares and technology characterizations for each of the sub-sector processes that have activity.
4. The Paper, pulp and print sub-sector is not as simple as the other sub-sectors, because pulp and paper facilities are often integrated. If activity shares exist, then these can be used, but if not an integrated set of end-use service shares and technology characterizations have been synthesized from the EPA data.

Table 7: Mapping of Starter and EPA Industry Subsectors

STARTER	EPA				
Iron and steel	Primary Steel	Secondary Steel			
Chemicals and petrochemicals	Organic Chemicals	Inorganic Chemicals	Plastics, fibers, resins	Agricultural Chemicals	Other Chemicals
Non-ferrous metals	Primary Aluminum	Secondary Aluminum	Other metals		
Non-metallic minerals	Cement	Glass	Other non-metals		
Transport equipment	Other				

Machinery	Other				
Mining and quarrying	Other				
Food and tobacco	Food				
Paper, pulp and print	Pulp	Paper	Paperboard	Other pulp & paper	
Wood and wood products	Other				
Construction	Other				
Textile and leather	Other				
Non-specified	Other				

The Industrial sector is handled in a similar manner to the rest of the EPA US9r referenced templates, in that the SETUP sheet controls what is and is not included for the sector. But because the sector is more complex and requires more local information than the other demand sectors, this Guideline document only provides an example of the set-up of one sector (Iron and Steel) with all other industry energy use incorporated into an Other Industry sector. As is the case with the other TIMES-Starter sector workbooks the ProcData_<subsector> sheets link directly to their EPA-TechData_<subsector> counterpart via VLOOKUPs, converting costs as specified on the SETUP sheet.

The Starter IND templates include placeholders for the following Industry subsectors, using the naming conventions shown in Table 8. Following this example for the Iron and Steel subsector, other sub-sectors can be activated by removing the * from Col-A of the Set-up tab and by adding the existing technology and new technology options for that subsector into new tabs in the BY and NT templates, as described more below.

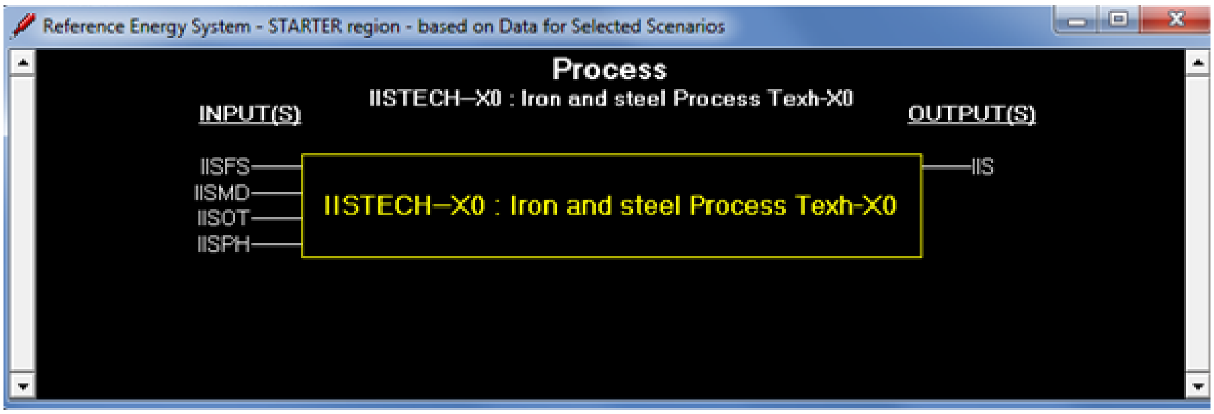
Table 8: Industry Subsector Options

ID	Description
IIS	Iron and steel
ICH	Chemical and petrochemical
INF	Non-ferrous metals
INM	Non-metallic minerals
ITE	Transport equipment
IMC	Machinery
IMM	Mining and quarrying
IFB	Food and tobacco
IPP	Paper, pulp and print
IWP	Wood and wood products
ICN	Construction
ITX	Textile and leather
IOT	Other
IFE	Industry Other (temp) - All

5.4.3.2 Configuring Industry Sub-sectors – Iron & Steel Example

This example of the Iron and Steel (IIS) industry is fully established in the TIMES-Starter, and the associated BY, NT and UC templates are discussed here. For the IIS sub-sector, there is a single demand, which corresponds to industry activity, and a single demand device (IISTECH-X0) which draws on each of the end-use services (PH-process heat, MD-motor drive, FS-feedstocks and OT-Facilities/Other) needed for that sector to deliver a unit of industrial output, as shown in Figure 25.

Figure 25: Industry – Steel End-use Services



The energy carriers used by the IIS subsector can be identified from the energy balance, but local information is then needed to determine what portion of these energy carriers are used for process heat facilities, motor drive and feedstocks. Subsector data should be used where available and expert judgment used in its absence. As shown below for IIS in the excerpt from the Setup tab of the BY-IND template, an existing technology has been characterized for each non-zero energy carrier/end-use combination, and the corresponding EPA technology identified in the EPA Tech column.

* Iron and Steel		
* Techs by fuel and end-use application		EPA Tech
IISCOAOBCPH-X0	Industry: Iron and steel - Bituminous (Brown Coal) -Process heat- Existing 00	IMSEPRHCOA
IISCOALIGPH-X0	Industry: Iron and steel - Lignite -Process heat- Existing 00	IMTEPRHCOA
IISCOAORGFS-X0	Industry: Iron and steel - Other coal product -Feedstock- Existing 00	IMSEFEDCOK
IISOILGSLOT-X0	Industry: Iron and steel - Gasoline -Facilities/Other- Existing 00	IMSEFACDST
IISOILKEROT-X0	Industry: Iron and steel - Kerosene -Facilities/Other- Existing 00	IMSEFACDST
IISOILDSLOT-X0	Industry: Iron and steel - Diesel -Facilities/Other- Existing 00	IMSEFACDST
IISOILFOIOT-X0	Industry: Iron and steel - Fuel Oil -Facilities/Other- Existing 00	IMTEOHTRFL
IISGASNATPH-X0	Industry: Iron and steel - Natural Gas -Process heat- Existing 00	IMTEPRHNGA
IISGASNATOT-X0	Industry: Iron and steel - Natural Gas -Facilities/Other- Existing 00	IMTEFACNGA
IISBIOPSFOT-X0	Industry: Iron and steel - Primary Solid Biofuels -Facilities/Other- Existing 00	IMTEOHTBIO
IISELCPH-X0	Industry: Iron and steel - Electricity -Process heat- Existing 00	IMTEPRHELC
IISELCMD-X0	Industry: Iron and steel - Electricity -Machine Drive- Existing 00	IMTEMDRELC
IISELCOT-X0	Industry: Iron and steel - Electricity -Facilities/Other- Existing 00	IMTEFACELC

Similarly, in the NT-IND template, both Standard and Improved new technology options are generated for the above Existing technology options along with any new energy carrier/end-use application combinations not currently existing but envisioned for the future (where the user needs to " " out the 0 in the BY-IND EB sheet to activate a commodity not in the current energy balance that is to be available in the future).

The next step in development of the IIS subsector is calibration of the Existing technologies by factoring in the efficiency of the end-use devices. Typical boiler efficiencies are used for the process heat applications, but for the other end-uses (feedstocks, facilities, and motor drive) the EPA database uses efficiency =1, so that only final energy is tracked for these end-use applications. Where end-use efficiency measures are desired, these can be modelled as conservation technologies that reduce final energy use when purchased and deployed.

The Calibration sheet determines the useful energy demand and capacity of existing technologies, and determines the proportions of each IIS end-use service needed to produce a unit of output. These values are used in the template to determine the fixed activity shares as shown below.

	Scenario	Parameter		Region	Process	CommGroup	TimeSlice	I/E	2013
M	BY-IND	ACT_FLO	?	STARTER	IISTECH-X0	IISFS	ANNUAL	0	0.0682
M	BY-IND	ACT_FLO	?	STARTER	IISTECH-X0	IISMD	ANNUAL	0	0.1321
M	BY-IND	ACT_FLO	?	STARTER	IISTECH-X0	IISOT	ANNUAL	0	0.1002
M	BY-IND	ACT_FLO	?	STARTER	IISTECH-X0	IISPH	ANNUAL	0	0.6995

For each of these end-use services there are a number of technology/energy carrier options, which are shown in Figure 26 for IIS Process heat applications. Here we can see that the IIS process heat demand can be met by existing, standard new and improved new technologies consuming coal, natural gas, electricity and process heat from cogeneration plants. A longer list of technology options is available to meet the facility/other services demand, as shown in Figure 27, as well as for feedstocks and motor drive demands.

Figure 26: Iron & Steel – Technologies for Process Heat Production

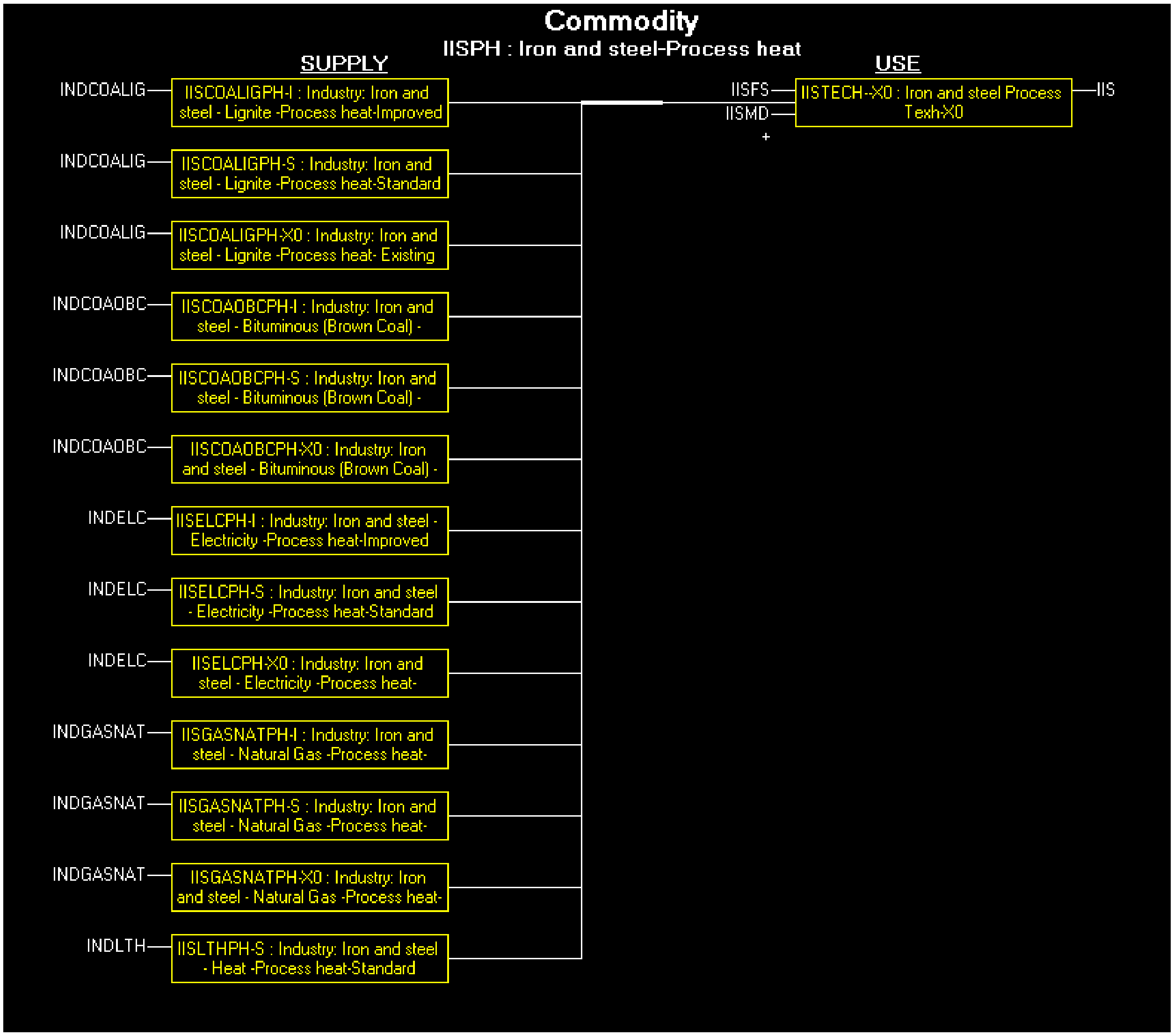
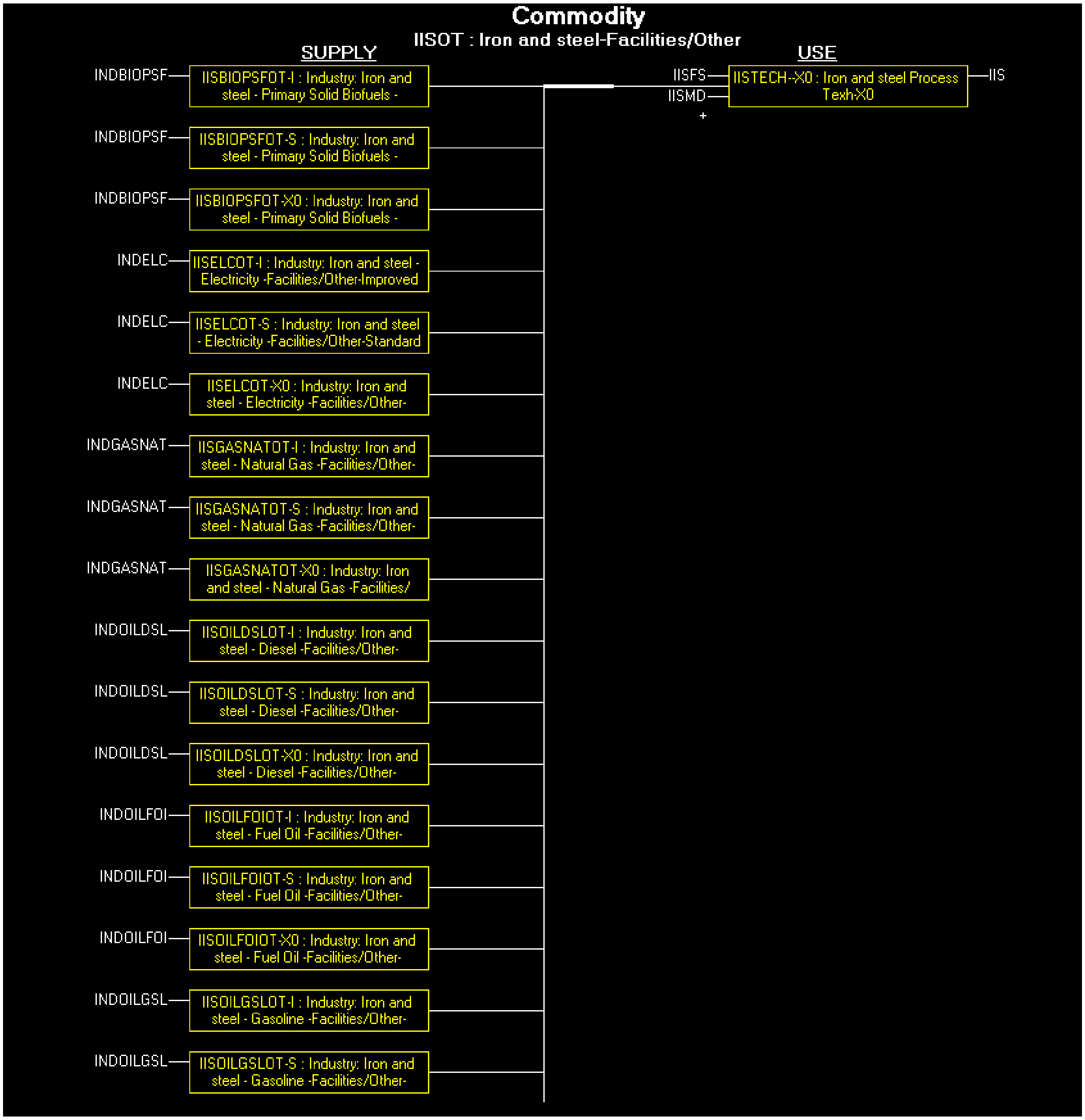


Figure 27: Iron & Steel – Technologies for Facilities/Other End-uses



The final step in establishing the IIS industry subsector is the enumeration of user constraints (UCs) for the sub-sector fuel shares, which will provide guidelines for the allowed changes in the share of a specific energy carrier. The starting shares (2015) are linked to the BY shares developed in the BY template on the calibration sheet, as seen in Figure 28. The user must then decide if each energy carriers/end-use application needs a bound. UP bounds will limit growth, while LO bounds will limit the decline of a technology.

Figure 28: Iron & Steel – UCs to Guide Future Fuel Shares

TS&TID DATA STARTER

Check Sheet | Parameter | Arg1 | Arg2 | Arg3 | Arg4 | Arg5 | Arg6 | I/E Opt

Populate DataYears

	LO	UP
Fuel Relaxation Factor	10%	10%
Tech Relaxation Factor	10%	10%

	AD	BE	IM
Max 2050 share	10%	20%	30%

Parameter	Constraint Name	EQ Side	Process or TechFilter	Commodity	Timeslice	Type	I/E Opt or Value	2013	2015	2020	2030	2040	2050	
* Iron & Steel - Facility														
UCRULE_MARK	IIS-OT-F-GSL-LO	-	IIS-OT-F-GSL	IISOT	-	LO	5		0.000				0.000	Pat DeLaquil: Replace calculated value with local data where available.
UCRULE_MARK	IIS-OT-F-KER-LO	-	IIS-OT-F-KER	IISOT	-	LO	5		0.000				0.000	
UCRULE_MARK	IIS-OT-F-DSL-LO	-	IIS-OT-F-DSL	IISOT	-	LO	5		0.000				0.000	
UCRULE_MARK	IIS-OT-F-FOI-LO	-	IIS-OT-F-FOI	IISOT	-	LO	5		0.013				0.013	Maintained at constant share
UCRULE_MARK	IIS-OT-F-GAS-UP	-	IIS-OT-F-GAS	IISOT	-	UP	5		0.108				0.208	
UCRULE_MARK	IIS-OT-F-PSF-LO	-	IIS-OT-F-PSF	IISOT	-	LO	5		0.000				0.000	
UCRULE_MARK	IIS-OT-F-ELC-UP	-	IIS-OT-F-ELC	IISOT	-	UP	5		0.879				0.879	Maintained at constant share
* Iron & Steel - Process Heat														
UCRULE_MARK	IIS-PH-F-OBC-LO	-	IIS-PH-F-OBC	IISPH	-	LO	5		0.005				0.000	
UCRULE_MARK	IIS-PH-F-LIG-LO	-	IIS-PH-F-LIG	IISPH	-	LO	5		0.003				0.000	
UCRULE_MARK	IIS-PH-F-GAS-UP	-	IIS-PH-F-GAS	IISPH	-	UP	5		0.043				0.143	
UCRULE_MARK	IIS-PH-F-ELC-UP	-	IIS-PH-F-ELC	IISPH	-	UP	5		0.950				0.950	Maintained at constant share

ANSv1-691-Home | ITEMS | TS&TID DATA-UC

5.4.3.3 Other Industry Subsectors

For the TIMES-Starter, the industry energy use from remaining subsectors is aggregated into a temporary all other industry demand (IFE). For this "other" category, only final energy shares for electricity and fuels are modeled. Once the local industry subsectors are removed from other and described by their existing and new technologies, this approach will be appropriate for the remaining other industry demand. For this example of the other industry sub-sector, the Industry Other (temp) demand (IFE) is met by a combination of fuels and electricity, which have market shares of 67.2% and 32.8% respectively. Within the fuels group, there are flow shares to apportion the fuels comprising the 67.2% of total energy demand, as shown in Table 9. These shares are set in the BY-IND template on the ProcData_IND(temp) sheet and in the Starter templates, kept constant over the planning horizon. However, the composition of fuels and electricity may be adjusted over time if the composition of the Other subsector is expected to change over time.

Figure 29: Industry – End-use Service Alignment between US9r and Country

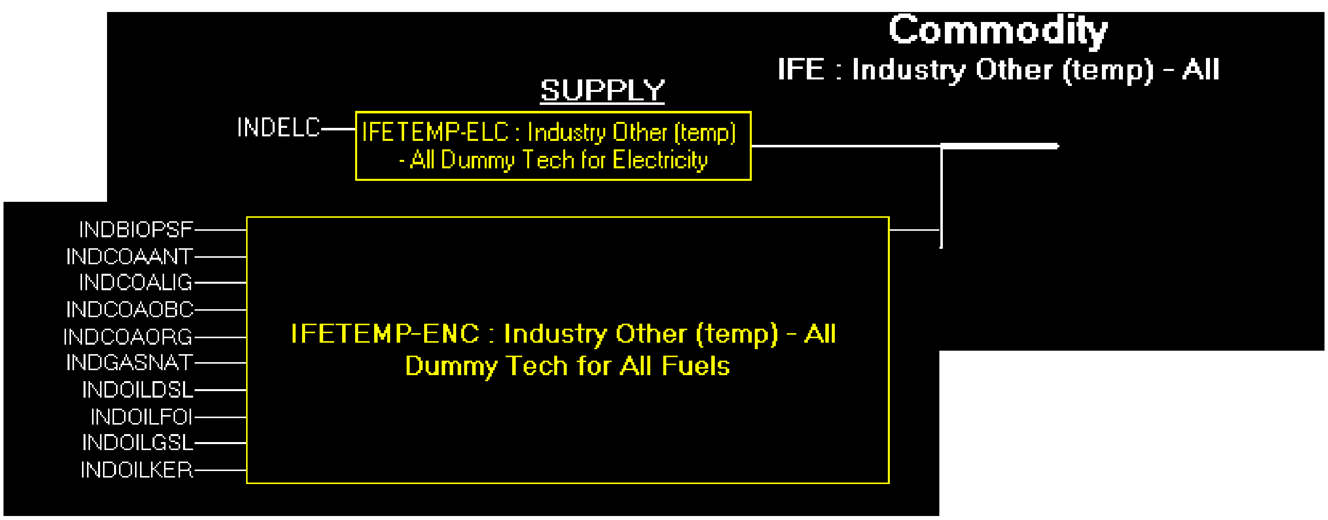


Table 9: Starter Industry Subsector Options

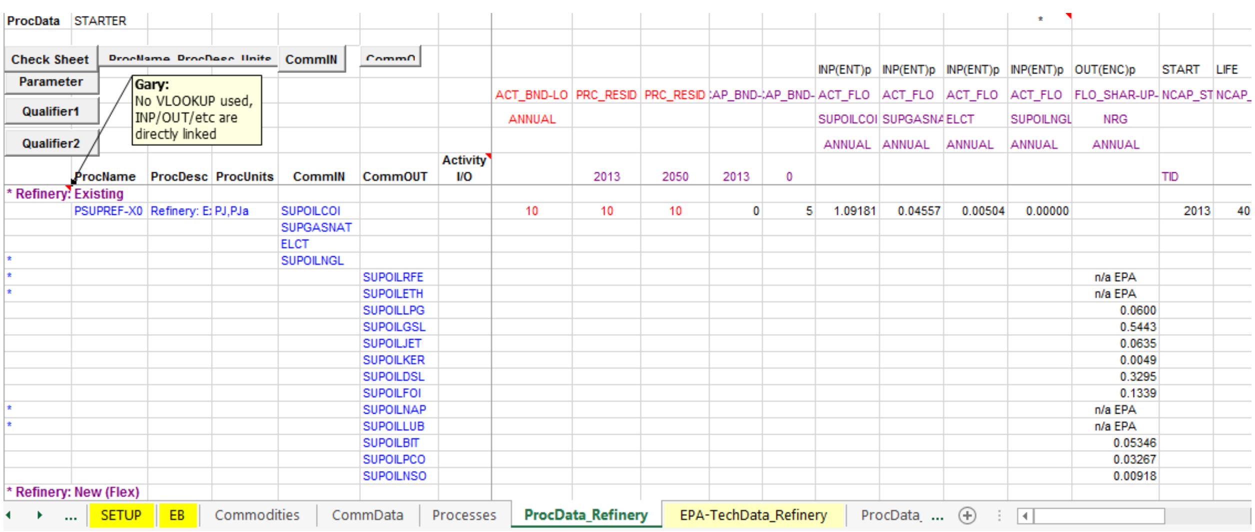
Energy Carrier	Flow Share	Market Share
INDCOAANT	1.20%	
INDCOAOBC	9.48%	
INDCOALIG	37.74%	
INDCOAORG	21.05%	
INDOILKER	0.05%	
INDOILDSL	13.62%	
INDOILFOI	0.25%	
INDGASNAT	14.53%	
IND<ent>		67.19%
INDELC		32.81%

5.4.4 Simple Flexible Oil Refinery

The AT2-Starter_RefineryO template is setup with an existing and a new limit refineries established based upon the US9r allocation for PADD2 in terms of costs and output mix maximum shares for each product in the slate (corresponding to the OUT(ENC)p/FLO_SHAR(up)), anticipating that the user will need to adjust these for their historic/expected situation in there. The refinery is output normalized, where 1 PJ of the output slate requires 1.09181PJ crude oil, 0.04557PJ natural gas, and 0.00504PJ electricity. For the existing refinery the current installed capacity (PRC_RESID) should be updated and perhaps the first period total output, as shown in red in Figure 30.

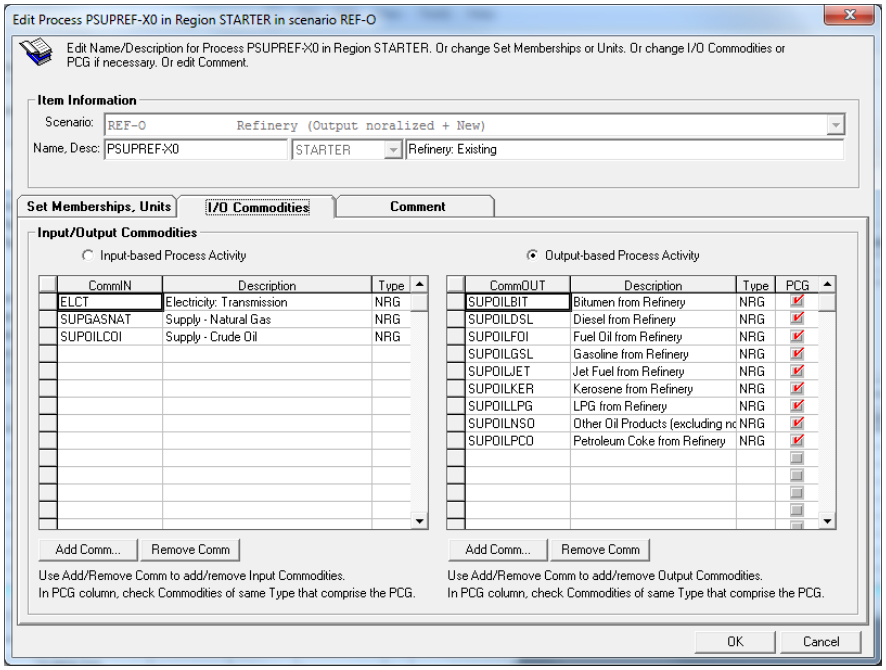
The Setup and Commodities sheet of the Refinery template link to the supply (SUP) template to get the names, descriptions, units and set membership of the commodities involved in the refinery operation.

Figure 30: Refinery Template



In ANSWER the Refinery setup with respect to the PCG (output) and SPG (input) can be seen nicely on the Edit I/O Commodities form, as seen in Figure 31.

Figure 31: Refinery PCG



5.4.4.1 *Calibration of the Initial Year*

To check the calibration of the refinery, that is the production slate or product mix in the first period, use the VEDA-BE Refinery Product Mix table, adjusting the FLO_SHAR in the 1st period as necessary – perhaps moving to FLO_SHAR(FX) for said period, then allowing more flexibility in the later years.

5.4.5 Residential

The structure of the Residential sector templates is very similar to those of the Commercial sector, where the list of energy service demands are defined for a set of end-use applications, as can be seen in Figure 32, with each of these applications serviced by multiple (sometimes many) devices. The energy service, building type, fuel consumed and device type are combined to form the name (and description) of each of the options. In the case of heating/cooling, the Building type is appended to the demand root so that if additional building types are added they are properly distinguished in all the device names. Figure 33 demonstrates this by listing some of the devices for Residential space heating as found in US9r. The layout of devices is similar for the other end-use applications. These various heating/cooling options need to be apportioned by the user according to the general situation in the area of study, otherwise the single most cost-effective option will dominate the service demand. The multiple vintages of a technology in the EPA MARKAL model are replaced by a single technology option by using the vintage feature in TIMES, and heat pumps are represented by a single technology in TIMES.

Figure 32: Residential End-Uses & Heating Technology Types

Building Type & End-Use Applications	Heating Technology Types

* **Building Types**		
	H	
* **Energy Services**		
	RHH	Residential Heating
	RHC	Residential Cooling
	RHW	Residential Water Heating
	RHR	Residential Refrigeration
*	RHK	Residential Freezing
	RHL	Residential Lighting
	RHO	Residential Other Appliances

* **Heating Device Type**		
	-F-	Furnace-
	-H-	Heat Pump-
	-R-	Radiant-
	-S-	Stove-

Figure 33: Residential Heating Technologies

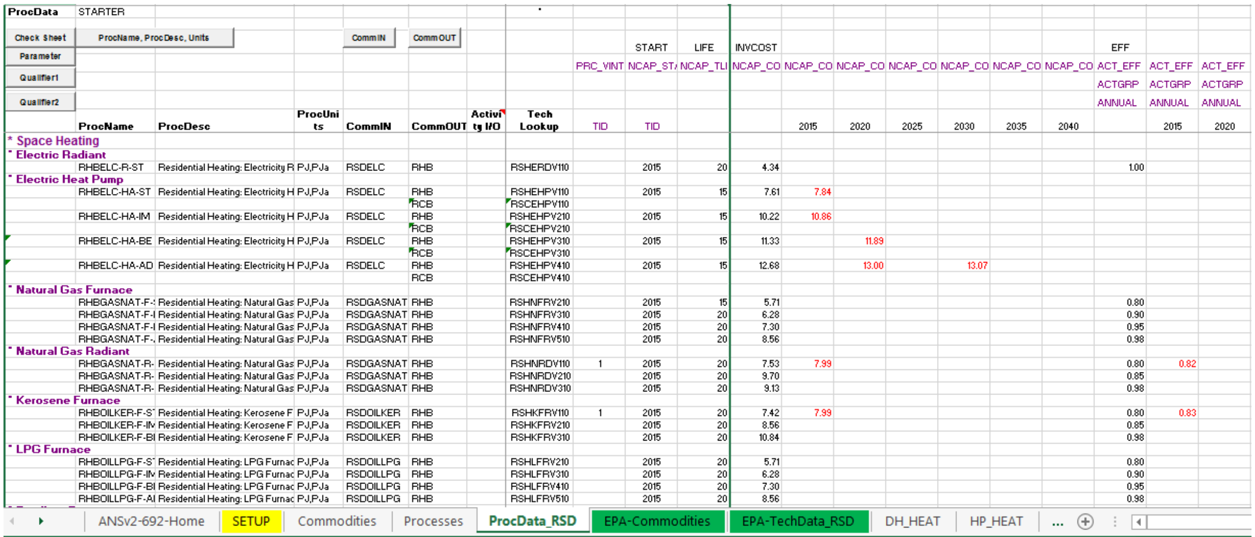
* **Space Heating**		
* **Electric Radiant**		
	RHHELC-R-ST	Residential Heating: Electricity Radiant-Standard
* **Electric Heat Pump**		
	RHHELC-HA-ST	Residential Heating: Electricity Heat Pump-Standard
	RHHELC-HA-IM	Residential Heating: Electricity Heat Pump-Improved
	RHHELC-HA-BE	Residential Heating: Electricity Heat Pump-Best
	RHHELC-HA-AD	Residential Heating: Electricity Heat Pump-Advanced
* **Natural Gas Furnace**		
	RHHGASNAT-F-ST	Residential Heating: Natural Gas Furnace-Standard
	RHHGASNAT-F-IM	Residential Heating: Natural Gas Furnace-Improved
	RHHGASNAT-F-BE	Residential Heating: Natural Gas Furnace-Best
	RHHGASNAT-F-AD	Residential Heating: Natural Gas Furnace-Advanced
* **Natural Gas Radiant**		
	RHHGASNAT-R-ST	Residential Heating: Natural Gas Radiant-Standard
	RHHGASNAT-R-IM	Residential Heating: Natural Gas Radiant-Improved
	RHHGASNAT-R-BE	Residential Heating: Natural Gas Radiant-Best
* **Kerosene Furnace**		
	RHHOILKER-F-ST	Residential Heating: Kerosene Furnace-Standard
	RHHOILKER-F-IM	Residential Heating: Kerosene Furnace-Improved
	RHHOILKER-F-BE	Residential Heating: Kerosene Furnace-Best

* **LPG Furnace**		
	RHHOILLPG-F-ST	Residential Heating: LPG Furnace-Standard
	RHHOILLPG-F-IM	Residential Heating: LPG Furnace-Improved
	RHHOILLPG-F-BE	Residential Heating: LPG Furnace-Best
	RHHOILLPG-F-AD	Residential Heating: LPG Furnace-Advanced
* **Distillate Furnace**		
	RHHOILFOI-F-ST	Residential Heating: Fuel Oil Furnace-Standard
	RHHOILFOI-F-IM	Residential Heating: Fuel Oil Furnace-Improved
	RHHOILFOI-F-BE	Residential Heating: Fuel Oil Furnace-Best
* **Distillate Radiant**		
	RHHOILFOI-R-ST	Residential Heating: Fuel Oil Radiant-Standard
	RHHOILFOI-R-IM	Residential Heating: Fuel Oil Radiant-Improved
	RHHOILFOI-R-BE	Residential Heating: Fuel Oil Radiant-Best
* **Wood**		
	RHHBIOPSF-S-ST	Residential Heating: Primary Solid Biofuels Stove-Standard
* **Ground Source Heat Pump**		
	RHHELC-HG-ST	Residential Heating: Electricity Ground Source Heat Pump-Standard
	RHHELC-HG-IM	Residential Heating: Electricity Ground Source Heat Pump-Improved
* **Natural Gas Heat Pump**		
*	RHHGASNAT-H-ST	Residential Heating: Natural Gas Heat Pump-Standard
*	RHHGASNAT-H-IM	Residential Heating: Natural Gas Heat Pump-Improved

As noted above, the BY template includes an EB sheet tied to the EB workbook, both the BY and NT templates have SETUP and Commodity/Process declaration sheets. The NT SETUP tab is linked directly to the corresponding BY sheet for the commodity and device names to help ensure consistency. The final sheet (ProcData_XPRCs) defines the sector fuel and emissions tracking processes (XRSD<fuel>) that link the supply commodities to the Residential sector, and is only found in the BY sheet. If new commodities not found in the original first year energy balance are needed for future years, as discussed in Section 6, the 0 on row-5 of the BY-RSD EB sheet for said fuel should be deleted, activating the fuel and associated XRSD<fuel> process.

The Residential sector is handled the same as the rest of the EPA US9r referenced templates, in that the SETUP sheet controls what is/is not included for the sector, and the ProcData_RSD sheet links directly to their EPA_RSD counterpart via VLOOKUP, converting costs as specified on the SETUP sheet. One difference from MARKAL is that heat pumps are represented as a single device servicing both heating and cooling demands, with differing capacity factors and efficiencies. A snapshot of the Residential load sheet is shown in Figure 34. All the residential service demands are in petajoules, with the exception of lighting in billion lumens (lbn-lum).

Figure 34: Residential New Technology Loadsheet



Any Residential component may be eliminated by entering "*" in Col-A on the SETUP sheet. If there is a need to add a new device type, do so by copying a similar type of devices' name on SETUP then Process data blocks on the appropriate ProcData_* sheets. Most of the names are carefully built from $references to their components, so after copying only minor adjustments need to be done to say change a fuel or technology instance. However, if adding a new technology there will be no corresponding data on the source data sheets, so the appropriate numbers will need to be provided. Also, be sure when adding an existing device not yet in the database that the device also gets added to the Calibration sheet appropriately (by copy/inserting a similar device in the same group).

> **Warning**: be sure to adhere to the basic naming convention of the components (that is use the same approach and number of characters as for some other entry) or the ANSWER named TechFilters and VBE Sets may no long operate properly!

5.4.5.1 Calibration of the Initial Year

The Residential and Commerical sectors are very similar in terms of preparing and performing the calibration as for the most part they tend to have the same kinds energy services and devices types that meet them. See Section 5.4.2.1 for further explanation and examples.

As discussed in Section 6, the work on the Calibration sheets in each BY workbook is the starting point for the calibration process. The cycle involves running the model (for just the first period if desired) and using the VBE calibration check workbook to see how well the model is aligning with the energy balance, returning to the BY Calibration sheets to devices shares assumptions as needed.

5.4.6 Transportation

The EPA US9r database contains an extensive transportation sector database, which is provided in its entirety. Transportation demands are expressed in terms of Petajoules, vehicle miles traveled, passenger-miles and tonne-miles in US9r, converted internally in the templates to kilometers on the ProcData sheets as specified on the SETUP tab. The transportation demands, along with the types of vehicles modelled are shown in Figure 35. As discussed below, these various competing vehicles need to be apportioned by the user according to the general situation in the area of study, otherwise the single most cost-effective option will dominate the service demand. The multiple vintages of a technology in the EPA MARKAL model are replaced by a single technology option by using the vintage feature in TIMES.

Figure 35: Transportation Modes & Technology Classes

Transport Demands by Mode

* Transport Services		
* Light Duty		
	TLD	Transport: Light Duty Vehicles
* Heavy Duty		
	TAI	Transport: Air
	TBU	Transport: Bus
	TMD	Transport: Medium Duty Trucks
	THS	Transport: HDV Short Haul
	THL	Transport: HDV Long Haul
	TSH	Transport: Ship
	TRF	Transport: Rail - Freight
	TRP	Transport: Rail - Passanger
	TCT	Transport: Commercial Truck
* Off Road		
	TOH	Transport: Off-road

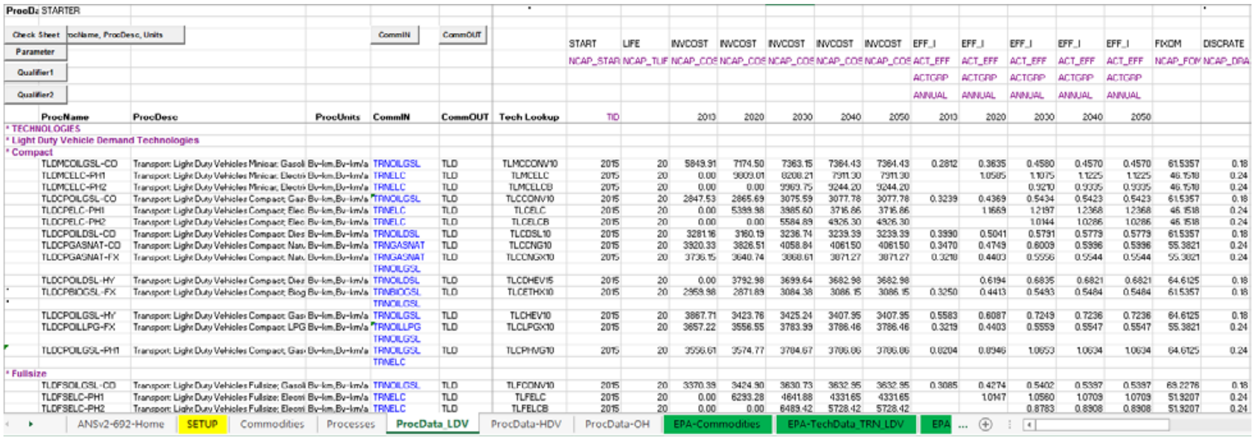
Vehicle Classes

* LDV Vehicle Class		* Technology Type	
CP	Compact	AD	Advanced
FS	Fullsize	CO	Conventional
LS	Large SUV	FX	Flex-fuel
MC	Minicar	HY	Hybrid
MV	Minivan	IM	Improved
PU	Pickup	PH	Plug-in
SS	Small SUV	SM	SmartWay
* Heavy Duty Truck Class		* Passanger Rail Category	
LH	Long haul	CO	Commuter
SH	Short haul	IC	Intercity
* Aviation		SS	Subways and Streetcars
GA	General aviation		
PA	Passanger		

As discussed above the BY template includes an EB sheet tied to the EB workbook, both the BY and NT templates have SETUP and Commodity/Process declaration sheets. The NT SETUP tab is linked directly to the corresponding BY sheet for the commodity and device names to help ensure consistency. Separate Process Data loadsheets are provided for light duty vehicles (LDV), heavy duty vehicles (HDV) and off-highway (OH) use. The final sheet (ProcData_XPRCs) defines the sector fuel and emissions tracking processes (XTRN<fuel>) that link the supply commodities to the Transportation sector, and is only found in the BY sheet. If new commodities not found in the original first year energy balance are needed for future years, as discussed in Section 6, the 0 on row-5 of the BY-TRN EB sheet for said fuel should be deleted, activating the fuel and associated XTRN<fuel> process.

The Transportation sector is handled the same as the rest of the EPA US9r referenced templates, in that the SETUP sheet controls what is/is not included for the sector, and the ProcData_TRN sheet links directly to their EPA_TRN counterpart via VLOOKUP, converting costs as specified on the SETUP sheet. A snapshot of the LDV load sheet is shown in Figure 36.

Figure 36: New Light Duty Vehicles Loadsheet



ProcDa	STARTER																			
Check Sheet	ocName, ProcDesc, Units			CommIN	CommOUT		START	LIFE	INVCOST	INVCOST	INVCOST	INVCOST	INVCOST	EFF_I	EFF_I	EFF_I	EFF_I	EFF_I	FIXOM	DISCRATE
Parameter							NCAP_STAR	NCAP_TLIF	NCAP_COS	NCAP_COS	NCAP_COS	NCAP_COS	NCAP_COS	ACT_EFF	ACT_EFF	ACT_EFF	ACT_EFF	ACT_EFF	NCAP_FOM	NCAP_DRA
Qualifier1														ACTGRP	ACTGRP	ACTGRP	ACTGRP	ACTGRP		
Qualifier2														ANNUAL	ANNUAL	ANNUAL	ANNUAL	ANNUAL		
	ProcName	ProcDesc	ProcUnits	CommIN	CommOUT	Tech Lookup	TID		2013	2020	2030	2040	2050	2013	2020	2030	2040	2050		
* TECHNOLOGIES																				
* Light Duty Vehicle Demand Technologies																				
* Compact																				
	TLDMCOILGSL-CO	Transport: Light Duty Vehicles Minicar: Gasoli	Bv-km,Bv-km/a	TRNOILGSL	TLD	TLMCCONV10	2015	20	5849.91	7174.50	7363.15	7384.43	7384.43	0.2812	0.3635	0.4580	0.4570	0.4570	61.5357	0.18
	TLDMCELC-PH1	Transport: Light Duty Vehicles Minicar: Electri	Bv-km,Bv-km/a	TRNELC	TLD	TLMCELC	2015	20	0.00	9809.01	8208.21	7911.30	7911.30		1.0585	1.1075	1.1225	1.1225	46.1518	0.24
	TLDMCELC-PH2	Transport: Light Duty Vehicles Minicar, Electri	Bv-km,Bv-km/a	TRNELC	TLD	TLMCELCB	2015	20	0.00	0.00	9969.75	9244.20	9244.20			0.9210	0.9335	0.9335	46.1518	0.24
	TLDCPOILGSL-CO	Transport: Light Duty Vehicles Compact; Gas	Bv-km,Bv-km/a	TRNOILGSL	TLD	TLCCONV10	2015	20	2847.53	2865.69	3075.59	3077.78	3077.78	0.3239	0.4369	0.5434	0.5423	0.5423	61.5357	0.18
	TLDCPELC-PH1	Transport: Light Duty Vehicles Compact; Elec	Bv-km,Bv-km/a	TRNELC	TLD	TLCELC	2015	20	0.00	5399.98	3985.60	3716.86	3716.86		1.1669	1.2197	1.2368	1.2368	46.1518	0.24
	TLDCPELC-PH2	Transport: Light Duty Vehicles Compact; Elec	Bv-km,Bv-km/a	TRNELC	TLD	TLCELCB	2015	20	0.00	0.00	5584.89	4926.30	4926.30			1.0144	1.0286	1.0286	46.1518	0.24
	TLDCPOILDSL-CO	Transport: Light Duty Vehicles Compact: Dies	Bv-km,Bv-km/a	TRNOILDSL	TLD	TLCDSL10	2015	20	3281.16	3160.19	3236.74	3239.39	3239.39	0.3990	0.5041	0.5791	0.5779	0.5779	61.5357	0.18
	TLDCPGASNAT-CO	Transport: Light Duty Vehicles Compact: Nat.	Bv-km,Bv-km/a	TRNGASNAT	TLD	TLCCNG10	2015	20	3920.33	3826.51	4058.84	4061.50	4061.50	0.3470	0.4749	0.6009	0.5996	0.5996	55.3821	0.24
	TLDCPGASNAT-FX	Transport: Light Duty Vehicles Compact: Nat.	Bv-km,Bv-km/a	TRNGASNAT	TLD	TLCCNGX10	2015	20	3736.15	3640.74	3868.61	3871.27	3871.27	0.3218	0.4403	0.5556	0.5544	0.5544	55.3821	0.24
				TRNOILGSL																
	TLDCPOILDSL-HY	Transport: Light Duty Vehicles Compact; Dies	Bv-km,Bv-km/a	TRNOILDSL	TLD	TLCDHEV15	2015	20	0.00	3792.98	3699.64	3682.98	3682.98		0.6194	0.6835	0.6821	0.6821	64.6125	0.18
*	TLDCPBIOGSL-FX	Transport: Light Duty Vehicles Compact; Biog	Bv-km,Bv-km/a	TRNBIOGSL	TLD	TLCETHX10	2015	20	2959.98	2871.89	3084.38	3086.15	3086.15	0.3250	0.4413	0.5493	0.5484	0.5484	61.5357	0.18
*				TRNOILGSL																
	TLDCPOILGSL-HY	Transport: Light Duty Vehicles Compact: Gas	Bv-km,Bv-km/a	TRNOILGSL	TLD	TLCHEV10	2015	20	3867.71	3423.76	3425.24	3407.95	3407.95	0.5583	0.6087	0.7249	0.7236	0.7236	64.6125	0.18
	TLDCPOILLPG-FX	Transport: Light Duty Vehicles Compact: LPG	Bv-km,Bv-km/a	TRNOILLPG	TLD	TLCLPGX10	2015	20	3657.22	3556.55	3783.99	3786.46	3786.46	0.3219	0.4403	0.5559	0.5547	0.5547	55.3821	0.24
				TRNOILGSL																
	TLDCPOILGSL-PH1	Transport: Light Duty Vehicles Compact, Gas	Bv-km,Bv-km/a	TRNOILGSL	TLD	TLCPHVG10	2015	20	3556.61	3574.77	3704.67	3706.06	3706.06	0.0204	0.0946	1.0653	1.0634	1.0634	64.6125	0.24
				TRNELC																
* Fullsize																				
	TLDFSOILGSL-CO	Transport: Light Duty Vehicles Fullsize; Gasoli	Bv-km,Bv-km/a	TRNOILGSL	TLD	TLFCONV10	2015	20	3370.39	3424.90	3630.73	3632.95	3632.95	0.3085	0.4274	0.5402	0.5397	0.5397	69.2276	0.18
	TLDFSELC-PH1	Transport: Light Duty Vehicles Fullsize: Electri	Bv-km,Bv-km/a	TRNELC	TLD	TLFELC	2015	20	0.00	6293.28	4641.88	4331.65	4331.65		1.0147	1.0560	1.0709	1.0709	51.9207	0.24
	TLDFSELC-PH2	Transport: Light Duty Vehicles Fullsize: Electri	Bv-km,Bv-km/a	TRNELC	TLD	TLFELCB	2015	20	0.00	0.00	6489.42	5728.42	5728.42			0.8783	0.8908	0.8908	51.9207	0.24

In addition, as discussed below, the vehicle type shares will need to be tailored to the country situation, where for example large cars, small cars, hybrids, etc. are all competing to provide passenger travel services. These shares are controlled by means of specifying the minimum or maximum percentage that each vehicle class (e.g., large (inefficient)) is projected to provide of the associated service demand.

Any Transportation component may be eliminated by entering "*" in Col-A on the SETUP sheet. If there is a need to add a new device type, do so by copying a similar type of vehicle's name on SETUP then Process data blocks on the appropriate ProcData_* sheets. Most of the names are carefully built from $references to their components, so after copying only minor adjustments need to be done to say change a fuel or technology instance. However, if adding a new technology there will be no corresponding data on the source data sheets, so the appropriate numbers will need to be provided. Also, be sure when adding an existing device not yet in the database that the device also gets added to the Calibration sheet appropriately (by copy/inserting a similar device in the same group).

> **Warning**: be sure to adhere to the basic naming convention of the components (that is use the same approach and number of characters as for some other entry) or the ANSWER named TechFilters and VBE Sets may no long operate properly!

5.4.6.1 Calibration of the Initial Year

The Transportation sector is similar to the other sectors (other than Industry) in terms of preparing and performing the calibration. Below in Figure 37and Figure 38 the EB and Calibration sheets are shown, where the user input of the splits for the end-use services is done on the former and for the assciated devices on the latter. When entering the device splits when there is more than one competing device consuming a fuel, shares are requested for all but one of them, with the remaining share calculated to ensure the service/fuel total is respected. There are separate Calibration and loadsheets for light duty vehicles (LDVs) and the rest of the transportation demands.

Figure 37: EB Sheet for Transportation

			OILLPG	OILGSL	OILJET	OILKER	OILDSL	OILFOI	OILLUB	OILNSO	GASNAT	BIOGAS	BIOGSL	BIOJKE	BIODSL	ELC	0
PJ	Sector Name		LPG	Gasoline	Jet Fuel	Kerosene	Diesel	Fuel Oil	Lubricants	specified Oil Products	Natural Gas	Biogases	Biogasoline	Kerosene	Biodiesels	Electricity	All Energy
International marine bunkers	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
International aviation bunkers	0		0	0	3.6561	0	0	0	0	0	0	0	0	0	0	0	3.6561
Transport	**TRN**		**0.0936**	**16.435**	**0.0306**	**0**	**17.127**	**0**	**0**	**0**	**1.965**	**0**	**0**	**0**	**0**	**1.0152**	**36.666**
Road	0		0.0936	16.4346	0	0	16.6816	0	0	0	1.965	0	0	0	0	0	35.1748
Domestic aviation	0		0	0	0.0306	0	0	0	0	0	0	0	0	0	0	0	0.0306
Rail	0		0	0	0	0	0.3908	0	0	0	0	0	0	0	0	1.0152	1.406
Pipeline transport	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Domestic navigation	0		0	0	0	0	0.055	0	0	0	0	0	0	0	0	0	0.055
Non-specified (transport)	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transport Services																	
Domestic aviation																	
Final Energy Consumption for Domestic aviation																	
	TAI	**Transport: Air**	**0**	**0**	**0.0306**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.03**
Domestic navigation																	
Final Energy Consumption for Domestic navigation																	
	TSH	**Transport: Ship**	**0**	**0**	**0**	**0**	**0.055**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.06**
Rail																	
Share by service																	
	TRF	Transport: Rail - Freight					50%										
	TRP	Transport: Rail - Passanger					50%									100%	
	Check 100%		**0%**	**0%**	**0%**	**0%**	**100%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**100%**	
Final Energy Consumption for Rail services																	
	TRF	Transport: Rail - Freight	0	0	0	0	0.1954	0	0	0	0	0	0	0	0	0	**0.20**
	TRP	Transport: Rail - Passanger	0	0	0	0	0.1954	0	0	0	0	0	0	0	0	1.0152	**1.21**
	Total		**0**	**0**	**0**	**0**	**0.3908**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1.0152**	**1.406**
	Check diff from FEC		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Road																	
Share by service																	
Light Duty																	
	TLD	Transport: Light Duty Vehicles	70%	50%			50%				50%						
Heavy Duty																	
	TBU	Transport: Bus		10%			10%				25%						
	TMD	Transport: Medium Duty Trucks	10%	10%			10%				10%						
	THS	Transport: HDV Short Haul	10%	10%			10%				15%						
	THL	Transport: HDV Long Haul	10%				10%										
	TCT	Transport: Commercial Truck		20%			10%										
	Check 100%		**100%**	**100%**	**0%**	**0%**	**100%**	**0%**	**0%**	**0%**	**100%**	**0%**	**0%**	**0%**	**0%**	**0%**	
Final Energy Consumption for Road services																	
Light Duty																	
	TLD	Transport: Light Duty Vehicles	0.07	8.22	-	-	8.34	-	-	-	0.98	-	-	-	-	-	**17.61**
Heavy Duty																	
	TBU	Transport: Bus	-	1.64	-	-	1.67	-	-	-	0.49	-	-	-	-	-	**3.80**
	TMD	Transport: Medium Duty Trucks	0.01	1.64	-	-	1.67	-	-	-	0.20	-	-	-	-	-	**3.52**
	THS	Transport: HDV Short Haul	0.01	1.64	-	-	1.67	-	-	-	0.29	-	-	-	-	-	**3.62**

Figure 38: Calibration Sheet for Transportation

Selected?	TRP	Transport: Rail - Passanger	Efficiency	Capacity Factor	Share of FEC	Final energy (PJ)	Demand (bn-pass-km)	Installed Capacity (bn-pass-km)	Fuel	Fuel share
	TRPOILDSL-CM-X0	Transport: Rail - Passanger; Diesel - Commuter - Existing 0	1.015934108	1	1.00	0.1954	0.1985	0.20	OILDSL	
	TRPOILDSL-IC-X0	Transport: Rail - Passanger; Diesel - Intercity - Existing 00	0.621542356	1	0.00	0.0000	0.0000	0.00	OILDSL	0.88
					0.00	0.0000			ELC	0.12
	TRPELC-CM-X0	Transport: Rail - Passanger; Electricity - Commuter - Existir	1.015934108	1	0.50	0.5076	0.5157	0.52	ELC	
	TRPELC-SS-X0	Transport: Rail - Passanger; Electricity - Subways and Stre	1.83557863	1	0.50	0.5076	0.9317	0.93	ELC	
						1.2106	**1.6459**	**1.6459**		
					from EB	1.21				
					check if zero	**0.0000**				

Selected?	TBU	Transport: Bus	Efficiency	Capacity Factor	Share of FEC	Final energy (PJ)	Demand (Bv-km)	Installed Capacity (Bv-km)	Fuel
	TBUOILDSL-X0	Transport: Bus; Diesel - Existing 00	0.055953541	1	1.00	1.6682	0.0933	0.09	OILDSL
	TBUOILGSL-X0	Transport: Bus; Gasoline - Existing 00	0.060429824	1	1.00	1.6435	0.0993	0.10	OILGSL
	TBUGASNAT-X0	Transport: Bus; Natural Gas - Existing 00	0.047574025	1	1.00	0.4913	0.0234	0.02	GASNAT
						3.8029	**0.2160**	**0.2160**	
					from EB	3.80			
					check if zero	**0.0000**			

Selected?	TMD	Transport: Medium Duty Trucks	Efficiency	Capacity Factor	Share of FEC	Final energy (PJ)	Demand (Bv-km)	Installed Capacity (Bv-km)	Fuel
	TMDOILGSL-X0	Transport: Medium Duty Trucks; Gasoline - Existing 00	0.095320218	1	1.00	1.6435	0.1567	0.16	OILGSL
	TMDOILDSL-X0	Transport: Medium Duty Trucks; Diesel - Existing 00	0.097424176	1	1.00	1.6682	0.1625	0.16	OILDSL
	TMDGASNAT-X0	Transport: Medium Duty Trucks; Natural Gas - Existing 00	0.07798367	1	1.00	0.1965	0.0153	0.02	GASNAT
	TMDOILLPG-X0	Transport: Medium Duty Trucks; LPG - Existing 00	0.085682657	1	1.00	0.0094	0.0008	0.00	OILLPG
						3.5175	**0.3353**	**0.3353**	
					from EB	3.52			
					check if zero	**0.0000**			

Selected?	THS	Transport: HDV Short Haul	Efficiency	Capacity Factor	Share of FEC	Final energy (PJ)	Demand (Bv-km)	Installed Capacity (Bv-km)	Fuel
	THSOILGSL-X0	Transport: HDV Short Haul; Gasoline - Existing 00	0.081936407	1	1.00	1.6435	0.1347	0.13	OILGSL
	THSOILDSL-X0	Transport: HDV Short Haul; Diesel - Existing 00	0.063102882	1	1.00	1.6682	0.1053	0.11	OILDSL
	THSGASNAT-X0	Transport: HDV Short Haul; Natural Gas - Existing 00	0.063275756	1	1.00	0.2948	0.0187	0.02	GASNAT
	THSOILLPG-X0	Transport: HDV Short Haul; LPG - Existing 00	0.059628806	1	1.00	0.0094	0.0006	0.00	OILLPG
						3.6157	**0.2591**	**0.2591**	
					from EB	3.62			
					check if zero	**0.0000**			

ANSv2-691-Home | SETUP | Commodities | EB | Calibration_LDV | Calibration_HDV&Off-road | CommData | Processes | ProcData_LDV

As discussed in Section 6, the work on the Calibration sheets in each BY workbook is the starting point for the calibration process. The cycle involves running the model (for just the first period if desired) and using the VBE calibration check workbook to see how well the model is aligning with the energy balance, returning to the BY Calibration sheets to devices shares assumptions as needed.

6 Calibration of the Base Year

The organization of the BY tempates was discussed in Section 2, including the basics of the Calibration sheet used for each sector to establish the technology mix according to the 1st year energy balance and local technologies in use today. This section provides details on the procedure to follow to calibrate the base year of the energy system as presented in TIMES, involving:

- checking that the first year resource supplies are properly reflected in the Supply workbook;
- establishing the power plant mix, and
- decomposing the energy balance for each demand sector to the service level and then establishing the existing techonology mix and contribution to meeting the service demand.

For all the sector workbooks two sheets are key to the calibration process: the energy balance (EB) sheet as carried across from the EB workbook for the sector, and the Calibration sheet where the work is done to decompose the sector level balance to the devices supplying the various end-uses, or in the case of the power sector the individual plant types. On each Calibration sheet there is a text box with instructions on completing its calibration. The essence of the process is to assign the percent of final energy fuel consumption associated with each of the end-use services on the EB sheet, and then apportion that down to the device level on the Calibration sheet. As the user enters these splits, the total within each group is cross-checked to ensure a good cailibration to the energy balance. But once setup the model needs to be run (for only the 1st period is fine) to see if the input splits et al provided indeed align with what is produced from the model. Troubleshooting differences between the original EB and that obtained from a model run is discussed in the next section.

To faciliate this comparison a VBE UpdateXLS workbook has been setup with tables corresponding to:

- resource supply by source and fuel type;
- power, CHP and heating plants consumption and generation by fuel type, and
- final energy consumption by sector and fuel.

These VBE dump tables, shown in Figure 39, are processed using VLOOKUP functions on the EB fuel/sector names to assemble the information on the EB Results sheet and assembled on the EB Results sheet (Figure 40), then said values are compared against the original EB (Figure 41) and the power sector details (Figure 42) to see that these are in alignment. The EB & PP_Calib Check sheets show any differences, which then need to be tracked down and resolved, as discussed in the next section.

Note: If the names/structure of the EB or the BY-PP calibration sheet are changed, the Calibration Check workbook needs to be adjusted accordingly.

Figure 39: Calibration VBE UpdateXLS Dump Tables

Table Name: Calib - Final Energy Consumption (by Sec & Fu

Active Unit: PJ

Scenario	Commodity\Period	2013
REF-09	AGRBIOPSF	0.0018
REF-09	AGRELC	0.1246
REF-09	AGRGASNAT	0.0588
REF-09	AGROILDSL	3.53E-01
REF-09	AGROILGSL	3.62E-02
REF-09	COMBIOPSF	3.36E-01
REF-09	COMCOAANT	1.30E-02
REF-09	COMCOALIG	0.0053
REF-09	COMELC	4.3256
REF-09	COMGASNAT	2.8712
REF-09	COMLTH	1.269
REF-09	COMOILFOI	0.1794
REF-09	COMOILLPG	0.0134
REF-09	COMRNWGEO	0.312
REF-09	COMRNWSOL	2.34E-02
REF-09	INDBIOPSF	9.00E-03
REF-09	INDCOAANT	0.219
REF-09	INDCOALIG	6.9236
REF-09	INDCOAOBC	1.76
REF-09	INDCOAORG	4.258
REF-09	INDELC	14.1582
REF-09	INDGASNAT	2.9157
REF-09	INDOILDSL	2.49E+00
REF-09	INDOILFOI	5.30E-02
REF-09	INDOILGSL	3.75E-01
REF-09	INDOILKER	9.30E-03
REF-09	RSDBIOPSF	19.7987
REF-09	RSDCOALIG	0.051
REF-09	RSDELC	13.0463
REF-09	RSDGASNAT	27.7172
REF-09	RSDLTH	6.10E+00
REF-09	RSDOILKER	8.60E-03
REF-09	RSDOILLPG	0.639
REF-09	RSDRNWSOL	0.0233
REF-09	TRNELC	1.0152
REF-09	TRNGASNAT	1.965
REF-09	TRNOILDSL	17.1274
REF-09	TRNOILGSL	1.64E+01
REF-09	TRNOILJET	3.06E-02
REF-09	TRNOILLPG	9.36E-02

Table Name: Calib - Electric Generation (by Type)

Active Unit: PJ

Scenario	ProcessSetDesc	Process\Period	2013
REF-09	Biofuel-fired	EEBIOGAS-CC-X	0.25
REF-09	Biofuel-fired	EEBIOGAS-EN-X	0.5
REF-09	Biofuel-fired	EEBIOGAS-GT-X	0.5
REF-09	Biofuel-fired	EEBIOGAS-ST-X	0.24894
REF-09	Biofuel-fired	EEBIOMSW-ST-X	1
REF-09	Biofuel-fired	EEBIOPSF-IG-XC	5.683107
REF-09	Biomass fired CHP	EHBIOPSF-ST-X	0.769231
REF-09	Coal fired CHPs	EHCOAANT-ST-X	1.3
REF-09	Coal-fired	EECOALIG-IG-XC	3
REF-09	Coal-fired	EECOALIG-ST-X	4.5
REF-09	Coal-fired	EECOAOBC-ST-X	1.5
REF-09	Coal-fired	EECOASBC-ST-X	1.5
REF-09	Gas fired CHPs	EHGASNAT-CC-X	1.428571
REF-09	Gas fired CHPs	EHGASNAT-EN-X	0.909091
REF-09	Gas-fired	EEGASNAT-CC-X	3
REF-09	Gas-fired	EEGASNAT-CT-X	3.3552
REF-09	Hydro	EERNWHYD-DM-	1.5
REF-09	Hydro	EERNWHYD-RR-	0.5
REF-09	Nuclear	EENUCLER-LWF	1
REF-09	Other Renewables	EERNWGEO-ST-	0.5
REF-09	Other Renewables	EERNWSOL-TC-	1
REF-09	Other Renewables	EERNWWIN-OF-	0.5
REF-09	Other Renewables	EERNWWIN-ON-	1
REF-09	Total		35.44414

Table Name: Calib - Heat Generation (by Type)

Active Unit: PJ

Scenario	ProcessSe	Process\P	2013
REF-09	Biomass f	EHBIOPS	2
REF-09	Biomass f	HPBIOPS	1
REF-09	Coal fired	EHCOAAN	1.69
REF-09	Electricity	HPELC-BI	0.499
REF-09	Electricity	HPELC-HI	0.5
REF-09	Gas fired	EHGASNA	1
REF-09	Gas fired	EHGASNA	1
REF-09	Gas fired	HPGASNA	0.5
REF-09	Total		8.189

Table Name: Calib - HPL Fuel Consumption

Active Unit: PJ

Scenario	Process	Commodit	2013
REF-09	HPBIOPS	PWRBIOF	0.99
REF-09	HPELC-BI	PWRELC	0.52894
REF-09	HPELC-HI	PWRELC	0.19
REF-09	HPGASNA	PWRGAS	0.5

Table Name: Calib - CHP Fuel Consumption

Active Unit: PJ

Scenario	Process	Commodit	2013
REF-09	EHBIOPS	PWRBIOF	4
REF-09	EHCOAAN	PWRCOA	5
REF-09	EHGASNA	PWRGAS	4
REF-09	EHGASNA	PWRGAS	5.222

EB_Check | PP_calib_check | EB | BY-PP | VBE_tables | EB_results

Figure 40: Calibration Results EB Table

EB constructed from model results

Country (Region) Name STARTER

PJ	Sector Name	BIOMSW Municipal Waste	BIOPSF Primary Solid Biofuels	BIOGAS Biogases	BIOGSL Biogasoline	BIOJKE Bio Jet Kerosene	BIODSL Biodiesels	BIOCHA Charcoal	NUCLER Nuclear	RNWHYD Hydro	RNWGEO Geothermal	RNWSOL Solar
Production		5.56	47.86	4.85						2.00	1.87	1.05
Imports									2.94			
Exports		-	-	-	-	-	-	-	-	-	-	-
International marine bunkers		-	-	-	-	-	-	-	-	-	-	-
International aviation bunkers		-	-	-	-	-	-	-	-	-	-	-
Stock changes		-	-	-	-	-	-	-	-	-	-	-
Total primary energy supply		**5.56**	**47.86**	**4.85**	**-**	**-**	**-**	**-**	**2.94**	**2.00**	**1.87**	**1.05**
Transfers		-	-	-	-	-	-	-	-	-	-	-
Statistical differences		0.000	0.000	0.000	-	-	-	-	0.000	-	-0.000	-0
Transformation Processes and Losses		**-5.56**	**-27.71**	**-4.85**	**-**	**-**	**-**	**-**	**-2.94**	**-2.00**	**-1.56**	**-1.00**
Main activity producer electricity plants	PWR	-5.56	-22.72	-4.85					-2.94	-2.00	-1.56	-1.00
District CHP plants	PWR		-4.00									
District heat only plants	PWR		-0.99									
Losses (from pipelines and transmission)												
Final consumption		**-**	**20.15**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**0.31**	**0.05**
Industry	**IND**	**-**	**0.01**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Transport	**TRN**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Other		**-**	**20.14**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**0.31**	**0.05**
Residential	RSD	-	19.80	-	-	-	-	-	-	-	-	0.02
Commercial	COM	-	0.34	-	-	-	-	-	-	-	0.31	0.02
Agriculture	AGR	-	0.00	-	-	-	-	-	-	-	-	-
Fishing	AGR											
Non-specified (other)												

EB_Check | PP_calib_check | EB | BY-PP | VBE_tables | EB_results

Figure 41: Calibration EB Comparison Table

Differences between EB and model resu		OILDSL	OILFOI	OILNAP	OILLUB	OILBIT	OILPCO	OILNSO	GASNAT	BIOIWA	BIOMSW	BIOPSF	BIOGAS
ountry (Region) Nam STARTER													
PJ	Sector Name	Diesel	Fuel Oil	Naphtha	Lubricants	Bitumen	Petroleum Coke	Other Oil Products (excluding non-energy uses)	Natural Gas	Industrial Waste	Municipal Waste	Primary Solid Biofuels	Biogases
Production		-	-	-	-	-	-	-	0.00	-	-	-	0.00
Imports		-	-	-	-	-	-	-	-	-	-	-	-
Exports		-	-	-	-	-	-	-	-	-	-	-	-
International marine bunkers		-	-	-	-	-	-	-	-	-	-	-	-
International aviation bunkers		-	-	-	-	-	-	-	-	-	-	-	-
Stock changes		-	-	-	-	-	-	-	-	-	-	-	-
Total primary energy supply		-	-	-	-	-	-	-	**0.00**	-	-	-	**0.00**
Transfers		-	-	-	-	-	-	-	-	-	-	-	-
Statistical differences		0.000	-0.000	-	-	-	-	-	0.000	-	-0.000	-0.000	-0.000
Transformation Processes and Losses		-	-	-	-	-	-	-	**-0.00**	-	**-0.00**	**-0.00**	**-0.00**
Main activity producer electrici	PWR	-	-	-	-	-	-	-	-0.00	-	-0.00	-0.00	-0.00
District CHP plants	PWR	-	-	-	-	-	-	-	-0.00	-	-	-0.00	-
District heat only plants	PWR	-	-	-	-	-	-	-	0.00	-	-	0.00	-
Losses (from pipelines and transmission)		-	-	-	-	-	-	-	-	-	-	-	-
Final consumption		-0.00	0.00	-	-	-	-	-	0.00	-	-	0.00	-
Industry	**IND**	0.00	0.00	-	-	-	-	-	0.00	-	-	0.00	-
Transport	**TRN**	-0.00	-	-	-	-	-	-	0.00	-	-	-	-
Other		-	-	-	-	-	-	-	0.00	-	-	-	-
Residential	RSD	-	-	-	-	-	-	-	0.00	-	-	-	-
Commercial	COM	-	-	-	-	-	-	-	0.00	-	-	-	-
Agriculture	AGR	-	-	-	-	-	-	-	-	-	-	-	-
Fishing	AGR	-	-	-	-	-	-	-	-	-	-	-	-
Non-specified (other)		-	-	-	-	-	-	-	-	-	-	-	-

EB_Check | PP_calib_check | EB | BY-PP | VBE_tables | EB_results

Figure 42: Calibration PP Comparison Table

selected		Checking Calibration of power and heat generation	Fuel	Fuel consumption			Electricity Produced		
				From BY-PP	From Results	DIFF (check if 0)	Est/known elc prod	From Results	DIFF (check if 0)
	Electricity Only Power Plants			PJ			PJ		
	* Hydro								
	EERNWHYD-DM-X0	Hydro (Dam) (Existing)	PWRRNWHYD	1.5	1.5	0.0	1.5	1.5	0.0
	EERNWHYD-RR-X0	Hydro (Run-of-River) (Existing)	PWRRNWHYD	0.5	0.5	0.0	0.5	0.5	0.0
*	EERNWHYD-PS-X0	Hydro (Pumped Storage) (Existing)	PWRRNWHYD						
*			PWRELC						
		Total		2			2		
	* Gas								
	EEGASNAT-CC-X0	Natural Gas - Combined cycle (Existing)	PWRGASNAT	6.67	6.7	0.0	3	3.0	0.0
	EEGASNAT-CT-X0	Natural Gas - Combustion turbine (Existing)	PWRGASNAT	11.98	12.0	0.0	3.3552	3.4	0.0
		Total		18.65			6.3552		
	* Coal								
	EECOAOBC-ST-X0	Bituminous (Brown Coal) - Steam turbine (Existing)	PWRCOAOBC	4.59	4.6	0.0	1.5	1.5	0.0
	EECOASBC-ST-X0	Sub-Bituminous Coal - Steam turbine (Existing)	PWRCOASBC	4.5	4.5	0.0	1.5	1.5	0.0
	EECOALIG-ST-X0	Lignite - Steam turbine (Existing)	PWRCOALIG	13.64	13.6	0.0	4.5	4.5	0.0
	EECOALIG-IG-X0	Lignite - Integrated Gasif. (Existing) Combined cycle	PWRCOALIG	8.57	8.6	0.0	3	3.0	0.0
		Total		31.3			10.5		
	* Nuclear								
	EENUCLER-LWR-X0	Nuclear - LWR (Existing)	PWRNUCLER	2.94	2.9	0.0	1	1.0	0.0

EB_Check | PP_calib_check | EB | BY-PP | VBE_tables | EB_results

6.1 Common Reasons and Remedies for Calibration Issues

Carefully checking all EB and Calibration sheets before running the model will minimize the chances of mis-calibration of initial year. Before checking the BY template calibration make sure that all the dependent templates are linked properly and have been updated (opened and saved) to ensure all children are “younger” than their parents.

First, make sure that “Check if 100%”, and “Check diff from FEC” yield correspondingly either 100% or 0 on sector “EB” sheets. If this is not the case, then the splits entered in the “split by end-use” section of each Calibration sheet are incorrect and need to be adjusted to ensure they sum to 100% or align with the FEC from the EB. The only exception from the "Check if 100%" rule is getting 0% instead of 100% for those energy commodities that are not consumed in corresponding sector at all.

Afterwards the "Calibration" sheet needs to be checked to ensure and make sure that the sum of "Share of FEC" for all technologies consuming the same fuel within the same end-use commodity is equal to 1. Also make sure that fuel consumption is not assigned to a process which has "*" in column A. Then, carefully look at the "Check if 0" cells to make sure that all values are equal to zero. If one is not, and if the checks above are all correct, the most likely reason for mis-calibration is that some fuel has been assigned to this end use in the EB sheet "split by end-use" section, but the list of technologies in "calibration" sheet" doesn't have a technology consuming this fuel.

For example, you may have geothermal energy use in residential water heating category in your model, but the current TIMES-Starter model does not have a geothermal-consuming technology in its list of available technologies for water heating, so the EB check will fail. The procedure for adding a new device is discussed in Section 14. In this case the corresponding technology needs to be added or the EB adjusted.

A similar case may occur during calibration of power sector (i.e. your EB has a plant consuming some fuel which is not listed in the TIMES-Starter technology list). But in this case you are notified that you are missing the plant using a specific fuel by the zero value in "from Calibration" section in EB sheet, whereas the "From Balance" section does have a value assigned for that fuel and power plant type. This will also result in non-zero values in the "Difference (check if zero)" section. Alternatively, these non-zero values may be an indication that fuel consumption and/or generation values on Calibration sheet have not been split correctly between different power plants. In this case please carefully check the Calibration sheet again.

Despite the care taken when filling the BY templates, it is not an unusual situation that the model results do not perfectly calibrate after the first runs of the model. As discussed above, use the CalibrationCheck VBE UpdateXLS workbook to examine which sectors and fuels are off. Always start checking the calibration with the demand sectors, moving backward through the RES, because calibration of power and supply sectors will not be possible until the demand sectors are all properly calibrated.

In all sectors, some common oversights or pitfalls to avoid include making sure that:

- as noted above, all child templates are younger than their parents;
- the calibration checks listed above have been performed and are correct;
- the values in the template align with those one sees in ANSWER, that is that the latest version of the template is indeed the one currently in the database;
- there is no UC in the current run that affects the end-use or power plant technologies in the BY, and
- only the scenarios relevant for the calibration are loaded in the Run form, that they are in the correct order, and that nothing overrides the 1st year values.

In addition to these general reminders, when considering the possible reasons for mis-calibration in the different sectors keep in mind that it may be the case that while focusing on a particular technology the mis-calibration may be due to something wrong with another technology in the same sector. The sections that follow discuss what may be the cause of an imbalance together with suggestions for how to go about determining the reasons and correcting them.

6.1.1 Mis-calibration in demand sectors

If mis-calibration is observed in the demand sectors, some possible reasons are noted below.

- Incorrect parameters have been used for one or more of the end-use technologies which can be either due to incorrect formulas in calibration, or the mismatch of parameter values in templates and the model scenarios. Try to figure out those technology (ies) that are causing mis-calibration. To do so, use ANSWER-TIMES and/or VEDABE and check all technologies consuming the affected fuel in the affected sector. To find which technology is causing the mis-calibration compare the final energy consumption values from model results with the "Final Energy" values in sectoral "calibration" sheets. They should be the same. After locating the technology responsible for mis-calibration do the following:
    - Carefully check the formulas for the affected technology in the calibration sheet and make sure that the values that are calculated there are those that are read by "ProcData" sheets. If you haven't made any changes to EB calibration and ProcData sheets, this generally shouldn't be the cause. Check separately bi-fuel or bi-enduse technologies, because the formulas for their calibration differ from formulas used for "standard" technologies. After finding the error – correct it.
    - Compare the values of parameters for the affected technology with those that are in the corresponding ANSWER-TIMES scenario, by selecting this scenario in ANSWER-TIMES (locating it in right hand upper window of ANSWER-TIMES console) and browsing the values for that technology. Make sure that the last version of template was read in the model. If values differ – reimport the Scenario. Also make sure that no other scenario changes the value of parameters and that if there is a scenario that changes the values it is not used in the current run overriding the BY-scenario of that sector.
- Make sure to have the correct end-use demand specified for the 1st period as obtained from the calibration workbook reflected in the Demand workbook and ANSWER.
- If the affected commodity is electricity or heat, the reason for mis-calibration may be due to incorrect COM_FRs. Check that the latest COM_FRs in the model database align with what is in the template and ANSWER.
- Dual fuel or service devices fixed shares need to be adjusted.
- Mis-calibration of end-use technologies can be also due to mis-calibration of upstream RES, i.e. power system and supply system (i.e. not enough fuel is coming from supply sector), discussed below.

6.1.2 Mis-calibration in power sector

The list bellow discusses the possible reasons for mis-calibration in power sector and the ways to remedy them.

- Make sure that there is no base year bound on the plant in PP-data affecting the behavior of the plant.

- Make sure that the latest year timeslices (G_YRFRs) are in the model database.
- Dual fuel plants with fixed ratios for the shares are not in the correct proportions, and need to be adjusted.
- CHP electricity to heat ratios are not in the correct proportions, and need to be adjusted.
- Mis-calibration of power plants may be due to mis-calibration of demand sectors (which should be corrected first) or the supply system including grids, which is discussed below.

6.1.3 Mis-calibration of supply system

If mis-calibration is due to the supply system the most likely reason will be the bounds on supply technologies, which come from the EB for the first period. For grids they are "built" (at no cost) according to the EB levels and a user provided utilization factor. Please check all the bounds on the supply and grid technologies in templates and in the model database. Also make sure that there is no scenario overriding the values.

You need to also make sure that there is a supply option for all energy carriers active in the energy balance in the initial period. An indication that there is none, or that the supply is not enough, is that the ZZBCKNRG backstop process enters the model results in the first period. To handle this type of mis-calibration you need to add the supply technology or change/remove the bounds.

7 Managing Scenarios in ANSWER and Submitting a Model Run

The ANSWERv6-TIMES Getting Started & User Manuals provide detailed documentation on all aspects of working with ANSWER-TIMES. Here brief guidelines for managing the Starter model via ANSWER-TIMES are presented.

7.1 Handling Updates

Changes are part of the game and when new versions of the various components of the TIMES modeling platform are announced by the developers, or an update to the US9r database is released, the user should move to apply these updates to their system. Before doing so it is always advisable to back your all model files!

When new versions of GAMS, ANSWER and/or VBE are released the update procedures (or in the case of GAMS, new distribution) should be followed and the system updated. In most all cases there will be no impact on your model directly. The one exception is where there is an update of the TIMES GAMS code (in the GAMS_SrcTI folder). After introducing the update it is recommended that the standard Template.GEN file be augmented to include the *GG* block of lines below, if not found in the file. These switches adjust the handling of aspects of the objective function and aspects of the reporting (see the TIMES documentation) that best suit that TIMES-Starter model.

```
*GG* Add the LevelizedCost/Cost_NPV switches
$ SET ANNCOST LEV
$ SET OBJ AUTO
$ SET OBLONG YES
$ SET MID_YEAR YES
$ SET RPT_OPT NCAP.1 -1
```

When a new release of the USEPA US9r technology database[12] is released, ETSAP will update the TIMES-Starter model templates and make new templates available to all users. Those with existing models assembled from TIMES-Starter will only need to consider US9r updates to the SUP and NT templates in terms of introduction and changes in international energy prices and new technology characterizations. To this end, USEPA will provide a fairly detailed list of any changes made including identifying any new technologies added. The TIMES-Starter version of these changes should be able to be introduced into your model directly by simply copying the version distributed over that being used in your templates model to adopt any updates. If EPA has added new technologies then your NT templates will need to be manually updated carefully by copying the SETUP/declaration/data sheets from the new TIMES-Starter into your templates after moving in the new EPA sheet.

In terms of managing your own templates, the approach recommended is to copy and rename your ANSWER_Databases\TIMES-Starter(country)_vXX folder to a new version, perhaps also renaming the MDB in said new folder. This will ensure that all the scenario/template mappings for the ANSWER ImportXLS operation remain intact and correct, as discussed in the next section. Note that the Calibration and AnalyticsXLS result handling workbooks are also retained in this folder and one may want to increment their version numbers with that of the new folder.

7.2 Aligning Templates with Scenarios

As presented in the previous sections, there are a number of ANSWER-TIMES "Smart" Excel workbooks that accompany this TIMES-Starter database. The full set of templates comprise a Starter model, and consist of three types of templates:

- AT_ "Smart" v1 templates where either commodity groups, IRE processes, or user constraints are assembled, or single parameter values set;
- AT2_ "Smart" v2 falling into three categories, Demand projection workbooks, Existing and New technologies, and
- S_ scenario workbooks which in some cases just carry out calculations or with a VBE ExportXLS table to grab Reference scenario results any apply policy targets, for example emissions, or power sector generation, or final energy consumption to evaluate emission reduction levels, renewable portfolio standards, or energy efficiency improvement. [Note that in some cases the S_scenario is easier to simply setup in ANSWER without an associated workbook, e.g., to test a higher price for nuclear power plants.]

[12] Note that to date there have not been any updates to the US9r database since the development of the TIMES-Starter model, so it is possible that these instructions may change somewhat after the first updated expected in October 2016.

The templates comprising the TIMES-Starter (that is EB, SUP, all BY/NT<sect>, Demand and UC<sect>) have been discussed in the previous sections or are elaborated in the sections that follow. Each of the templates has an associated Scenario in ANSWER into which it is to be loaded (at times more than one template may be in a scenario) as discussed below. The Scenario/Template alignment is shown in Figure 43. All the templates are kept in the same folder as the ANSWER database to facilitate version control. When looking to freeze a current model instance, the entire folder can be copied, perhaps appending the date. This enables the ANSWER import templates "Same Folder" option, discussed in the next section, to be employed.

All the templates comprising the TIMES-Starter model have a Country field on the SETUP sheet which links to the associated EB workbook (which will enable the TIMES-Starter to accommodate multi-region models).

Figure 43: Scenario/Templates Alignment

Starter Model Templates & Scenarios		
Name	Description	Reference Scenarios
BASE	BASE scenario	Globals/Timeslices – manually entered from EB
BOUNDLO	Impose lower bounds on operation of selected existir	REF_BOUNDLO
BOUNDLO-RED	Reduced lower bounds on operation of selected exis	REF_BOUNDLO-RED
BY-AGR	BY Agriculture	AT2_Starter_BY-AGR
BY-COM	BY commercial	AT2_Starter_BY-COM
BY-IND	BY-Industry (dummy)	AT2_Starter_BY-IND
BY-PP	BY Power Sector	AT2_Starter_BY-PP
BY-RSD	BY residential	AT2_Starter_BY-RSD
BY-TRN	BY Transport	AT2_Starter_BY-TRN
DEMAND-REF	Demand Projections REF	AT2_Starter_Demand-REF
NT-AGR	New Agriculture Devices	AT2_Starter_NT-AGR
NT-COM	New Commercial Devices	AT2_Starter_NT-COM
NT-PP	New Power Plants	AT2_Starter_NT-PP
NT-RSD	New Residential Devices	AT2_Starter_NT-RSD
NT-TRN	New Transport Vehicle	AT2_Starter_NT-TRN
S_CO2LIM20	Limit on CO2 Emissions (10% in 2020 to 20% in 2050)	S_CO2-20
S_CO2LIM30	Limit on CO2 Emissions (15% in 2020 to 30% in 2050)	S_CO2-30
S_CO2LIM40	Limit on CO2 Emissions (15% in 2020 to 40% in 2050)	S_CO2-40
		S_CO2-50
S_CO2TAX	CO2 Tax	S_CO2TAX
S_GHGLIM20	Limit on CO2EQ Emissions (10% in 2020 to 20% in ...	Scen_GHG-20
S_LIMFEC	Limit on Final Energy Consumption (15% in 2030)	Scen_LIMFEC
S_LIMFELC	Limit Final Electrcity Consumption	Scen_LIMFELC
S_RPS	Renewable Electricity Share	Scen_RPS
SUP	Supply	AT_Starter_Supply
TECH-BOUND	Limits on capacity of new technologies	ANSWER scenario (no XLS)
UC-COM	Reference Guidance Constraints for COM	AT_UC-COM
UC-COM50	Loosened Guidance Constraints for COM - 50%	AT_UC-COM-50
UC-COM90	Loosened Guidance Constraints for COM	AT_UC-COM-90
UC-RSD	Reference Guidance Constraints for RSD	AT_UC-RSD
UC-RSD50	Loosened Hi EFF Guidance Constraints for RSD - ...	AT_UC-RSD-50
UC-RSD90	Loosened Hi EFF Guidance Constraints for RSD	AT_UC-RSD-90
UC-TRN	Reference Guidance Constraints for TRN	AT_UC-TRN
UC-TRN50	Loosened Hi EFF Guidance Constraints for TRN - ...	AT_UC-TRN-50
UC-TRN90	Loosened Hi EFF Guidance Constraints for TRN	AT_UC-TRN-90
XIND-UC	Industry Fuel & Service Shares (pending)	pending
XNT-IND	New Industrial Processes (pending)	pending
ZZDMY	Backstops ZZDMY for DEM/NRG/ELC	AT_Starter_ZZDMY

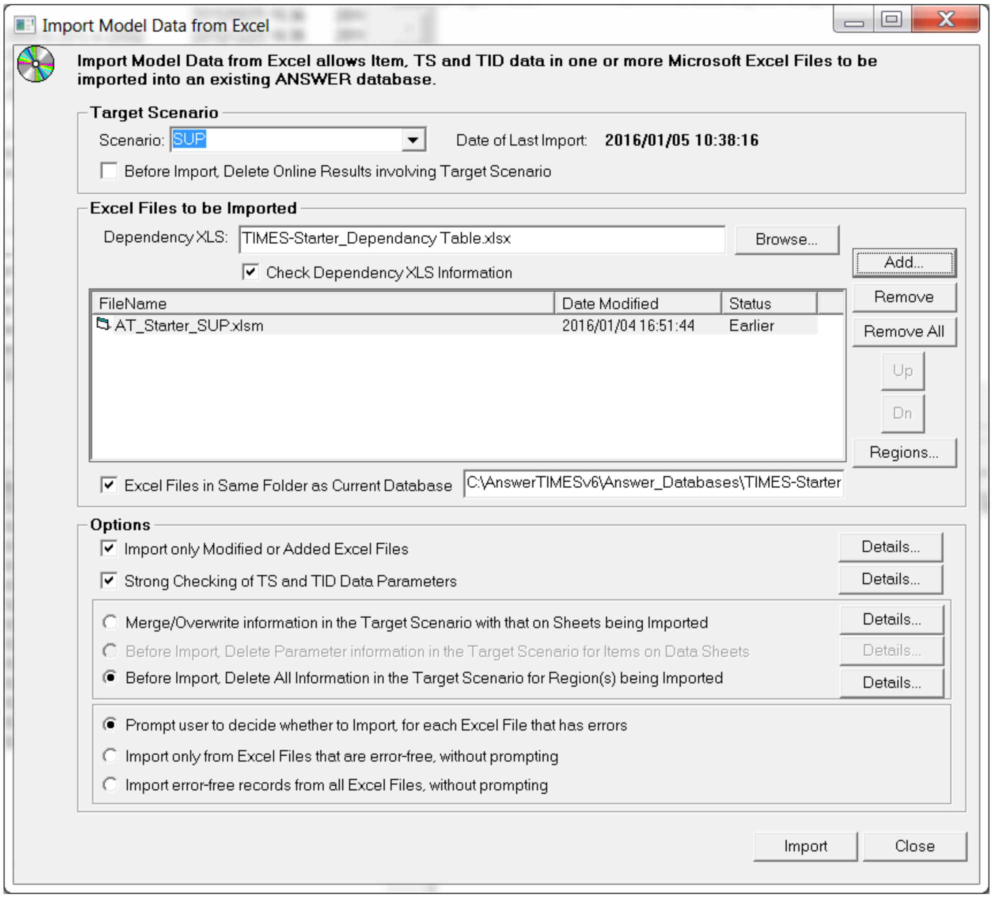
7.3 Importing Templates into ANSWER

The ANSWER File/Import/Model Data from Excel option [Ctrl-I] can be used to bring the templates into their associated Scenario. An example for New Power Plants is shown in Figure 44. Some particular things to note in terms of the switches on the Import template include:

- Pay careful attention to the Target Scenario to make sure you're loading into the correct scenario;
- The list of FileNames to be imported (one file for each other than Industry and Demands at this time) indicates when the associated template(s) was imported and whether said template is newer (later) or already in the database (earlier), where only the former will be imported, unless the "Only Modified/Added" Option is unchecked;
- For all scenarios (other the BASE, which is handled manually) the “Delete Before Importing” option should be employed to "clean out" the existing information in the scenario prior to importing, and
- For those scenarios consisting of more than one template, the scenario data from templates not being updated may or may not be consistent with the updated data. The “Before Import Delete Results” switch is a reminder that depending upon the nature of the changes made, the user should decide whether they want to dump all associated data, or not, when importing. Thus the safe thing to do is to import (force if necessary) all the templates associated with a scenario. If importing more than one template into a single scenario and only one of them has been changed, the Import only Modified or Added Excel Files must be UNCHECKED so that the "Earlier" template(s) will also be re-imported as part of the scenario.

Note the checked Check Dependency Information and specification of the workbook with the dependency table, as shown in Table 2 and discussed in Section 2. Should any Child which is older than its Parent(s) be reported in the log, it is recommended that these be opened and resaved prior to importing any such potentially out of synch template.

Figure 44: ANSWER Template Import



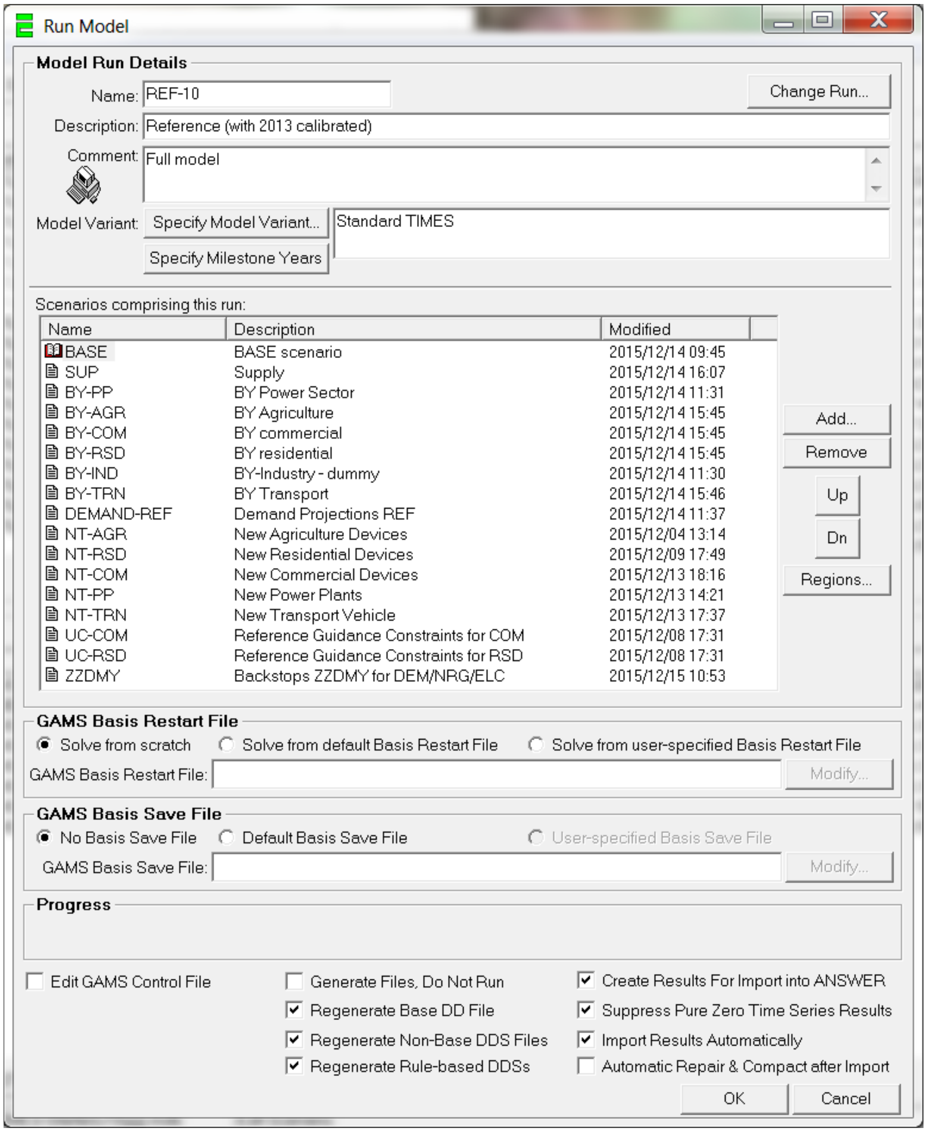
Note that as the model evolves if may be desirable to have fewer individual scenarios. To this end, combining all the BY-<sector> base scenarios into BY-REF and all the NT-<sector> into a single NT-TCH may be worth considering. Having said this, one advantage of keeping the sectors in their own templates is to facilitate team model development where several individuals are building the model so that changes can be made along sector lines and introduced selectively as appropriate.

7.4 Submitting a Model Run

With the templates imported into ANSWER they may be assembled into model runs by providing the list of scenarios to be included in a run, as shown in Figure 45 for the current Reference scenario. When assembling the scenario list it is important to keep in mind that:

- The order of the scenarios is important, as GAMS processes them in the order presented;
- Thus the TIMES code only "sees" the last value submitted, and any repeated parameter values (e.g., bounds) will overwrite the earlier values;
- For the Starter model it is important to have the Supply scenario appear before any of the sector scenarios, since the supply commodities (SUP<root><nrg>) are declared in it, and
- In general, the Run check box switches active below will work just fine.

Figure 45: ANSWER Run Submission



Once the OK button is hit:

- the model data will be assembled by ANSWER in the GAMS run folder;
- a Windows Command Prompt window will open and the model run undertaken, and
- the TIMES results are "dumped" for ANSWER (if requested) are imported (if Import Results Automatically selected).

As the run finishes up TIMES will also produce the results files needed for VBE, see Section 0.

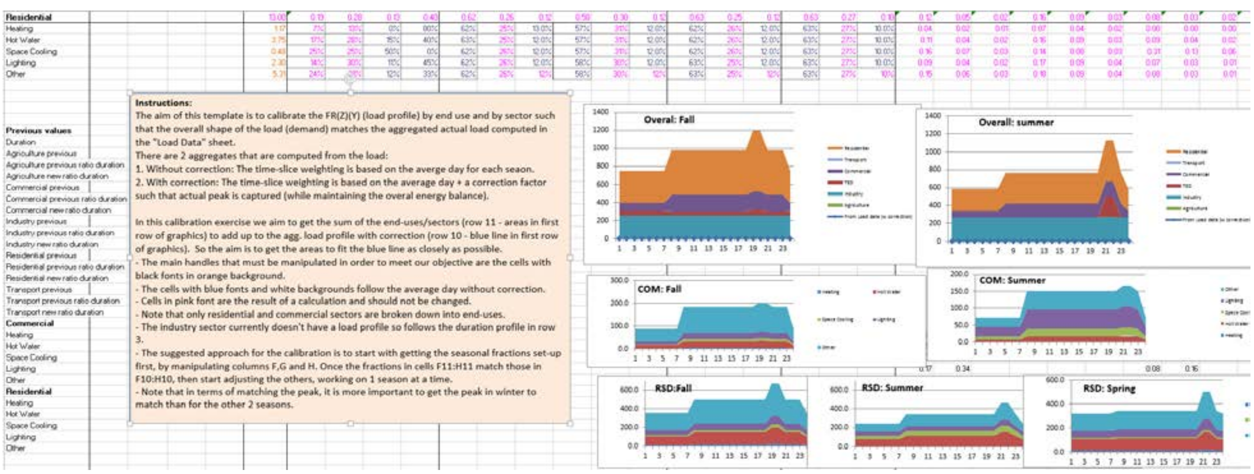
8 Adjusting the Load Duration Curve

An important aspect of defining the electric sector is creating the annual timeslices for the model that match the base year load duration curve. The TIMES-Starter is setup with twelve divisions of the year corresponding to four seasons (summer, fall, winter and spring) and three times of the day (day, night and peak) that apportion the load curve adequately for long-term planning purposes. While the user is free to change the number of divisions this needs to be done carefully and is not described here. We suggest that only very experienced modelers attempt to do so without expert guidance.

The number of months and hours of the day corresponding to each timeslice are defined on the Load data tab of the Loadcalibration workbook by entering the start and end day for each season. Based on the load duration curve, which consists of 8760 hourly electricity load values the base year (or most recent year available), the user must iterate on the load fractions for each timeslice and sector to get a reasonable approximation of the associated aggregate load curve that will be used by the model.

The timeslice information generated in the LoadCalibration workbook consists of the year breakdown (G_YRFRs) and the demand timing fractions (COM_FRs). This timeslice information is linked to the EB_Starter workbook, and then cascades into each of the sector workbooks. The timeslice information – particularly the period definitions, need to be taken into consideration when assigning the demand timing fractions for each end-use service with timing requirements (e.g., heating, cooling, lighting in particular).

Figure 46: Load Calibration Worksheet



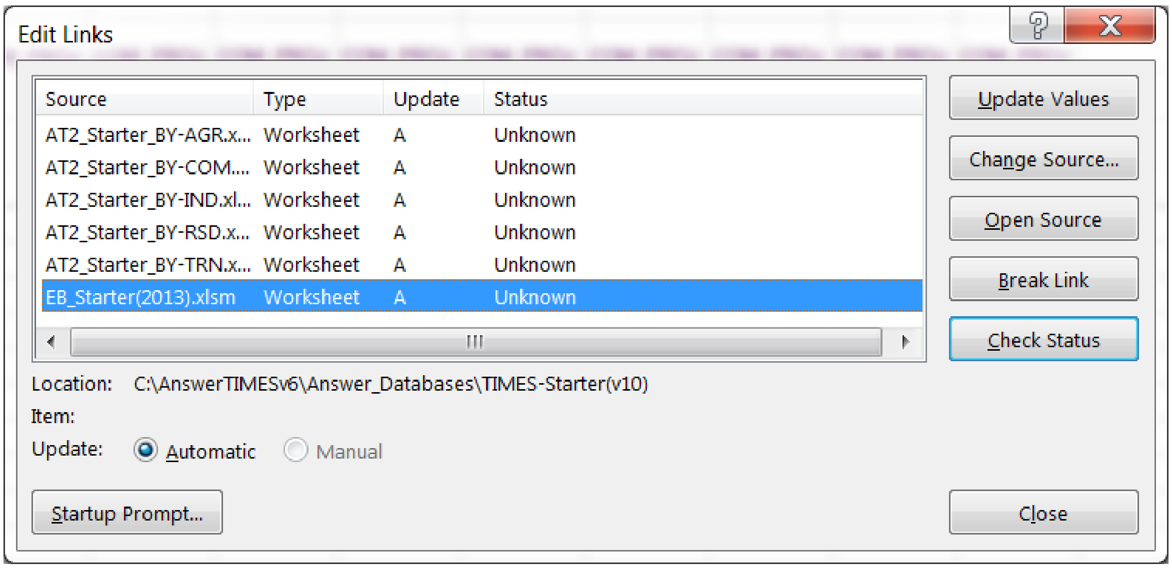
9 Forecasting Demands

A TIMES model solves to meet the projected future demand for energy services for each and every end-use service. Thus the demand projection is perhaps the first most important aspect of establishing a TIMES model. The Demand template has four (4) types of worksheets, each of which are discussed in this section.

- Base year calibration data;
- Demand drivers;
- Demand projection for each sector, and
- The ANSWER-TIMES loadsheets with the commodities (end-use service demand definitions) and projection (end-use service levels).

While there are various sophistications in terms of approaches to forecasting the energy service demands, including linking to macro-economic models[13], a rather straightforward yet reasonable and transparent approach is employed for the TIMES-Starter. The demand projections are seeded by the initial period energy service demand, as determined by the calibration process.   Figure 47 shows that these BY values are coming from the BY templates, and Figure 48 shows the current levels as collected on the base year calibration data tab.   The <sect> Demand tabs use the various demand drivers and sector-based elasticities to project future energy demands for each of the model demands as shown in Figure 49.

Figure 47: Demand Template Dependencies



For the Industry subsectors, two approaches are available. One uses subsector-based production growth indices, as shown in Figure 49, and the other uses elasticities to GDP, such as shown in the Residential demand example in Figure 50.

[13] Workshop on linking TIMES with economic model can be found at http://www.iea-etsap.org/web/UCC_Workshop14.asp and http://www.iea-etsap.org/web/Copenhagen_Nov2014.asp and summarized in '*Economic Impacts of Future Changes in the Energy System—Global Perspectives* chapter in **Springer Book** 'Informing energy and climate policies using energy systems models' 2015.

Figure 48: BY Calibration Demand Levels

Start year		2013	
		Base Year Data per Sector	
		Agriculture sector	
	BASE YEAR DATA (from BY templates)		PJ
	AWP	Agriculture Water Pumping	0.04
	ATH	Agriculture Tractors	0.07
*	ATF	Agriculture Tractors - Farm Op.	-
	AOE	Agriculture Other Use	-
		Commercial sector	
	BASE YEAR DATA (from BY templates)		PJ
	CSH	Commercial Heating	6.98
	CSC	Commercial Cooling	2.79
	CWH	Commercial Water Heating	0.93
*	CVT	Commercial Ventilation	-
	CCK	Commercial Cooking	0.64
	CLT	Commercial Lighting	0.46
	CRF	Commercial Refrigeration	0.98
*	COF	Commercial Office Equipment	-
		Residential sector	
	BASE YEAR DATA		PJ
	RHH	Residential Heating	46.26
	RHC	Residential Cooling	8.38
	RHW	Residential Water Heating	4.26
	RHR	Residential Refrigeration	0.54
*	RHK	Residential Freezing	-
	RHL	Residential Lighting	2.17
	RHO	Residential Other Appliances	1.30

	Transport sector		
BASE YEAR DATA			
* Light Duty			
TLD	Transport: Light Duty Vehicles	5.61	Bv-km
* Heavy Duty			
TAI	Transport: Air	0.02	bn-pass-km
TBU	Transport: Bus	0.22	Bv-km
TMD	Transport: Medium Duty Trucks	0.34	Bv-km
THS	Transport: HDV Short Haul	0.26	Bv-km
THL	Transport: HDV Long Haul	0.11	Bv-km
TSH	Transport: Ship	0.17	bn-t-km
TRF	Transport: Rail - Freight	0.86	bn-t-km
TRP	Transport: Rail - Passanger	1.65	bn-pass-km
TCT	Transport: Commercial Truck	0.82	Bv-km
* Off Road			
TOH	Transport: Off-road	-	Bv-km
	Industrial sector		
BASE YEAR DATA (from BY templates)		PJ	
ICHT	Chemical High Temperature	0.21	
ICLT	Chemical Low Temperature	-	
ICMD	Chemical Mechanical	0.93	
IFHT	Food High Temperature	1.92	
IFLT	Food Low Temperature	-	
IFMD	Food Mechanical	0.92	
IIHT	Iron Steel High Temperature	1.46	
IILT	Iron Steel Low Temperature	-	
IIMD	Iron Steel Mechanical	2.31	
IMHT	Non-metallic High Temperature	10.37	
IMLT	Non-metallic Low Temperature	-	
IMMD	Non-metallic Mechanical	0.38	
IOHT	Other High Temperature	0.95	
IOLT	Other Low Temperature	-	
IOMD	Other Mechanical	0.71	

Figure 49: Demand Drivers

			Demand Drivers							
		2013	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Driver										
GDP	**unit**	6,187	6,589	8,017	10,232	13,059	16,667	21,271	27,148	34,649
Population	**1000 persons**	4400	4400	4511	4625	4742	4862	4984	5110	5239
Number of persons per household		3.80	3.76	3.67	3.58	3.49	3.40	3.32	3.24	3.16
GDP growth			3.20%	4.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%
Population growth			0.00%	0.50%	0.50%	0.50%	0.50%	0.50%	0.50%	0.50%
GDP/pop			3.20%	3.48%	4.48%	4.48%	4.48%	4.48%	4.48%	4.48%
Number of persons per household			-0.50%	-0.50%	-0.50%	-0.50%	-0.50%	-0.50%	-0.50%	-0.50%
Non-energy gas consumption			30.00%	4.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%
Degree days base year	2553									
Degree days average	2584	1.012								
Number of years after first period	2									
Number of years per period after second period	5									
production index growth			2015	2020	2025	2030	2035	2040	2045	2050
Chemical industry			3.20%	4.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%
Food, Beverages and Tobaco industry			3.20%	4.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%
Iron and steel industry			3.20%	4.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%
Non-metallic minerals industry			3.20%	4.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%
Other manufacturing industry			3.20%	4.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%
Construction			3.20%	4.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%
Non-ferrous metals industry			3.20%	4.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%
		100	103.20	107.33	112.69	118.33	124.25	130.46	136.98	143.83

In addition to the demand drivers and elasticities, there are other factors that shape the demand projections, such as the number of persons per household, dependency of the service to the driver(s), saturation rate for the service, and so on. See the instructions on each of the sheets in the workbook.

Once all the components of the projection are assembled they are applied to prepare the forecast for each end-use, where the Residential sector is shown Figure 50.

Figure 50: Residential Demand Forecast

Number of dwellings	**2013**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Population	4400	4400	4511	4625	4742	4862	4984	5110	5239
Number of persons per household	3.80	3.76	3.67	3.58	3.49	3.40	3.32	3.24	3.16
Total number of households	1158	1170	1230	1293	1359	1429	1502	1579	1660
destruction rate per year (destrate)	0.2%								
old dwellings	1158	1153	1142	1130	1119	1108	1097	1086	1075
new dwellings		16	88	162	240	321	405	493	584
TOTAL	1158	1170	1230	1293	1359	1429	1502	1579	1660
SPACE HEATING									
Correction for degree days of total heat d	46.82								
heat demand new/old (neffgain)	1.0								
AEI factor for old (deffgain) (per year)	0.01								
	2013	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Elasticity for evolution with GDP/POP		0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Heating demand per old dwelling	0.0404	0.0404	0.0405	0.0412	0.0419	0.0426	0.0434	0.0441	0.0449
Heating demand per new dwelling		0.0404	0.0404	0.0405	0.0412	0.0419	0.0426	0.0434	0.0441
Heating demand total old dwellings	46.8207	46.5963	46.2356	46.5662	46.8992	47.2345	47.5722	47.9124	48.2550
Heating demand total new dwellings		0.6588	3.5452	6.5664	9.8737	13.4311	17.2560	21.3672	25.7846
Total Heating Demand (PJ)	46.82	47.26	49.78	53.13	56.77	60.67	64.83	69.28	74.04
HOT WATER HEATING									
	2013	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Elasticity for evolution with GDP/pop		1.0	1.0	1.0	0.8	0.6	0.4	0.2	0.1
Hot water demand per dwelling and per p	0.0010	0.0010	0.0012	0.0015	0.0018	0.0021	0.0023	0.0024	0.0024
Total Hot Water Demand (PJ)	4.26	4.54	5.53	7.05	8.62	10.09	11.31	12.12	12.71
SPACE COOLING									
Cooling demand per dwelling	**2013**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Apartments - Urban		4.00%	4.00%	4.00%	4.00%	4.00%	4.00%	4.00%	4.00%
Share of dwellings with cooling	30.00%	34.00%	38.00%	42.00%	46.00%	50.00%	54.00%	58.00%	62.00%
Elasticity for evolution with GDP/POP		0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Cooling demand per dwelling	0.0241	0.0247	0.0265	0.0290	0.0317	0.0346	0.0378	0.0413	0.0452
Total Cooling Demand (PJ)	8.38	9.84	12.39	15.73	19.79	24.72	30.67	37.84	46.47

10 Reference Scenario Guidance

The Reference (or sometimes called business-as-usual (BAU)) scenario strives to describe the evolution of the energy system following current practices and trends, while also reflecting all policies on the books that might influence that process. This scenario then serves as the point of departure for using TIMES to conduct an assessment of alternate futures in response to technology developments and policy interventions. But as discussed in the rest of this section there is a bit of an art to designing a viable Reference scenario that remains flexible enough to respond to these altered futures that are to be evaluated to assist with advising the formulation of such policies and measures.

10.1 The Need to Guide the Reference Scenario

A TIMES model makes all choices based upon a strict least-cost optimization. In principle, the better one depicts *all* relevant costs in the model, the better a Reference scenario can represent a BAU evolution of the energy system. However, there are many costs, both “hard” monetary costs and “soft” transaction, information, and consumer preference costs, that are difficult to value and enter into the model, but which cause real-world economic choices to differ from the choices an unguided TIMES model would make. Some of these costs are identified here.

- Infrastructure costs: There may be limitations on the ability to deliver some fuels to some sectors/businesses/dwellings, for example, owing to limited distribution infrastructure. In principle, where data exists for these costs, they should be represented in the model and included in its calculations. However, estimating these costs can be a very geographically specific process, and so good data may not be available. An alternative approach may be to limit the penetration of the relevant commodity within each sector/demand according to the status of infrastructure availability, potentially including a projection of availability increase over time..
- Hardware conversion costs: Even where fuels are available, there may be costs associated with converting an individual plant/dwelling from one fuel to another. Again, in principle it would be desirable to include these costs in the model, but in practice they are very difficult to estimate, and often consumers have inertia in that they prefer to stay with what they know rather than move to something else.
- Information and transaction costs/limitations: New or advanced devices may not be as widely available as standard devices, or individual sector decision-makers may be unfamiliar with them and unaware of their life-cycle cost effectiveness, or they may simply prefer to stick with devices they are familiar with.
- Financing costs/ limitations: Although individual sector decision-makers may prefer a new/advanced device due to its lower life-cycle costs, they may not be able to finance the upfront capital cost.
- Split incentives: In the residential or commercial sectors, when capital costs are paid by building owners and fuel costs are paid by renters, mismatched incentives may prevent higher capital cost, higher efficiency devices and conservation measures (such as insulating) from being selected.
- Other consumer preferences: Consumers may value attributes of a more expensive fuel or device beyond its direct costs and efficiency. Examples include the range of consumer preferences for light duty vehicles (LDV) of different sizes, which must be imposed on the model to prevent it from meeting the entire LDV demand with compact cars, and preferences for more convenient and cleaner liquid and gaseous fuels over solid fuels for space heating.

In order to represent these costs, or the impacts of these costs, on real world choices, a variety of mechanisms are used to guide the Reference scenario to better reflect likely BAU outcomes.

10.2 Types of Guidance Mechanisms

To handle each of the challenges mentioned in the previous section a variety of available mechanisms and how they have been implemented in the TIMES-Starter Model are discussed in the next subsections. The sections that follow also discuss considerations that must be thought through in determining whether and how to adjust these mechanisms in policy scenario runs.

10.2.1 Forced operation of existing devices

Uncontrolled, the model may choose to abandon (stop using) existing power plants and demand devices before the end of their technical life, if they are sufficiently inefficient relative to new devices that the model finds it cheaper to replace them. While this may be efficient from a system perspective, in a BAU world, individuals rarely toss out an appliance or scrap a car before it "dies" and capital may be unavailable to prematurely replace existing devices. To represent this limitation, the existing devices may be forced to continue to operate at a specified fraction of their potential output but setting a gradually fading away lower bound.

In the TIMES-Starter model, this mechanism has been illustrated in the BOUNDLO scenario, which forces operation of existing power plants over the initial model periods at a declining percentage of their base year operation levels. Figure 51 shows a screenshot of the ProcData sheet of the BOUNDLO scenario template. As a starting point, it provides a lower bound on activity (ACT_BND-LO) for all existing electricity, CHP, and district heating plants in two model periods, 2015 and 2025, with interpolation between them. The lower bound for each process is calculated as the product of its base year electricity or heat production, as entered in the Calibration worksheet in the PP-BY template, and the desired minimum level of operation relative to that base year operation, as specified in the orange cells. Different control cells for ELE, CHP, and HPLs have been provided, and in 2025, ELEs have been further differentiated by fuel type, so that the user may easily release bounds on some processes in policy scenarios that might benefit from the option to reduce utilization of some units, for example, in a renewable portfolio standard (RPS) scenario. An example of such a reduction is provided in the BOUNDLO-RED (for reduced) scenario, which has been included in place of BOUNDLO in several of the example policy scenarios in the Starter database.

The user may wish to customize this scenario by setting different forced operation levels for different plants, or by extending the time horizon of forced operation (taking care that no devices are forced to operate beyond their technical LIFE, which will lead to an infeasibility.)

Figure 51: BOUNDLO Scenario Template

	A	B	C	D	E	F	G	H	I	J
1	ProcData	STARTER								
2										
3	Check Sheet	ProcName, ProcDesc, Units			CommIN	CommOUT				
4	Parameter				*			ACT_BND-LO	ACT_BND-LO	ACT_BND-LO
5	Qualifier1							ANNUAL	ANNUAL	ANNUAL
6	Qualifier2									
7		ProcName	ProcDesc	ProcUnits	CommIN	CommOUT	Activity I/O	2015	2025	0
8		EERNWHYD-DM-X0	Hydro (Dam) (Existing)	PJ,GW	PWRRNWH\	ELCT		1.425	0.975	1
9		EERNWHYD-RR-X0	Hydro (Run-of-River) (Existing)	PJ,GW	PWRRNWH\	ELCT		0.475	0.325	1
10	*	EERNWHYD-PS-X0	Hydro (Pumped Storage) (Existing)	PJ,GW	PWRRNWH\	ELCT		0	0	1
11		EEGASNAT-CC-X0	Natural Gas - Combined cycle (Existing)	PJ,GW	PWRGASNA	ELCT		2.85	1.95	1
12		EEGASNAT-CT-X0	Natural Gas - Combustion turbine (Existing)	PJ,GW	PWRGASNA	ELCT		3.18744	1.308528	1
13		EECOAOBC-ST-X0	Bituminous (Brown Coal) - Steam turbine (Ex	PJ,GW	PWRCOAOE	ELCT		1.425	0.585	1
14		EECOASBC-ST-X0	Sub-Bituminous Coal - Steam turbine (Existin	PJ,GW	PWRCOASB	ELCT		1.425	0.585	1
15		EECOALIG-ST-X0	Lignite - Steam turbine (Existing)	PJ,GW	PWRCOALIC	ELCT		1.425	0.975	1
16		EECOALIG-IG-X0	Lignite - Integrated Gasif. (Existing) Combine	PJ,GW	PWRCOALIC	ELCT		0.95	0.65	1
17		EENUCLER-LWR-X0	Nuclear - LWR (Existing)	PJ,GW	PWRNUCLEI	ELCT		10.45295155	7.152019481	1
18		EEBIOGAS-EN-X0	Biogases - Engine (Existing)	PJ,GW	PWRBIOGA!	ELCT		0.475	0.195	1
19		EEBIOGAS-GT-X0	Biogases - Gas turbine (Existing)	PJ,GW	PWRBIOGA!	ELCT		0.475	0.195	1
20		EEBIOGAS-ST-X0	Biogases - Steam turbine (Existing)	PJ,GW	PWRBIOGA!	ELCT		0.2375	0.0975	1
21		EEBIOGAS-CC-X0	Biogases - Combined cycle (Existing)	PJ,GW	PWRBIOGA!	ELCT		0.2375	0.0975	1
22		EEBIOMSW-ST-X0	Municipal Waste - Steam turbine (Existing)	PJ,GW	PWRBIOMS\	ELCT		0.95	0.65	1
23		EEBIOPSF-IG-X0	Primary Solid Biofuels - Integrated Gasif. Com	PJ,GW	PWRBIOPSF	ELCT		0.646	0.442	1
24		EERNWGEO-ST-X0	Geothermal - Steam turbine (Existing)	PJ,GW	PWRRNWGE	ELCT		0.475	0.325	1
25		EERNWSOL-TC-X0	Solar - Thermal Central (Existing)	PJ,GW	PWRRNWSC	ELCT		0.95	0.65	1
26		EERNWWIN-ON-X0	Wind - Onshore (Existing)		PWRRNWWI	ELCT		0.95	0.65	1
27		EERNWWIN-OF-X0	Wind - Offshore (Existing)		PWRRNWWI	ELCT		0.475	0.325	1
28		EHBIOPSF-ST-X0	Coupled Heat & Power Primary Solid Biofuels - Steam turb		PWRBIOPSF	ELCT		0.730769231	0.5	1
29						LTHC				
30		EHCOAANT-ST-X0	Coupled Heat & Power Anthracite (Hard Coal) - Steam tur		PWRCOAAN	ELCT		1.235	0.845	1
31						LTHC				
32		EHGASNAT-CC-X0	Coupled Heat & Power Natural Gas - Combined cycle (Exi		PWRGASNA	ELCT		1.357142857	0.928571429	1
33						LTHC				
34		EHGASNAT-EN-X0	Coupled Heat & Power Natural Gas - Engine (Existing)		PWRGASNA	ELCT		0.863636364	0.590909091	1
35						LTHC				
36	*	EHOILFOI-ST-X0	Coupled Heat & Power Fuel Oil - (Existing)		PWROILFOI	ELCT		0	0	1
37						LTHC				

	L	M	N	O	P	Q	R	S	T	U	V	W
4	2015 MIN %	ELE	CHP	HPL		2025 MIN %	ELE-COAL	ELE-GAS	ELE-RE	ELE-NUC	CHP	HPL
5		95%	95%	95%			65%	65%	65%	65%	65%	65%

Evelyn:
Enter desired minimum operation levels, relative to base year operation.

10.2.2 Market share constraints

Market share constraints can be imposed to provide "friction" in the model, slowing it from switching between devices or groups of devices used to produce a given commodity or commodities, or meet a demand. For example, they may be used to maintain the share of heating demand met by a particular fuel or kind of device (e.g., stove vs furnace), or to slow the penetration of a class of improved devices, such as LED light bulbs.

Devices can be forced to a minimum or maximum share of the consumption or production of a specified commodity (including energy service demands) using the FLO_MARK parameter for an individual device or the UCRULE_MARK user constraint to restrict a class or group of devices. To impose a market share constraint on a group of technologies, the TIMES user constraint capability is used along with ANSWER Named Filters. In order to group existing and new technologies together, and retain flexibility for the user to add multiple devices in each demand/fuel/type set, the user constraint mechanism has been used in the TIMES-Starter model instead of the FLO_MARK parameter. Section 10.3 provides a closer look at how these market share user constraints have been implemented in the TIMES-Starter model.

10.2.3 Hurdle rates

Although the model contains an overall global discount rate (G_DRATE) used to discount all costs to a base year, technology-specific discount rates may be set (using NCAP_DRATE) to represent financing costs applicable to a particular device or sector. (For example, power plants may face financing costs in the range of 10-15 percent, while residential purchases may face higher financing costs reflecting the use of credit cards or consumer loans for purchases.) This parameter may also be used to represent some of the soft costs described above that impede the penetration of more efficient devices. In this usage, the parameter is called a "hurdle" rate, as it represents additional impediments that a device must overcome in order to be attractive to consumers. For example, households may behave as if they face financing costs of 50 percent or higher, or they require very short payback periods in order to choose a more efficient device with a higher upfront cost.

While a technically sound approach to modeling these soft costs, hurdle rates can be challenging to use in practice because the appropriate values are difficult to estimate, and they introduce an artificial cost into the objective function that can make scenario cost comparisons difficult. So in TIMES what is usually done is apply hurdle rates to improved devices that slow their penetration in the Reference scenario to an acceptable level, which may mean keeping them out altogether. Then when doing policy scenarios that are aimed at lowering the barriers to the uptake of such technologies, the hurdle rates can be lowered and their penetration evaluated. To help with this task the TIMES report writer splits out the core investment expenditures (using the global discount rate) and the amount arising due to the higher discount rate. This helps give a sense of the potential costs and benefits of policies that have the potential to lower these hurdle rates.

{Although the templates contain entries for NCAP_DRATE (from USEPA), they are commented out for demand devices at this time (though are used for some heating plants (HPLs). A mechanism will be introduced where hurdle rates may be used in place to UC_<sect> new technology market penetration limiting constraints.}

10.2.4 BOUNDS and GROWTH rates on new technology uptake

It may be the case that for some technologies there are real-world impediments to them quickly being adapted and deployed. Examples might be that the necessary skills to put up wind turbines or the number of electric car charging stations are limited, or it may be difficult to gain consumer acceptance or financing for the first examples of new technology adoption. To handle such situations one may specify a direct bound on such a technology or use the TIMES dynamic bound user constraint facility that limits the penetration of a new technology based upon a specified percent increase over what is already deployed.

An example of the former has been provided in the TECH-BOUND scenario, which places an upper capacity bound (CAP_BND-UP) on the CHP technology EHGASNAT-CC, which proved to be very attractive in policy runs using the default Starter model configuration. The bound starts at 50 MW in 2015, the year of the device's first availability, and ramps up to 500 MW, or approximately 15% of total model capacity, by the end of the horizon. The user should review this bound to see if it is appropriate for their model, as well as assess whether there are other technologies that should receive a bound to directly slow their penetration rate.

10.3 A Closer Look at Market Share User Constraints in the TIMES-Starter Model

Market share constraints enable various aspects of the evolution of the energy system to be guided while not imposing explicit bounds on individual technologies options. The mechanism can be easily implemented in an ANSWER-TIMES model by use of the UC_MARK parameter, when a single commodity (demand) is involved. To identify the group of technologies that are to be subjected to a market share constraint, an ANSWER Named Filter is used.

The following categories of Named Filters have been created in the TIMES-Starter model, where the lead character is used as part of naming the filters and the corresponding market share constraints.

- **F**uel: used to group devices by demand served and fuel consumed, for example, natural gas residential space heaters, or electric commercial cooking devices. Constraints built using these filters represent inhibitions on consumers switching fuels used to meet demands, due to infrastructure or hardware limitations, or familiarity and preferences.
- **T**ype: used to group devices of any previously defined type. Constraints built using these filters may be used to slow penetration of a class of advanced devices, such as hybrid vehicles, or may represent limitations on the applicability of one type of device to meeting only a portion of a given demand, such as walk-in freezers, or rooftop commercial air conditioners. As described in Section 5.4, these types have been incorporated into demand device names by means of strict naming conventions in each SETUP sheet, in order to facilitate their use in building Named Filters.
- **Q**uality: used to group devices of a similar designated level of energy efficiency. Options include: standard, improved, best, and advanced. (Note: "advanced" devices have higher efficiencies than those named "best".) As with types, these quality levels have been built into device names to facilitate their grouping into Named Filter sets. Example constraints using these filters have

been constructed to illustrate how to use them to slow penetration of high-efficiency devices across whole sectors and individual demands.

- **S**<u>ize</u>: used only for size classes of light-duty vehicles, such as compact, full-size, minivan, etc. These vehicle classes have inherently different efficiencies due to their weight and configuration, and it is necessary for the user to specify the evolution of consumer preferences for these size classes.

These filters are built manually in ANSWER, using the Named Filters facility shown in Figure 52 for the natural gas devices meeting the Residential Water Heating demand. The resulting TIMES user-defined constraint equation can be previewed by going to the Constraints tab, highlighting the constraint of interest, and requesting via the right-mouse Resolve Rule-based Constraint, with the resulting equation components displayed along the lines shown in Figure 53.

Figure 52: ANSWER Named Filter Specification Form

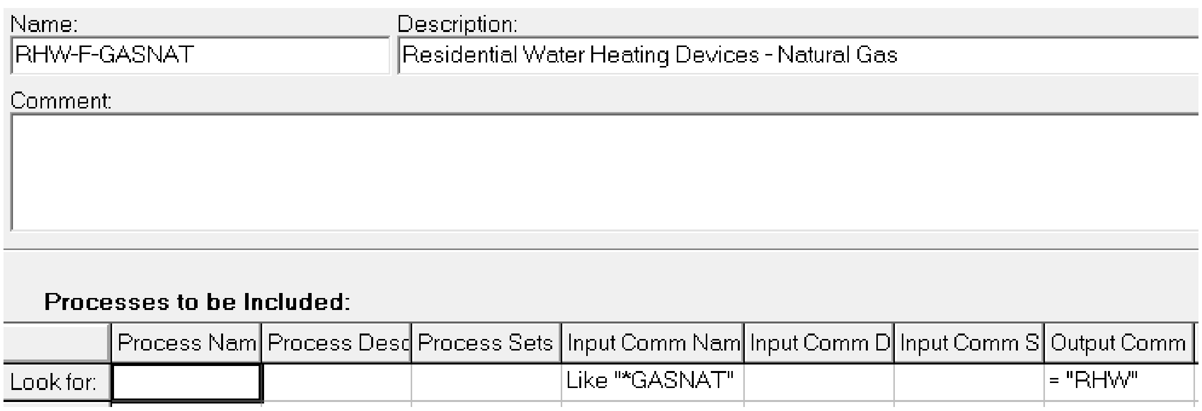
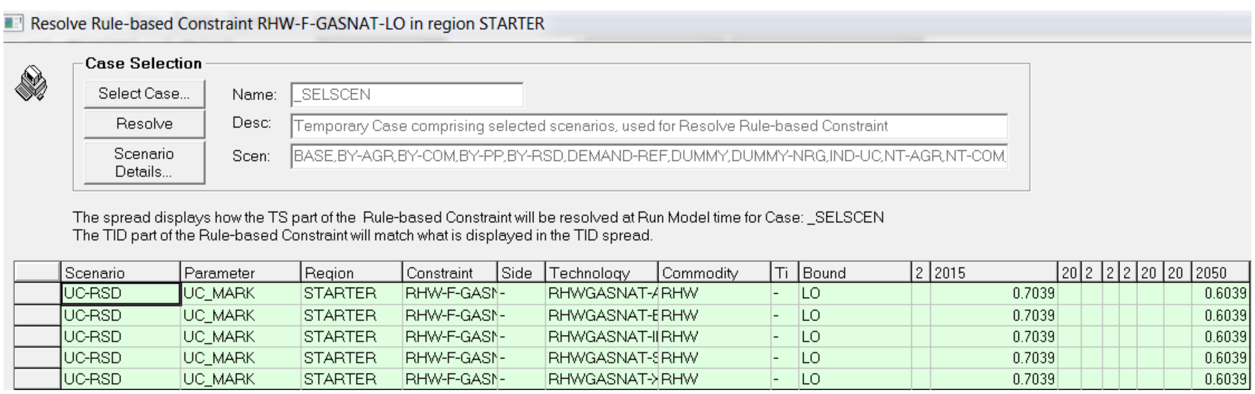


Figure 53: ANSWER Resolve User Constraint Display



	Scenario	Parameter	Region	Constraint	Side	Technology	Commodity	Ti	Bound	2	2015	20	2	2	2	20	20	2050
	UC-RSD	UC_MARK	STARTER	RHW-F-GASN	-	RHWGASNAT-A	RHW	-	LO		0.7039							0.6039
	UC-RSD	UC_MARK	STARTER	RHW-F-GASN	-	RHWGASNAT-E	RHW	-	LO		0.7039							0.6039
	UC-RSD	UC_MARK	STARTER	RHW-F-GASN	-	RHWGASNAT-II	RHW	-	LO		0.7039							0.6039
	UC-RSD	UC_MARK	STARTER	RHW-F-GASN	-	RHWGASNAT-S	RHW	-	LO		0.7039							0.6039
	UC-RSD	UC_MARK	STARTER	RHW-F-GASN	-	RHWGASNAT-X	RHW	-	LO		0.7039							0.6039

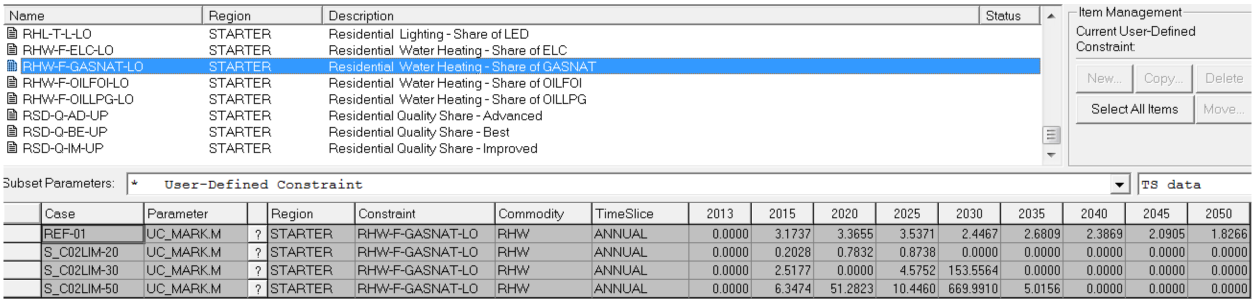
To complete the naming of the user constraints built in TIMES to control the market shares the sector, fuel, and sense are incorporated, as seen below for the list of current Residential share constraints, where RH = Residential Heating, H = Households, F = Fuel type constraint, GASNAT = the fuel, and LO = sense of the equation.

Figure 54: Residential Market Share Constraints

RHC-F-ELC-LO	STARTER	Residential Cooling - Share of ELC
RHC-F-GASNAT-UP	STARTER	Residential Cooling - Share of GASNAT
RHC-T-C-LO	STARTER	Residential Cooling - Share of Central
RHC-T-R-LO	STARTER	Residential Cooling - Share of Room
RHH-F-BIOPSF-UP	STARTER	Residential Heating - Share of BIOPSF
RHH-F-ELC-LO	STARTER	Residential Heating - Share of ELC
RHH-F-GASNAT-LO	STARTER	Residential Heating - Share of GASNAT
RHH-F-OILFOI-LO	STARTER	Residential Heating - Share of OILFOI
RHH-F-OILKER-LO	STARTER	Residential Heating - Share of OILKER
RHH-F-OILLPG-LO	STARTER	Residential Heating - Share of OILLPG
RHH-Q-AD-UP	STARTER	Residential Heating Quality Share - Advanced
RHH-Q-BE-UP	STARTER	Residential Heating Quality Share - Best
RHH-Q-IM-UP	STARTER	Residential Heating Quality Share - Improved
RHH-T-F-LO	STARTER	Residential Heating - Share of Furnace
RHH-T-H-LO	STARTER	Residential Heating - Share of Heat Pump
RHH-T-R-LO	STARTER	Residential Heating - Share of Radiant
RHH-T-S-LO	STARTER	Residential Heating - Share of Stove
RHL-T-C-LO	STARTER	Residential Lighting - Share of CFL
RHL-T-F-LO	STARTER	Residential Lighting - Share of Fluorescent
RHL-T-H-LO	STARTER	Residential Lighting - Share of Halogen
RHL-T-I-LO	STARTER	Residential Lighting - Share of Incandescent
RHL-T-L-LO	STARTER	Residential Lighting - Share of LED
RHW-F-ELC-LO	STARTER	Residential Water Heating - Share of ELC
RHW-F-GASNAT-LO	STARTER	Residential Water Heating - Share of GASNAT
RHW-F-OILFOI-LO	STARTER	Residential Water Heating - Share of OILFOI
RHW-F-OILLPG-LO	STARTER	Residential Water Heating - Share of OILLPG
RSD-Q-AD-UP	STARTER	Residential Quality Share - Advanced
RSD-Q-BE-UP	STARTER	Residential Quality Share - Best
RSD-Q-IM-UP	STARTER	Residential Quality Share - Improved

Another important consideration when setting up the market share mechanism is the sense of the constraint, that is whether it imposes an Upper or Lower limit on the fuel or technology group. Upper limits need to be applied when something is excessively attractive to the model and lower limits used when it is not attractive, but some minimum level must be met, which may differ for the TIMES-Starter and your model. The way to ascertain this is to look at whether the constraints are binding (hitting their limit) or not by looking at the UC_MARK.M parameter in ANSWER or the Marginal Prices (User Constraint) table in VBE. For the Residential natural gas for water heating constraint above, notice that there is a lower bound applied as gas is not the least-cost choice for water heating in the Starter model and so it must be forced in, which can be seen in the ANSWER snapshot of constraint marginals shown in Figure 55. Where there are no marginals, the limit has not been reached, indicating that perhaps the sense of the equation needs to be reversed. This trial and redo process needs to be completed for all the market share constraints as part of readying the Reference scenario.

Figure 55: Market Share Constraint Marginals



Name	Region	Description	Status
RHL-T-L-LO	STARTER	Residential Lighting - Share of LED	
RHW-F-ELC-LO	STARTER	Residential Water Heating - Share of ELC	
RHW-F-GASNAT-LO	STARTER	Residential Water Heating - Share of GASNAT	
RHW-F-OILFOI-LO	STARTER	Residential Water Heating - Share of OILFOI	
RHW-F-OILLPG-LO	STARTER	Residential Water Heating - Share of OILLPG	
RSD-Q-AD-UP	STARTER	Residential Quality Share - Advanced	
RSD-Q-BE-UP	STARTER	Residential Quality Share - Best	
RSD-Q-IM-UP	STARTER	Residential Quality Share - Improved	

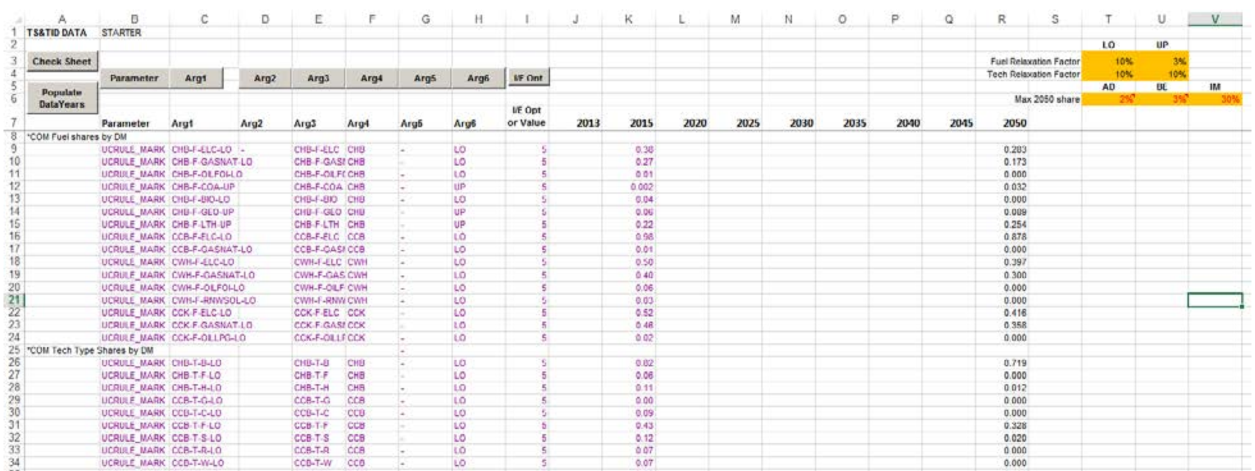
Item Management
Current User-Defined Constraint:
New... Copy... Delete
Select All Items Move...

Subset Parameters: * User-Defined Constraint TS data

Case	Parameter		Region	Constraint	Commodity	TimeSlice	2013	2015	2020	2025	2030	2035	2040	2045	2050
REF-01	UC_MARK.M	?	STARTER	RHW-F-GASNAT-LO	RHW	ANNUAL	0.0000	3.1737	3.3655	3.5371	2.4467	2.6809	2.3869	2.0905	1.8266
S_CO2LIM-20	UC_MARK.M	?	STARTER	RHW-F-GASNAT-LO	RHW	ANNUAL	0.0000	0.2028	0.7832	0.8738	0.0000	0.0000	0.0000	0.0000	0.0000
S_CO2LIM-30	UC_MARK.M	?	STARTER	RHW-F-GASNAT-LO	RHW	ANNUAL	0.0000	2.5177	0.0000	4.5752	153.5564	0.0000	0.0000	0.0000	0.0000
S_CO2LIM-50	UC_MARK.M	?	STARTER	RHW-F-GASNAT-LO	RHW	ANNUAL	0.0000	6.3474	51.2823	10.4460	669.9910	5.0156	0.0000	0.0000	0.0000

The user constraints have been constructed in AT version 1 workbooks, one for each of the COM, RSD, and TRN sectors, providing a starting point for users to adjust to their own study area. Figure 56 shows a screenshot of the fuel and technology type constraints in the UC-COM template. The 2015 share values are linked to the useful energy shares by technology group calculated on the Calibration sheet of each BY sector workbook, as discussed in Section 5.4.2.1. The 2050 values are loosened from the starting values by means of the orange-shaded control cells in the upper right corner. These cells specify the fraction of the demand that is free to move into/out of the relevant fuel/type by 2050. Note that because we tend to use the UPper bound on fuels that are less desirable (like coal and biomass) or have limits on availability and/or infrastructure (like district heat), the default relaxation value for the UPper fuel UCs has been set lower than for the LOwers.

Figure 56: UC-COM Template



TS&TID DATA STARTER

Check Sheet | Populate DataYears | Parameter | Arg1 | Arg2 | Arg3 | Arg4 | Arg5 | Arg6 | I/E Opt

	LO	UP	
Fuel Relaxation Factor	10%	3%	
Tech Relaxation Factor	10%	10%	
	AD	BE	IM
Max 2050 share	2%	3%	30%

	Parameter	Arg1	Arg2	Arg3	Arg4	Arg5	Arg6	I/E Opt or Value	2013	2015	2020	2025	2030	2035	2040	2045	2050
*COM Fuel shares by DM																	
	UCRULE_MARK	CHB-F-ELC-LO	-	CHB-F-ELC	CHB	-	LO	5		0.38							0.283
	UCRULE_MARK	CHB-F-GASNAT-LO		CHB-F-GASI	CHB		LO	5		0.27							0.173
	UCRULE_MARK	CHB-F-OILFOI-LO		CHB-F-OILF(	CHB	-	LO	5		0.01							0.000
	UCRULE_MARK	CHB-F-COA-UP		CHB-F-COA	CHB	-	UP	5		0.002							0.032
	UCRULE_MARK	CHB-F-BIO-LO		CHB-F-BIO	CHB	-	LO	5		0.04							0.000
	UCRULE_MARK	CHB-F-GEO-UP		CHB-F-GEO	CHB		UP	5		0.06							0.009
	UCRULE_MARK	CHB-F-LTH-UP		CHB-F-LTH	CHB		UP	5		0.22							0.254
	UCRULE_MARK	CCB-F-ELC-LO		CCB-F-ELC	CCB	-	LO	5		0.98							0.878
	UCRULE_MARK	CCB-F-GASNAT-LO		CCB-F-GASI	CCB	-	LO	5		0.01							0.000
	UCRULE_MARK	CWH-F-ELC-LO		CWH-F-ELC	CWH	-	LO	5		0.50							0.397
	UCRULE_MARK	CWH-F-GASNAT-LO		CWH-F-GAS	CWH	-	LO	5		0.40							0.300
	UCRULE_MARK	CWH-F-OILFOI-LO		CWH-F-OILF	CWH	-	LO	5		0.06							0.000
	UCRULE_MARK	CWH-F-RNWSOL-LO		CWH-F-RNW	CWH	-	LO	5		0.03							0.000
	UCRULE_MARK	CCK-F-ELC-LO		CCK-F-ELC	CCK		LO	5		0.52							0.416
	UCRULE_MARK	CCK-F-GASNAT-LO		CCK-F-GASI	CCK		LO	5		0.48							0.358
	UCRULE_MARK	CCK-F-OILLPG-LO		CCK-F-OILLI	CCK	-	LO	5		0.02							0.000
*COM Tech Type Shares by DM						-											
	UCRULE_MARK	CHB-T-B-LO		CHB-T-B	CHB	-	LO	5		0.02							0.719
	UCRULE_MARK	CHB-T-F-LO		CHB-T-F	CHB		LO	5		0.06							0.000
	UCRULE_MARK	CHB-T-H-LO		CHB-T-H	CHB	-	LO	5		0.11							0.012
	UCRULE_MARK	CCB-T-G-LO		CCB-T-G	CCB	-	LO	5		0.00							0.000
	UCRULE_MARK	CCB-T-C-LO		CCB-T-C	CCB	-	LO	5		0.09							0.000
	UCRULE_MARK	CCB-T-F-LO		CCB-T-F	CCB		LO	5		0.43							0.328
	UCRULE_MARK	CCB-T-S-LO		CCB-T-S	CCB		LO	5		0.12							0.020
	UCRULE_MARK	CCB-T-R-LO		CCB-T-R	CCB	-	LO	5		0.07							0.000
	UCRULE_MARK	CCB-T-W-LO		CCB-T-W	CCB	-	LO	5		0.07							0.000

Below the fuel and type constraints on this sheet are sample device quality constraints, one for each of ADvanced, BEst, and IMproved devices, as shown in Figure 57. Examples have been provided for the entire commercial sector and for the commercial space heating demand. The 2050 maximum penetration for each quality level is specified in the bottom row of orange control cells.

Figure 57: Device Quality Constraints in the UC-COM Template

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
1	TS&TID DATA	STARTER																				
2																				LO	UP	
3	Check Sheet																		Fuel Relaxation Factor	10%	3%	
4		Parameter	Arg1	Arg2	Arg3	Arg4	Arg5	Arg6	I/E Opt										Tech Relaxation Factor	10%	10%	
5	Populate DataYears																			AD	BE	IM
6																			Max 2050 share	2%	3%	30%
7		Parameter	Arg1	Arg2	Arg3	Arg4	Arg5	Arg6	I/E Opt or Value	2013	2015	2020	2025	2030	2035	2040	2045	2050				
47		UCRULE_MARK	CPL-T-D-LO		CPL-T-D	CPL	-	LO	5		0.70							0.596				
48		UCRULE_MARK	CPL-T-L-LO		CPL-T-L	CPL	-	LO	5		0.29							0.194				
49	*COM Tech Quality Class by sector																					
50		UC__RHSRT	COM-Q-AD-UP	-	-	-	-	UP	5		0											
51		UCRULE_ACT	COM-Q-AD-UP	LHS	COM-ALL	-	ANNUAL	-	5		-1%							-2%				
52		UCRULE_ACT	COM-Q-AD-UP	LHS	COM-Q-AD	-	ANNUAL	-	5		1							1				
53		UC__RHSRT	COM-Q-BE-UP	-	-	-	-	UP	5		0											
54		UCRULE_ACT	COM-Q-BE-UP	LHS	COM-ALL	-	ANNUAL	-	5		-1%							-3%				
55		UCRULE_ACT	COM-Q-BE-UP	LHS	COM-Q-BE	-	ANNUAL	-	5		1							1				
56		UC__RHSRT	COM-Q-IM-UP	-	-	-	-	UP	5		0											
57		UCRULE_ACT	COM-Q-IM-UP	LHS	COM-ALL	-	ANNUAL	-	5		-1%							-30%				
58		UCRULE_ACT	COM-Q-IM-UP	LHS	COM-Q-IM	-	ANNUAL	-	5		1							1				
59	*COM Tech Quality Class by demand - heating example provided																					
60		UCRULE_MARK	CSH-Q-IM-UP		CSH-Q-IM	CHB	-	UP	5		-1%							-30%				
61																						
62																						

Because many policy goals may entail encouraging increased uptake of more efficient devices, the user may wish to release these quality constraints somewhat in policy scenarios. UC-50 and 90 versions of the UC workbooks, with correspondingly higher 2050 UPper bounds for these quality constraints have been provided. This issue is discussed further in the next section.

10.4 Considerations for Policy Analysis

All of the mechanisms described above, when properly applied, will serve to slow down change in the energy system away from its present configuration to one that uses different fuels and higher efficiency devices. When analyzing a policy that is designed to shift the evolution of the energy system, such as a carbon policy or an energy efficiency standard, care must be taken to determine whether and how any of these mechanisms should be loosened and how to interpret the results.

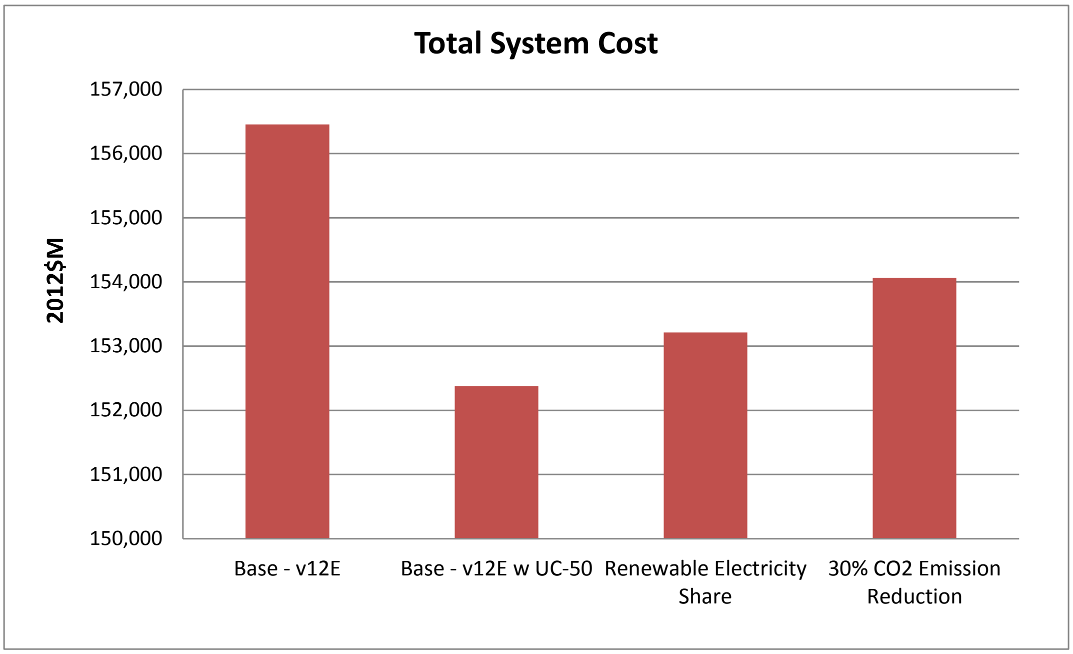
For example, a policy to promote energy efficiency will likely include measures that aim to reduce the “soft” costs described in Section 10.1. It may provide information to individual sector decision-makers about high efficiency options, offer subsidized financing, provide energy audits that identify least cost choices for consumers, or subsidize conversion costs. To evaluate the impact of these measures the user will need to loosen the mechanisms designed to represent these costs. Therefore, one way to model such a policy is to run the model with loosened guidance mechanisms and identify where the largest cost and energy savings occur. Keep in mind that when any of these mechanisms are loosened (that is, a lower bound is reduced or eliminated, an upper bound is increased or eliminated, or hurdle rates are lowered), the system cost will be reduced relative to the previously constrained scenario because the model has more freedom to make lower cost choices. In the case of this analysis, the total savings from loosening these mechanisms can be compared to the estimated costs of the policies and measures in order to determine their cost effectiveness. Alternatively, individual measures targeted at particular sectors or subsectors can be assessed by loosening only the relevant constraints/mechanisms (such as a residential energy efficiency policy that reduces hurdle rates or loosens constraints on the penetration of advanced devices.)

On the other hand, if a policy designed to induce change in the system – such a carbon constraint or price, or a standard that limits total final/primary energy or energy intensity – is implemented without loosening the Reference guidance mechanisms, the model may have little room to respond to the policy and/or the policy may be quite expensive. This approach simulates, for example, the imposition of a carbon tax without any complementary measures designed to reduce transactions and other soft costs. In this case, the user may wish to compare four scenarios:

- The Reference scenario;
- A scenario with guidance mechanisms loosened, but no other policies imposed, to represent energy efficiency promotion measures;
- The policy scenario, keeping Reference level guidance mechanisms in place, and
- The policy scenario with loosening of guidance mechanisms, to represent the policy plus complementary measures.

Figure 58 provides an example, where the Base and Base with UC-50 represents the savings inherent with reducing the soft costs discussed above, and the costs increases of the RPS and CO2 scenarios, which use UC-50 represent the additional costs of the policies after implementation of the implied soft cost measures.

Figure 58: System cost example with and without relaxed guidance mechanisms



In all cases, what is necessary is to be clear about what is being modeled in each scenario and to check if each type and instance of guidance mechanism is appropriate or not to the policy under consideration, as discussed in the next section.

11 Alternate Scenarios Basics

Alternate scenarios are usually designed to test the impact of possible changes from the Reference scenario arising from policy, supply, price or technology interventions that may alter the evolution of the energy system. Therefore, these scenarios, with a leading prefix S_, are usually based upon imposing explicit changes from Reference scenario values. These can take the form of:

- A forced change in the absolute value of a Reference scenario result, e.g. decrease in final energy consumption of 25% by a target year;
- A forced change in the share of a Reference scenario result, e.g., a target share of 50% renewable electricity generation by a target year, and
- The introduction of a cost or tax on the system, e.g., imposing a price on carbon emissions.

In the case of those scenarios that are based upon setting a target derived from a Reference scenario level, these scenarios must be seeded with the appropriate Reference scenario values, which may be done via Copy/Paste from the appropriate VBE table, and then the desired policy described and imported into ANSWER as a separate scenario that can be then be included in model runs independently of or in combination with other such scenario variants. This ability to directly impose a policy goal or other alternative view of the future and have TIMES reconfigure the resulting energy system to find the new least-cost evolution of the energy system adhering to this new development is one of the key differences between an optimization framework such as TIMES and a simulation or accounting framework (such as LEAP[14]).

As mentioned in the previous section, under most policy situations the user will want to replace the Reference scenario UCs and other Reference guidance mechanisms that restrict the rate at which fuel switching and new technology uptake can take place with looser versions that permit more fuel switching and more rapid uptake of new technologies.

11.1 Managing ANSWER Scenarios

The Starter model includes a set of example scenarios for some of the most common types of scenarios used.

- Target for renewable electricity generation (called RPS for Renewable Portfolio Standard);
- Forced reduction in CO_2 emissions by a fixed percent from the Reference scenario results;
- Forced reduction in final energy consumption by a fixed percent from the Reference scenario results
- Forced reduction in electricity consumption by a fixed percent from the Reference scenario results (setup directly in ANSWER);
- CO2 Tax, and
- GHG emissions limits;

Management of these scenarios fall into essentially two categories, those based on the Reference that require model results to be exported from VBE and simpler scenarios that can be easily setup directly in ANSWER. To facilitate the creation and reuse of such common policy scenarios the TIMES-Starter comes with a series of simple workbooks that contain a VBE table (updated via either Copy/Paste or UpdateXLS) to handle the former, and a couple of examples of the latter built directly in ANSWER, as discussed in the rest of this section. It is important when using these workbooks to make sure that the

[14] http://www.energycommunity.org/default.asp?action=47

Reference scenario and alternative scenario to be used/prepared and checked are BOTH selected as the Global Filter for the UpdateXLS operation.

The top-level result for each policy scenarios is the total discounted system cost (or model objective function), and a couple of explanations are necessary to understand change in the objective function results, shown in Figure 59. Note first off that the REF-01-50/90 scenarios are less expensive than the REF-01 itself. This is due to allowing a faster uptake of efficient technologies, which is also the case in the other S_policy runs. So the best indicator of the incremental cost of each S_policy run can be seen by comparing them against the REF-01-50 scenario, since all the policy runs use that improvement assumption in terms of the rate of technology update. Furthermore, the policy scenarios also loosen the requirements to use some existing technologies that are imposed for the REF scenarios, which gives the model a bit more freedom to shape more rapid change in the energy system. And in the case of the S_RPS scenario a higher level of hydro, solar, geothermal and wind actually enables a more cost effective configuration of the energy system then was otherwise possible, despite the extra requirement to use more renewables for electricity generation. Each of these findings is discussed in more detail under each scenario result.

Figure 59: Policy Run Objective Function Values (Total Discounted System Cost)

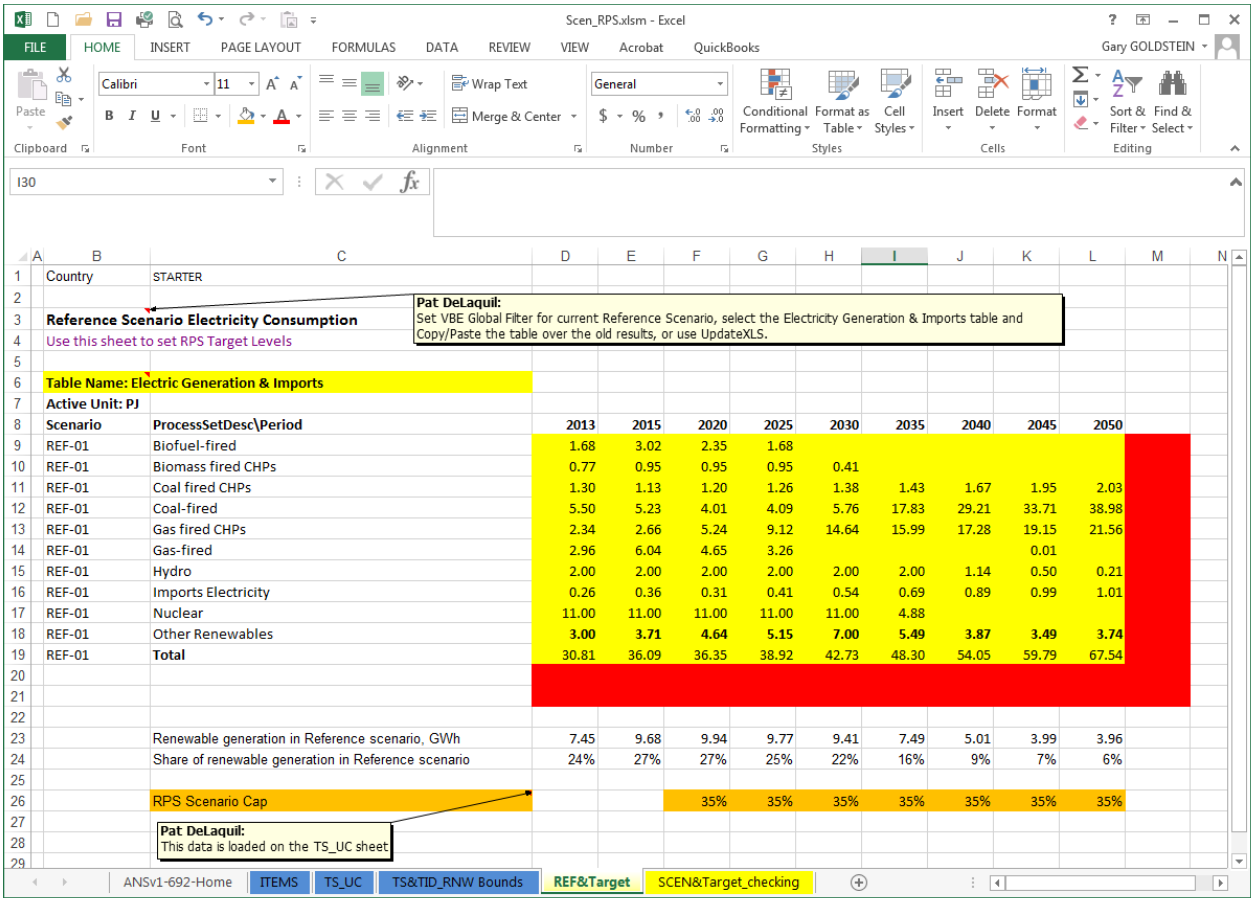
Scenario	ObjZ
REF-01	150,184
REF-01-50	146,119
REF-01-90	144,471
S_CO2LIM-20	146,647
S_CO2LIM-30	150,831
S_CO2LIM-40	151,466
S_CO2LIM-50	153,200
S_CO2TAX	214,428
S_GHGLIM-20	146,273
S_LIMFEC	150,252
S_LIMFELC	148,848
S_RPS	145,958

11.2 Renewable Electricity Portfolio Requirement (Scen_RPS)

This scenario template allows the user to set a target for a minimum percentage of electricity generation to be produced from renewable energy sources by creating a user constraint that forces electricity generated by all renewable power plants (including CHPs) to be at least the target level of total electricity generation.   The User Constraint is named P_RPS and is declared on the ITEMS sheet of this AT ver1 workbook. The target levels are specified to the model via the TS_UC tab, but they are generated on the REF&Target tab, where the Reference scenario results are captured by copy-pasting the specified VBE table as shown in the screen shot below. The VBE table shows total electricity generation & imports, and the calculations below the table provide the Reference scenario percentage of renewable energy generation to allow the target levels to be better determined.   These target levels are user-specified in the orange cells and may vary over time.

The proper operation of the scenario may be checked on the SCEN&Target_checking tab – by using the same VBE table for electricity generation, but copy-pasting the S_RPS scenario results into this checking sheet, where any variation can be seen.

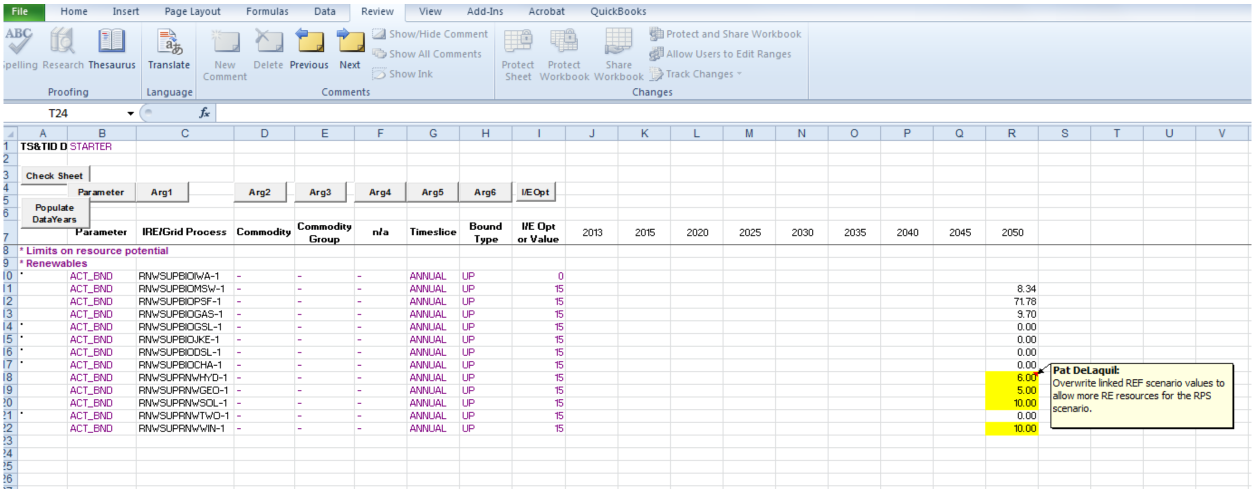
Figure 60: Renewable Electricity Portfolio Requirement Specification Table



Country	STARTER									
Reference Scenario Electricity Consumption										
Use this sheet to set RPS Target Levels										
Table Name: Electric Generation & Imports										
Active Unit: PJ										
Scenario	ProcessSetDesc\Period	2013	2015	2020	2025	2030	2035	2040	2045	2050
REF-01	Biofuel-fired	1.68	3.02	2.35	1.68					
REF-01	Biomass fired CHPs	0.77	0.95	0.95	0.95	0.41				
REF-01	Coal fired CHPs	1.30	1.13	1.20	1.26	1.38	1.43	1.67	1.95	2.03
REF-01	Coal-fired	5.50	5.23	4.01	4.09	5.76	17.83	29.21	33.71	38.98
REF-01	Gas fired CHPs	2.34	2.66	5.24	9.12	14.64	15.99	17.28	19.15	21.56
REF-01	Gas-fired	2.96	6.04	4.65	3.26				0.01	
REF-01	Hydro	2.00	2.00	2.00	2.00	2.00	2.00	1.14	0.50	0.21
REF-01	Imports Electricity	0.26	0.36	0.31	0.41	0.54	0.69	0.89	0.99	1.01
REF-01	Nuclear	11.00	11.00	11.00	11.00	11.00	4.88			
REF-01	Other Renewables	3.00	3.71	4.64	5.15	7.00	5.49	3.87	3.49	3.74
REF-01	Total	30.81	36.09	36.35	38.92	42.73	48.30	54.05	59.79	67.54
	Renewable generation in Reference scenario, GWh	7.45	9.68	9.94	9.77	9.41	7.49	5.01	3.99	3.96
	Share of renewable generation in Reference scenario	24%	27%	27%	25%	22%	16%	9%	7%	6%
	RPS Scenario Cap			35%	35%	35%	35%	35%	35%	35%

When running such an RPS scenario, it may be the case that the Reference scenario assumptions with respect to renewable potential in particular may not permit attainment of higher level targets. To accommodate this, the scenario file allows for an additional set of input changes that permit easy adjustment of the renewable resource supply bounds. The TS&TID_RNW Bounds tab reflects the levels of renewable energy resource potential in the Reference scenario. However, a renewable energy target scenario implies greater incentives to develop renewable energy resources, and those upper bounds highlighted in yellow have values that were increased for this scenario, as shown below.

Figure 61: Renewable Resource Potential Adjustment Table



The S_RPS run specification in ANSWER includes the UC-50 and BOUNDLO-REDuced versions of the Reference guidance scenarios, as discussion in Section 10.

11.3 CO2 Targets (Scen_CO2-xx)

The Starter model includes four example scenarios that force reductions in CO_2 emissions by 20, 30, 40 and 50% below the Reference scenario levels. The structure of this template, shown in Figure 62, is similar to that used for the RPS scenario, with a REF&Target tab where the Reference scenario CO_2 levels are entered from the indicated VBE table and the target levels, which vary over time, are calculated based on the reduction percentages entered in the yellow highlight cells.

Figure 62: CO_2 Emission Reduction Adjustment Table

Country	STARTER									
Reference Scenario CO2 Emissions										
Use this sheet to set CO2 Target Levels										
Table Name: CO2 Emissions (by Sector)										
Active Unit: kt										
Scenario	CommodityDesc\Period	2013	2015	2020	2025	2030	2035	2040	2045	2050
REF-12E	Carbon dioxide - Agriculture	32	24	25	26	28	30	33	36	40
REF-12E	Carbon dioxide - Commercial	178	181	193	218	232	251	274	302	333
REF-12E	Carbon dioxide - Industry	1266	1305	1433	1614	1817	2046	2303	2593	2920
REF-12E	Carbon dioxide - Power Generation	3274	3316	3718	5017	7081	10588	13920	15894	17988
REF-12E	Carbon dioxide - Residential	1601	1651	1747	1866	1939	2060	2258	2337	2377
REF-12E	Carbon dioxide - Transport	2526	2622	2894	3061	3232	3522	3981	4426	5003
REF-12E	Total	8877	9098	10010	11802	14329	18497	22770	25588	28660
	Target, % below the Reference	0	0	15%	17.5%	20.0%	22.5%	25.0%	27.5%	30%
	Target Emissions, Kt	8877	9098	8509	9736	11463	14335	17078	18551	20062

Pat DeLaquil: Set VBE Global Filter for current Reference Scenario, select CO2 Emissions (by Sector) table and Copy/Paste the table over the old results.

Anna: This data is loaded on the CommData_target sheet

Anna: Insert CO2 reduction target in this row, by year

11.4 Final Energy Consumption Reduction (Scen_LIMFEC)

The final energy consumption reduction scenario is often used to examine policies to promote energy efficiency. The structure of this template is similar to that used for the RPS and CO_2 scenarios, with a

REF&Target tab, shown in Figure 63, where the Reference scenario FEC levels, by sector) are entered from the indicated VBE table and the target levels, which vary over time, are calculated based on the reduction percentages entered in the yellow highlight cells. The FEC reductions are currently do not include the IND sector, but that will be corrected once the IND sector is built out.

Figure 63: FEC Reduction Scenario Adjustment Table

Country	STARTER									
Reference Scenario Final Energy Consumption										
Use this sheet to set FEC Target Levels										
Table Name: Final Energy Consumption (by Sector)										
Active Unit: PJ										
Scenario	**ProcessSetDesc\Period**	**2013**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
REF-12E	Agriculture	0.57	0.48	0.50	0.54	0.59	0.64	0.71	0.77	0.85
REF-12E	Commercial	9.35	9.57	10.44	11.74	13.21	14.40	15.45	16.55	18.21
REF-12E	Industry	33.17	34.18	37.55	42.28	47.60	53.59	60.34	67.94	76.49
REF-12E	Residential	67.38	66.84	66.84	68.20	69.81	72.76	77.40	80.19	80.44
REF-12E	Transportation	36.67	38.13	42.31	45.18	48.21	53.11	60.18	67.33	76.20
REF-12E	Total	147.15	149.20	157.65	167.94	179.41	194.50	214.07	232.77	252.19
	Reduction target (%)			5%	10%	15%	15%	15%	15%	15%
	Final Energy Consumption Cap		115	114	113	112	120	131	140	149

Pat DeLaquil: Set VBE Global Filter for current Reference Scenario, select Final Energy Consumption (by Sector) table and Copy/Paste the table over the old results.

Anna: Enter reduction target by year in this row

Pat DeLaquil: This data is loaded on the TS_UC sheet

11.5 Reduction of Electricity Consumption (SCEN_LIMELC)

EE policies, such as described in the previous section, often result in an increase in electricity consumption since very often when forcing a reduction in total consumption TIMES may turn heavily to electric devices given their relative efficiency (which does not take into account the conversion losses at the point of generation). This scenario forces a reduction in electricity consumption as a counterbalance to this tendency. Its structure is similar to that used for the RPS and CO_2 scenario, with a REF&Target tab where the Reference scenario ELC consumption levels, by sector) are entered from the indicated VBE table and the target levels, which vary over time, are calculated based on the reduction percentages entered in the yellow highlight cells.

11.6 GHG Emission Reduction (SCEN_GHG)

The structure of this scenario is similar to the CO_2 reduction scenarios described in Section 11.3, but is applied to the basket of Greenhouse Gas (GHG) tracked in the model including CO_2, CH4 and N2O.

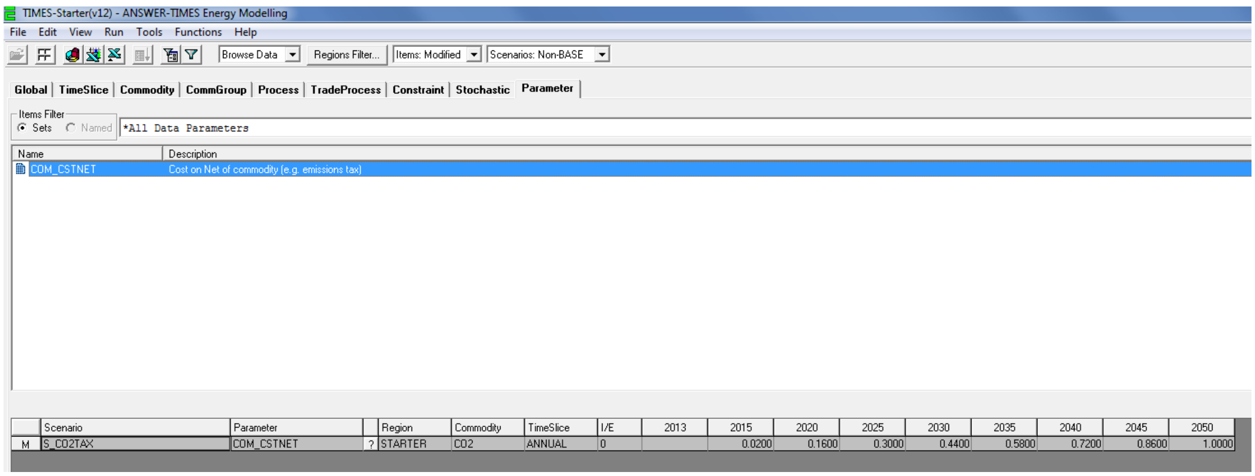
11.7 Simpler Scenario Handling Directly In ANSWER

Some scenarios are not dependent on Reference scenario results and/or require only a small amount of data to be introduced to the model, and can be handled most expeditiously directly in ANSWER, for example:

- Applying a price on CO_2. A scenario file was created for this example, but the figure below shows the ANSWER data which defines this scenario requires only one line of data to enter the price level;
- Imposing a cumulative CO_2 limit. This scenario can be defined by a single entry value, which specified the limit on cumulative CO_2 emissions (using the COM_CUMPRD parameter) so that TIMES determines the optimal timing to achieve the desired reduction level.
- Adjusting the price of oil (other energy resource), and
- Changing the cost of a technology (e.g., a nuclear power plant).

The snapshots below show an example the CO_2 price in the form of the ANSWER parameter specifications that enable it to be applied.

Figure 64: Scenario Parameter Specification in ANSWER



12 TIMES-Starter VBE Database

VEDA Back-End (VBE) is a simple to use, yet very powerful platform for managing and digging into TIMES model results. Refer to the “Using VEDA-BE with ANSWER-TIMES” manual for a fuller description of how to use VBE in conjunction with ANSWER. Here we discuss how VBE is configured to support the TIMES-Starter model.

VBE relies on solid naming conventions, like those employed for the Starter model, to ensure that the user-defined sets created for the Starter model capture all the components of the RES needed to build tables that organize the raw model results into common analysis tables, such as primary energy use, final energy use, electricity or gas production, emissions by sector, etc.. For example, the Starter VBE has sets that group fuels by their “root name” (all oil-based commodities or all forms of coal), or power plant types according to the fuels they use (all coal-fired plants), as discussed in Section 3, so that the basic energy system analysis tables included in the Starter VBE provide meaningful and digestible results that can be presented to non-modelers.

12.1 TIMES-Starter VBE Sets

The current list of Commodity Sets employed for the Starter model is shown in Figure 65. These include basic sets for energy, electricity and heat, sectoral demand and fuel-based energy sets. Note that the sets with black text are generated by TIMES, and the red-text sets were created for the Starter model which may be augmented by the user. Figure 66 shows a partial list of the Process sets employed for the Starter model, with the Commercial space heating process set selected. Process sets are often used to create subsets for energy use, capacity additions, investment requirements and emissions, and other parameters according to the fuel or plant/device type or demand sector. The list of process sets should be studied to understand what has already been created and to avoid making duplicate sets.

Figure 65: TIMES-Starter VBE Commodity Sets

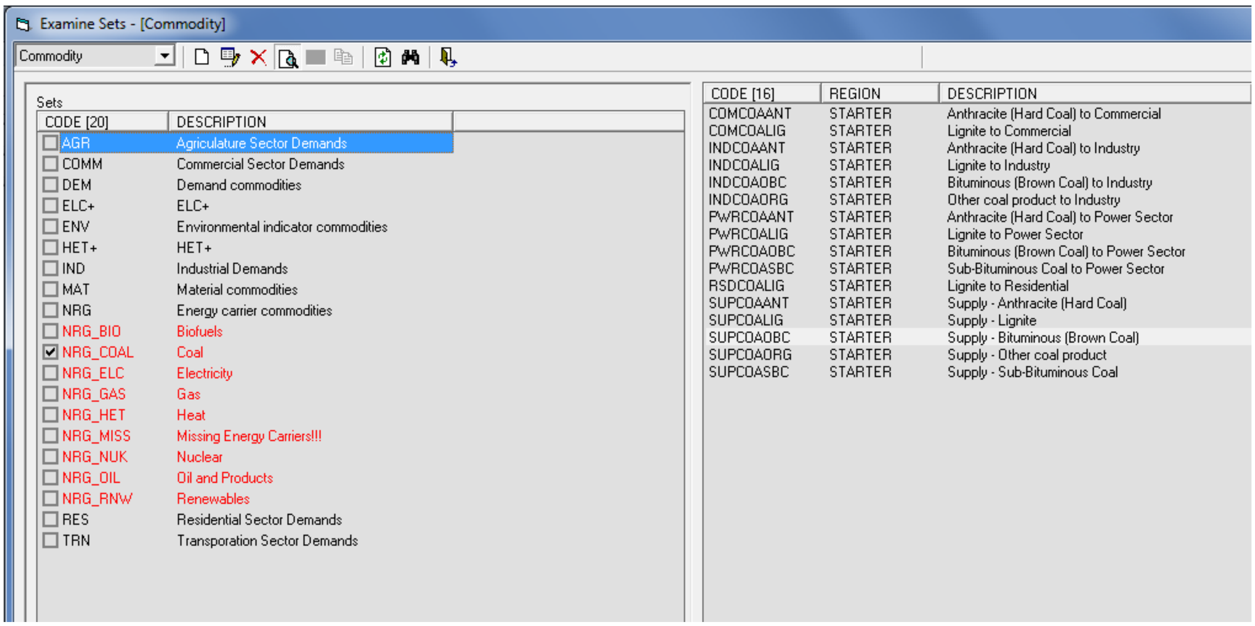
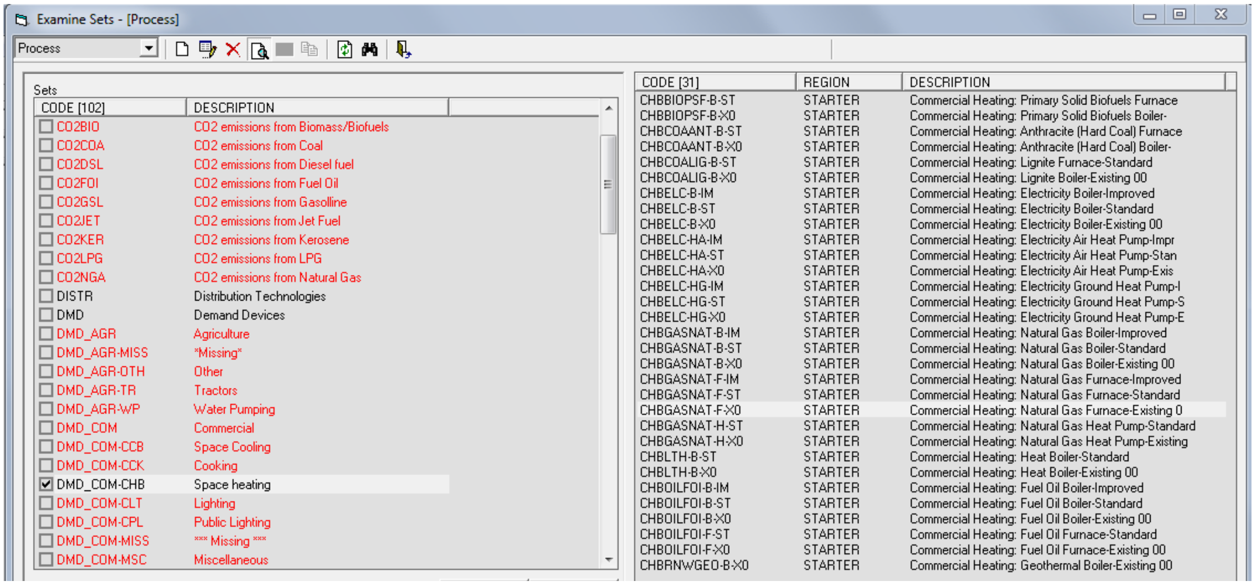
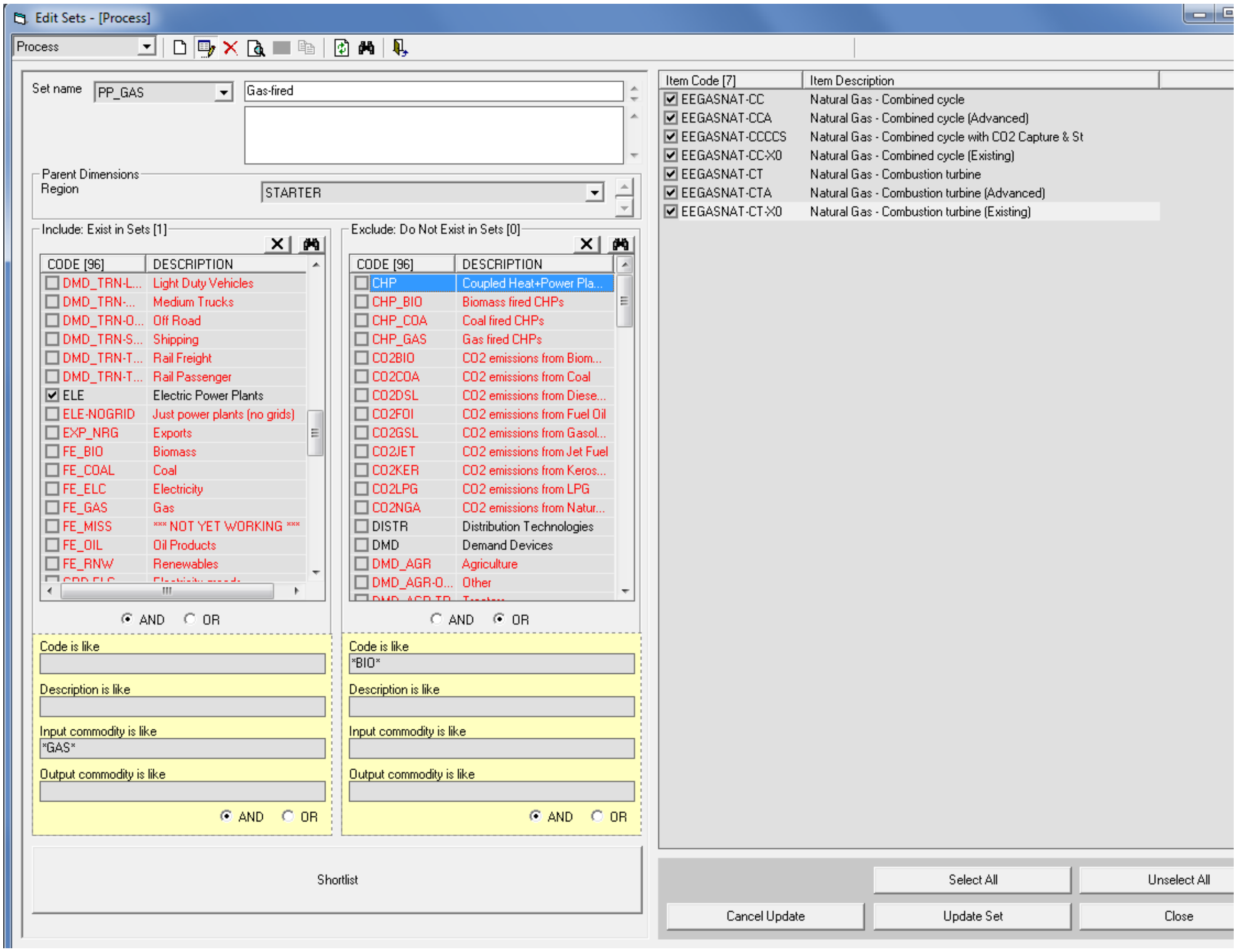


Figure 66: TIMES-Starter VBE Process Sets (Partial List)



Sets are built by specifying the "rules" that properly identify all of the appropriate entities to be included in that set by means the VBE Edit Sets form, and only those elements, as shown in Figure 67. The set shown, PP_GAS, is the set of all gas-fired power plants, and it is specified as process belonging to the set ELE with input commodity names that include GAS anywhere in the name, but exclude any input commodities that also have BIO in their name. Note that the process (or commodity) name, description, and output commodity can also be used when specifying set rules.

Figure 67: VBE Process Set Specification



12.2 TIMES-Starter VBE Tables

The VBE database that comes with the Starter model includes a full set of energy systems analysis tables as shown in Figure 68. These tables have also been organized into subsets for Costs, Final Energy, Marginals, Power Plants, and Primary Energy by means of the VBE Table Master facility shown in the figure.

Figure 68: TIMES-Starter List of Tables

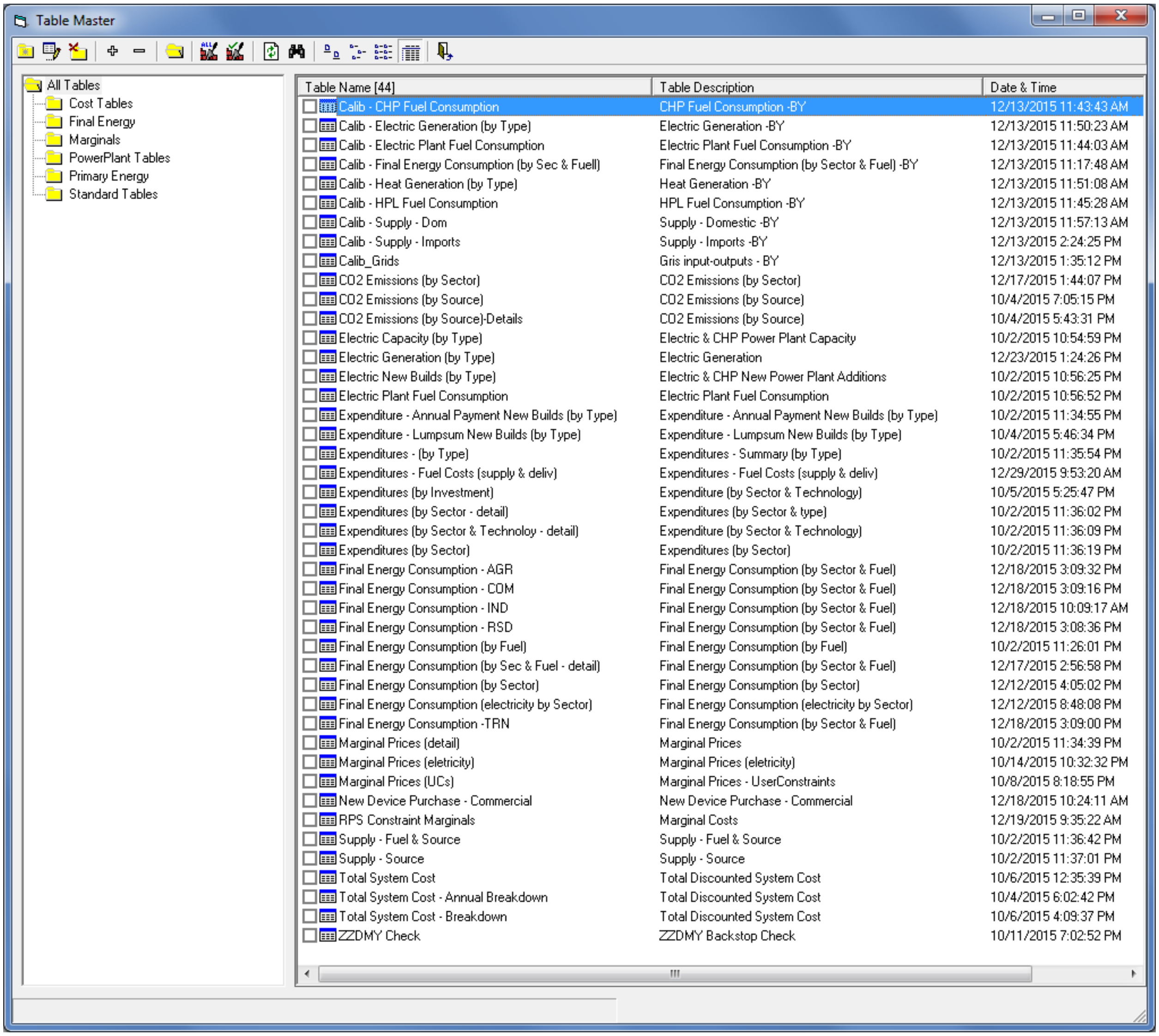
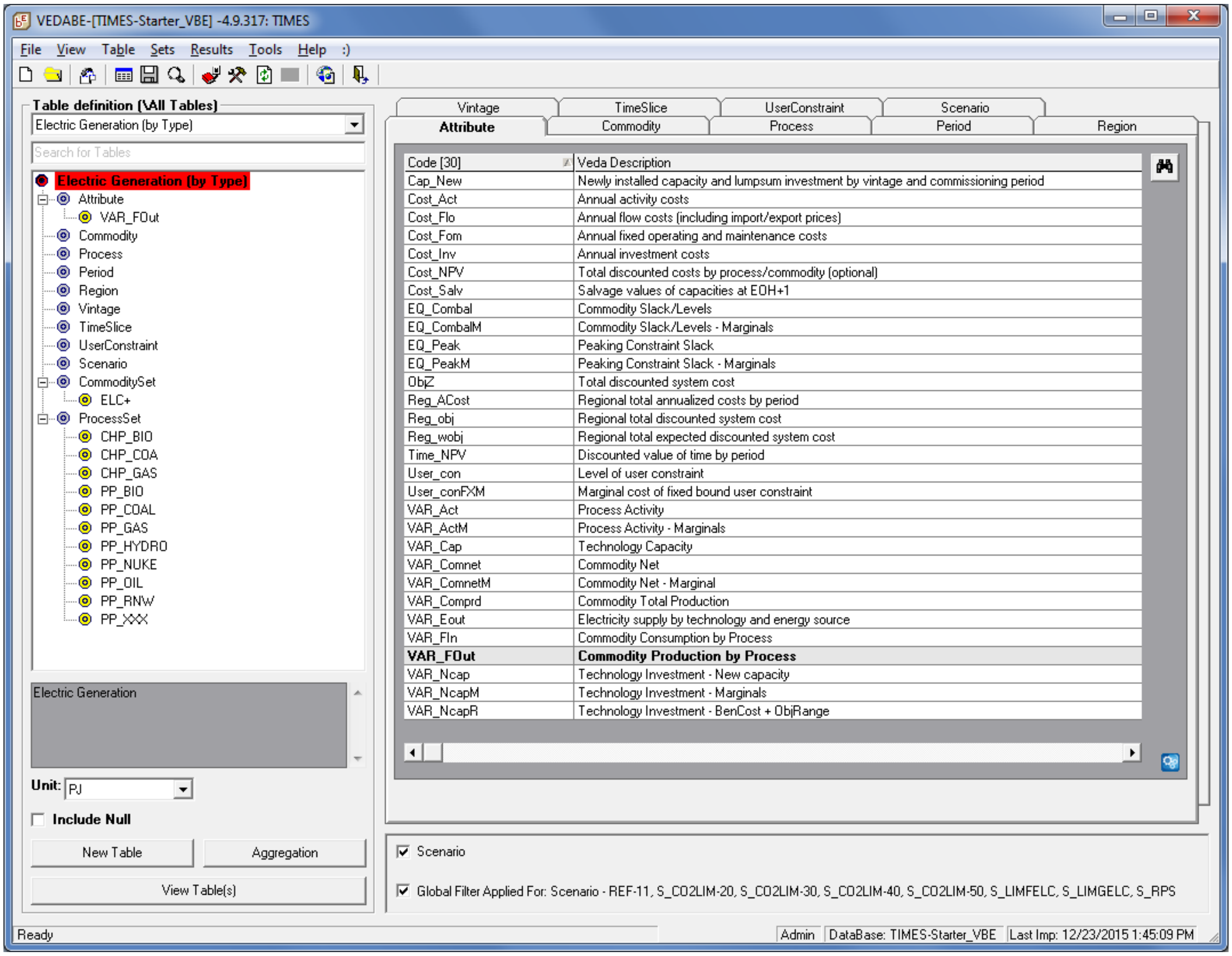


Table Name [44]	Table Description	Date & Time
Calib - CHP Fuel Consumption	CHP Fuel Consumption -BY	12/13/2015 11:43:43 AM
Calib - Electric Generation (by Type)	Electric Generation -BY	12/13/2015 11:50:23 AM
Calib - Electric Plant Fuel Consumption	Electric Plant Fuel Consumption -BY	12/13/2015 11:44:03 AM
Calib - Final Energy Consumption (by Sec & Fuell)	Final Energy Consumption (by Sector & Fuel) -BY	12/13/2015 11:17:48 AM
Calib - Heat Generation (by Type)	Heat Generation -BY	12/13/2015 11:51:08 AM
Calib - HPL Fuel Consumption	HPL Fuel Consumption -BY	12/13/2015 11:45:28 AM
Calib - Supply - Dom	Supply - Domestic -BY	12/13/2015 11:57:13 AM
Calib - Supply - Imports	Supply - Imports -BY	12/13/2015 2:24:25 PM
Calib_Grids	Gris input-outputs - BY	12/13/2015 1:35:12 PM
CO2 Emissions (by Sector)	CO2 Emissions (by Sector)	12/17/2015 1:44:07 PM
CO2 Emissions (by Source)	CO2 Emissions (by Source)	10/4/2015 7:05:15 PM
CO2 Emissions (by Source)-Details	CO2 Emissions (by Source)	10/4/2015 5:43:31 PM
Electric Capacity (by Type)	Electric & CHP Power Plant Capacity	10/2/2015 10:54:59 PM
Electric Generation (by Type)	Electric Generation	12/23/2015 1:24:26 PM
Electric New Builds (by Type)	Electric & CHP New Power Plant Additions	10/2/2015 10:56:25 PM
Electric Plant Fuel Consumption	Electric Plant Fuel Consumption	10/2/2015 10:56:52 PM
Expenditure - Annual Payment New Builds (by Type)	Expenditure - Annual Payment New Builds (by Type)	10/2/2015 11:34:55 PM
Expenditure - Lumpsum New Builds (by Type)	Expenditure - Lumpsum New Builds (by Type)	10/4/2015 5:46:34 PM
Expenditures - (by Type)	Expenditures - Summary (by Type)	10/2/2015 11:35:54 PM
Expenditures - Fuel Costs (supply & deliv)	Expenditures - Fuel Costs (supply & deliv)	12/29/2015 9:53:20 AM
Expenditures (by Investment)	Expenditure (by Sector & Technology)	10/5/2015 5:25:47 PM
Expenditures (by Sector - detail)	Expenditures (by Sector & type)	10/2/2015 11:36:02 PM
Expenditures (by Sector & Technoloy - detail)	Expenditure (by Sector & Technology)	10/2/2015 11:36:09 PM
Expenditures (by Sector)	Expenditures (by Sector)	10/2/2015 11:36:19 PM
Final Energy Consumption - AGR	Final Energy Consumption (by Sector & Fuel)	12/18/2015 3:09:32 PM
Final Energy Consumption - COM	Final Energy Consumption (by Sector & Fuel)	12/18/2015 3:09:16 PM
Final Energy Consumption - IND	Final Energy Consumption (by Sector & Fuel)	12/18/2015 10:09:17 AM
Final Energy Consumption - RSD	Final Energy Consumption (by Sector & Fuel)	12/18/2015 3:08:36 PM
Final Energy Consumption (by Fuel)	Final Energy Consumption (by Fuel)	10/2/2015 11:26:01 PM
Final Energy Consumption (by Sec & Fuel - detail)	Final Energy Consumption (by Sector & Fuel)	12/17/2015 2:56:58 PM
Final Energy Consumption (by Sector)	Final Energy Consumption (by Sector)	12/12/2015 4:05:02 PM
Final Energy Consumption (electricity by Sector)	Final Energy Consumption (electricity by Sector)	12/12/2015 8:48:08 PM
Final Energy Consumption -TRN	Final Energy Consumption (by Sector & Fuel)	12/18/2015 3:09:00 PM
Marginal Prices (detail)	Marginal Prices	10/2/2015 11:34:39 PM
Marginal Prices (eletricity)	Marginal Prices (eletricity)	10/14/2015 10:32:32 PM
Marginal Prices (UCs)	Marginal Prices - UserConstraints	10/8/2015 8:18:55 PM
New Device Purchase - Commercial	New Device Purchase - Commercial	12/18/2015 10:24:11 AM
RPS Constraint Marginals	Marginal Costs	12/19/2015 9:35:22 AM
Supply - Fuel & Source	Supply - Fuel & Source	10/2/2015 11:36:42 PM
Supply - Source	Supply - Source	10/2/2015 11:37:01 PM
Total System Cost	Total Discounted System Cost	10/6/2015 12:35:39 PM
Total System Cost - Annual Breakdown	Total Discounted System Cost	10/4/2015 6:02:42 PM
Total System Cost - Breakdown	Total Discounted System Cost	10/6/2015 4:09:37 PM
ZZDMY Check	ZZDMY Backstop Check	10/11/2015 7:02:52 PM

Tables are built in VBE by specifying the Attribute(s), which correspond to the desired model results, and the commodity and process Sets for which these results are to be organized and presented. Figure 69 presents the VBE Table specification form, which also oversees requesting preparation of the table for viewing, for the Table: Electricity Generation (by Type). The Atttribute VAR_FOut is commodity production from a process, the commodity specified is electricity (so as to avoid heat from the CHPs and any emissions perhaps accounted for at the power plant level (for CCS)), and the specified process sets give a breakdown for power plants and combined heat and power plants by fuel type. Note that PP_XXX is a null set that is designed to catch naming convention errors. Its includes the set of all power plants, but it excludes all the power plant subsets, so that if a power plant technology is added to the model, but does not get allocated to a subset, it will show in this null set as a flag to the user to properly define this process's subset – though it is expected to always not appear in the actual table presented in the cube.

Figure 69: VBE Table Specification for Electricity Generation by Fuel Type



Any of the existing tables can be viewed in the VBE dynamic data cube environment, as shown in Figure 70. VBE allows the analyst to dissect and reorganize the model results in order to determine the impacts of different model assumptions – here moving scenarios to the right so as to easily see where results have changed. Furthermore, as discussed in Section 13, the VBE tables can be exported to Excel, and in particular the AnalyticsXLS assembled for the TIMES-Starter model that presents multi-case comparison graphs to facilitate visualizing these impacts.

Figure 70: VBE Data Cube View

Electric Generation

Original Units: PJ Active Unit GWh Data values filter:

Attribute | Commodity | Region | *Vintage* | *TimeSlice* | CommoditySet | *Process*

Scenario	ProcessSet	2013	2015	2020	2025	2030	2035	2040	2045	2050
REF-01	Biofuel-fired	82.4	87.7	100.3	143.5	249.9	372.6	471.9	678.6	801.4
	Coal-fired	341.8	543.3	872.2	1,377.1	1,608.7	2,471.3	3,676.0	5,228.7	6,528.1
	Hydro	555.6	555.6	555.6	555.6	555.6	555.6	555.6	138.9	138.9
	Other Renewables	2,932.9	2,932.9	2,932.9	2,932.9	2,932.9	2,794.0	2,589.2	2,500.0	2,500.0
	Total	3,912.6	4,119.4	4,460.9	5,009.0	5,347.1	6,193.4	7,292.6	8,546.2	9,968.4
S_C02LIM-20	Biofuel-fired	82.8	64.5	110.3	160.2		328.4	417.5	603.0	711.3
	Coal-fired	341.4	417.1	541.9	958.5	1,078.6	1,690.4	3,059.8	4,472.9	5,627.5
	Gas-fired					99.5				
	Hydro	555.6	555.6	555.6	555.6	555.6	555.6	555.6	138.9	138.9
	Nuclear					277.8	277.8			
	Other Renewables	2,932.9	2,932.9	2,932.9	2,932.9	2,932.9	2,794.0	2,589.2	2,500.0	2,500.0
	Total	3,912.6	3,970.0	4,140.5	4,607.0	4,944.3	5,646.1	6,622.1	7,714.8	8,977.8
S_C02LIM-30	Biofuel-fired	82.8	64.5	128.0	171.5		329.1	417.8	603.0	710.7
	Coal-fired	341.4	417.1	416.7	728.2	1,541.0	1,696.8	3,062.8	4,472.9	5,621.0
	Hydro	555.6	555.6	555.6	555.6	555.6	555.6	555.6	138.9	138.9
	Nuclear					277.8	277.8			
	Other Renewables	2,932.9	2,932.9	2,932.9	2,932.9	2,932.9	2,794.0	2,589.2	2,500.0	2,500.0
	Total	3,912.6	3,970.0	4,033.0	4,388.1	5,307.2	5,653.1	6,625.4	7,714.8	8,970.5
S_C02LIM-50	Biofuel-fired	75.2	70.5	416.0	416.7		306.3	402.6	625.8	711.9
	Coal-fired	350.0	412.7	416.7	474.3	2,099.0	2,481.7	3,977.9	4,967.3	5,632.8
	Gas-fired					99.5				
	Hydro	555.6	555.6	555.6	555.6	555.6	555.6	555.6	138.9	138.9
	Nuclear				17.5	277.8	277.8			
	Other Renewables	2,932.9	2,932.9	2,932.9	2,932.9	2,932.9	2,794.0	2,589.2	2,500.0	2,500.0
	Total	3,913.6	3,971.6	4,321.1	4,396.8	5,964.7	6,415.2	7,525.2	8,232.0	8,983.5

Electric Generation

Original Units: PJ Active Unit GWh Data values filter:

Attribute | Commodity | Region | *Vintage* | *TimeSlice* | CommoditySet | *Process*

ProcessSet	Scenario	2013	2015	2020	2025	2030	2035	2040	2045	2050
Biofuel-fired	REF-01	82.4	87.7	100.3	143.5	249.9	372.6	471.9	678.6	801.4
	S_C02LIM-20	82.8	64.5	110.3	160.2		328.4	417.5	603.0	711.3
	S_C02LIM-30	82.8	64.5	128.0	171.5		329.1	417.8	603.0	710.7
	S_C02LIM-50	75.2	70.5	416.0	416.7		306.3	402.6	625.8	711.9
Coal-fired	REF-01	341.8	543.3	872.2	1,377.1	1,608.7	2,471.3	3,676.0	5,228.7	6,528.1
	S_C02LIM-20	341.4	417.1	541.9	958.5	1,078.6	1,690.4	3,059.8	4,472.9	5,627.5
	S_C02LIM-30	341.4	417.1	416.7	728.2	1,541.0	1,696.8	3,062.8	4,472.9	5,621.0
	S_C02LIM-50	350.0	412.7	416.7	474.3	2,099.0	2,481.7	3,977.9	4,967.3	5,632.8
Gas-fired	S_C02LIM-20					99.5				
	S_C02LIM-50					99.5				
Hydro	REF-01	555.6	555.6	555.6	555.6	555.6	555.6	555.6	138.9	138.9
	S_C02LIM-20	555.6	555.6	555.6	555.6	555.6	555.6	555.6	138.9	138.9
	S_C02LIM-30	555.6	555.6	555.6	555.6	555.6	555.6	555.6	138.9	138.9
	S_C02LIM-50	555.6	555.6	555.6	555.6	555.6	555.6	555.6	138.9	138.9
Nuclear	S_C02LIM-20					277.8	277.8			
	S_C02LIM-30					277.8	277.8			
	S_C02LIM-50				17.5	277.8	277.8			
Other Renewables	REF-01	2,932.9	2,932.9	2,932.9	2,932.9	2,932.9	2,794.0	2,589.2	2,500.0	2,500.0
	S_C02LIM-20	2,932.9	2,932.9	2,932.9	2,932.9	2,932.9	2,794.0	2,589.2	2,500.0	2,500.0
	S_C02LIM-30	2,932.9	2,932.9	2,932.9	2,932.9	2,932.9	2,794.0	2,589.2	2,500.0	2,500.0
	S_C02LIM-50	2,932.9	2,932.9	2,932.9	2,932.9	2,932.9	2,794.0	2,589.2	2,500.0	2,500.0

Note that for Commercial and Residential Heat Pumps while the output is properly report separately for heating and cooling demands, the fuel consumption to end-use services puts the total electric and/gas against the heating demand. Only by further processing the tables taking into consideration the amount of each demand serviced by the heat pump and the device efficiencies for each can the final energy consumed be apportioned properly to each end-use service.

An important and often used feature of VBE is the Global Filter, which enables temporary filters to be applied outside of any specification embodied in the table definition. This is most often used for Scenarios to facilitate focusing in on a subset of the scenarios. A second commonly used Global Filter is for Periods, when one is not interested in seeing results for all the periods in a run.

Once fluent in the use of VBE, users can create new Sets and Tables as needed for a particular analysis (see the ANSWER VBE manual).

13 Using the Analytics Results Comparison Graphing Workbook

The Analytics Results Comparison Graphing Workbook (AnalyticsXLS) is a VBA-enabled Excel workbook that allows a full set of analysis scenario results to be stored, updated and viewed according to smaller subsets for analyzing model results and preparing report and presentation quality graphics of model results. The VBE Update Excel tool is used to automatically update the results tables in the AnalyticsXLS whenever new or updated model run results are available. The DWG-Analytics "Smart" Excel Workbook User's Guide provides a complete description of how to effectively work with the AnalyticsXLS.

13.1 AnalyticsXLS Graphing Tables

Table 10 provides the complete list of the AnalyticsXLS (AXLS) tables currently developed for the TIMES-Starter model. In general, each sheet presents one set of model results for whatever combination of scenarios is selected. The model results for each table are first assembled on so-called "VEDA Dump" sheets, as also designated in Table 10, which correspond directly (and identically) with the associated VBE table. The Index sheet in the AXLS, corresponding to the table below, provides links to each graph comparison sheet and dump table.

Table 10: List of AnalyticsXLS Tables for TIMES-Starter

Sheet Name & Link	**Description**	**Dump Sheet Location & Link**
Scenarios	Control sheet with all Scenarios	NA
Metrics 2030	Aggregate result metrics to 2030	NA
Metrics 2050	Aggregate result metrics to 2050	NA
System cost	Total discounted system cost (Objective Function)	VEDA Dump_Cost
Annual System Cost	Annual undiscounted components of the system cost	VEDA Dump_Cost
System Cost Breakdown	Components of the Total discounted system cost	VEDA Dump_Cost
Primary energy_ByFuel	Primary energy by fuel	VEDA Dump_Energy
Primary energy_Source	Primary energy by domestic or imports	VEDA Dump_Energy
Electricity generation_fuel	Electricity generation by fuel	VEDA Dump_Energy
Electricity capacity_fuel	Electricity capacity by fuel	VEDA Dump_Energy
Electric Power plant Builds	Capacity of new electric power plants	VEDA Dump_Energy
Power plant fuel use	Fuel use by all types of power plants	VEDA Dump_Energy
Final energy_Fuel	Final energy use by fuel type	VEDA Dump_Energy
Final energy_Sector	Final energy use by fuel type	VEDA Dump_Energy
CO2 Emissions_Sector	CO2 Emissions by sector	VEDA Dump_Emissions
CO2 Emissions_Fuel	CO2 Emissions by fuel used	VEDA Dump_Emissions
Expenditure - Summary	Summary of Total Annual Expenditures	NA
Expenditure_Type	Activity and O&M Costs	VEDA Dump_Cost
Expenditure_Investment	Investment expenditures by supply and demand sectors	VEDA Dump_Cost
Fuel Expenditure	Fuel Expenditures	VEDA Dump_Cost
Power Plant investment	Electricity powerplant newbuild investment	VEDA Dump_Cost
Sector Final energy_AGR	Final Energy Use by Application - AGR	VEDA Dump_Sector
Sector Final energy_COM	Final Energy Use by Application - COM	VEDA Dump_Sector
Sector Final energy_IND	Not Included yet	VEDA Dump_Sector
Sector Final energy_RSD	Final Energy Use by Application - RSD	VEDA Dump_Sector
Sector Final energy_TRN	Final Energy Use by Application - TRN	VEDA Dump_Sector

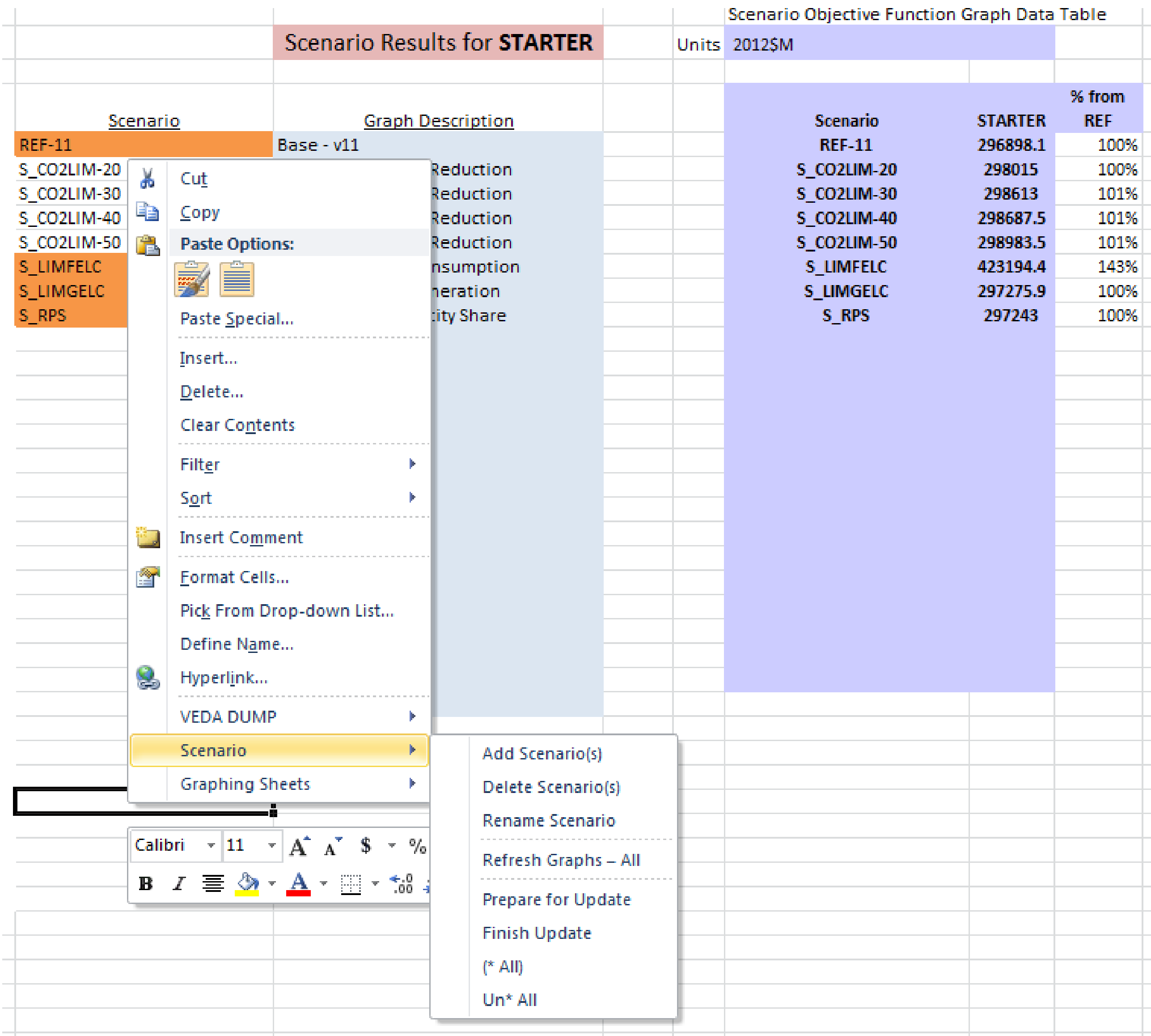
13.2 Managing Scenarios

The definition, addition, deletion and updating of scenario results is all done from the Scenarios tab, which contains the complete list of loaded scenarios. These include the current Reference scenario and each of the example policy scenarios. The AXLS scenario management features are accessed through a right click anywhere in the Scenarios tab, as shown in Figure 71. These commands allow scenarios to be added, deleted and renamed, and allow for the scenario results to be updated for all or only selected scenarios. The VBE Update Excel facility also allows for updating of all tables in the workbook, or only selected tables as specified in the Update Excel facility.

As also shown in Figure 71, the Scenarios tab shows (through orange color coding) which scenarios are selected for graphing, and the Refresh Graphs - All command is used to change this selection. Prepare for Update allows selective scenario updating by not updating any scenario when a “star” is placed next to the scenario name in col-A, in which case the user most also remember to set the VBE Global Filter accordingly. Finish Update undoes that process. See User’s guide for detailed steps for updating the workbook.

Note that the VBE UpdateXLS functions is quite demanding and may take some time to perform the update operation. The Prepare for Update feature also changes Formula Calculation Options to Manual which greatly reduces the time the update takes. The Finish Update switches this back to Automatic refreshing all the links, formulas and thereby graphs in the workbook.

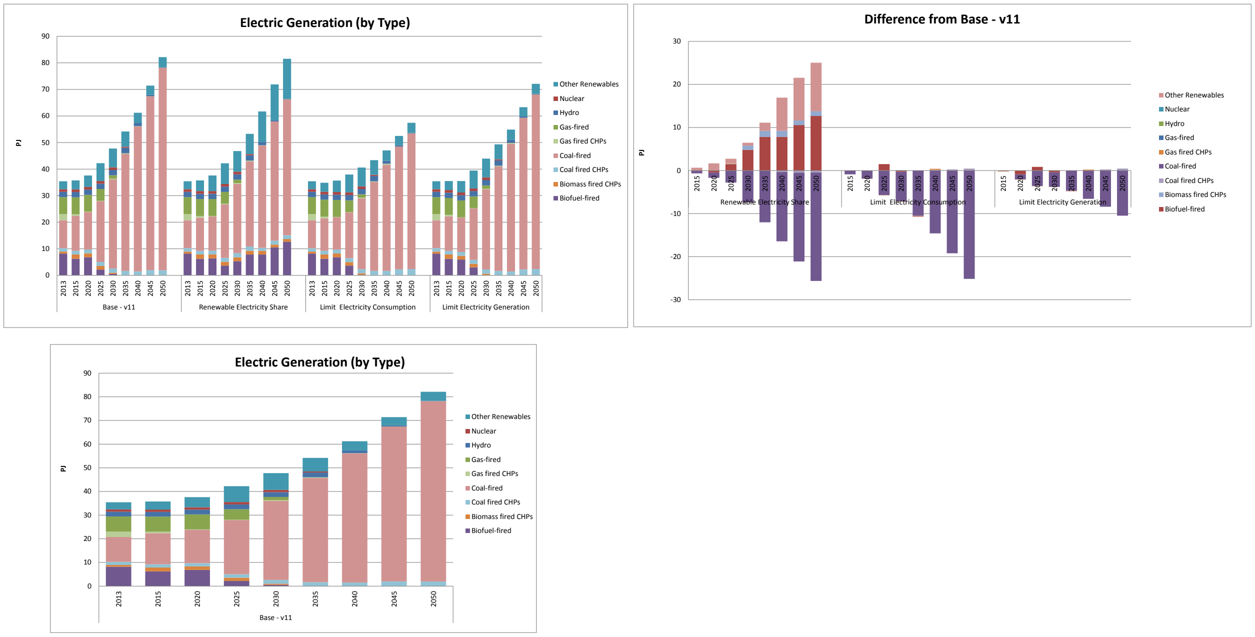
Figure 71: Screenshot of AnalyticsXLS Scenarios tab



13.3 Example Graphing Sheets

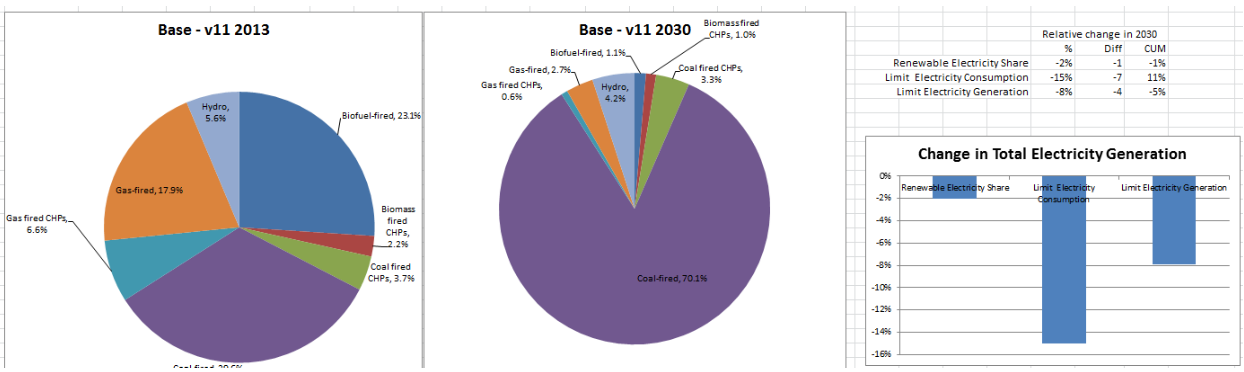
The graphing sheets present their results in both tabular and chart form, Figure 72 shows the charts for Electricity Generation by Plant Type. The Reference scenario (1st one) is graphed separately and in combination with three other scenarios, and the difference between the scenarios and the Reference is also graphed.

Figure 72: Screenshot of AnalyticsXLS Graphing Sheet - 1



The graphing sheets also present pie charts that show how each scenario changes over time, and a bar chart that compares other overall changes between scenarios, as shown in Figure 73.

Figure 73: Screenshot of AnalyticsXLS Graphing Sheet - 2



13.4 Metrics Tables

There are two Metrics tabs which calculate cumulative results for selected model parameters out to 2030 and out to 2050. Figure 74 shows the cumulative metrics selected for the Starter model, which includes Total System Cost, Primary Energy Supply, Electricity Generation, Final Energy Consumption, New Power Plant Builds, Investment in New Power Plant Capacity, Fuel Expenditures, and CO_2 Emissions. The cumulative values are calculated from each respective graphing sheet, with care taken to accommodate the variable length (in rows 2-3) and number of periods, and to properly account for annual values versus per period results.

Figure 74: Cumulative Metrics Tables to 2030

Scenario	System Cost			Scenario	Power Plant Builds	
	2012$M	% Difference			GW	% Difference
Base - v11	109,937			Base - v11	1.28	
Renewable Electricity Share	109,874	-0.1%		Renewable Electricity Share	1.21	94.7%
Limit Electricity Consumption	111,223	1.2%		Limit Electricity Consumption	0.96	75.1%
Limit Electricity Generation	110,073	0.1%		Limit Electricity Generation	1.07	83.9%

Scenario	Primary Energy			Scenario	Electricity Investment	
	PJ	% Difference			2012$M	% Difference
Base - v11	5,245			Base - v11	3,190	
Renewable Electricity Share	5,226	-0.4%		Renewable Electricity Share	2,907	-8.9%
Limit Electricity Consumption	5,322	1.5%		Limit Electricity Consumption	2,472	-22.5%
Limit Electricity Generation	5,163	-1.6%		Limit Electricity Generation	2,817	-11.7%

Scenario	Electrity Generation			Scenario	Fuel Expenditures	
	PJ	% Difference			2012$M	% Difference
Base - v11	21			Base - v11	50,163	
Renewable Electricity Share	21	0.0%		Renewable Electricity Share	49,997	-0.3%
Limit Electricity Consumption	21	0.0%		Limit Electricity Consumption	52,462	4.6%
Limit Electricity Generation	21	0.0%		Limit Electricity Generation	50,098	-0.1%

Scenario	Final Energy Consumption			Scenario	CO2 Emissions	
	PJ	% Difference			kt	% Difference
Base - v11	2,489			Base - v11	293,340	
Renewable Electricity Share	2,485	-0.2%		Renewable Electricity Share	278,965	-4.9%
Limit Electricity Consumption	2,673	7.4%		Limit Electricity Consumption	288,736	-1.6%
Limit Electricity Generation	2,484	-0.2%		Limit Electricity Generation	284,537	-3.0%

Because these metric results are refreshed each time a new set of scenarios is selected, each Metrics tab also contains an Archive section, where updated results for each scenario can be saved using Copy/Paste Values to create a table with the complete set of results for all the scenarios in the workbook.

14 Procedures for Adapting TIMES-Starter

The TIMES-Starter model comprises all the modeling components necessary to build a model relevant to most any study area. However, it is only the starting point and besides the calibration activities discussed in Section 6, a series of steps needs to be followed to prepare the Starter model for the new situation. Each of the basic steps are described in this Section.

14.1 Changing Country Name

The first thing that one needs to do is establish the name of the study area, which for now we'll assume is a <country>. To accomplish this the following steps should be undertaking in the order listed.

1. Copy the TIMES-Starter folder to another folder name under the Answer_Databases folder.
2. Rename the TIMES-Starter(vXX).MDB to TIMES- <country>(v01).MDB.
3. Open the TIMES-<country>(vXX) database & edit the Region name, changing STARTER to <country>.
4. Repeat steps 2 and 3 for the TIMES-Starter(vXXxls).MDB for each region.
5. Replace **Starter** with <country> in the name of each of the templates.
6. In the EB_<country> (2013) template change **Starter** to <country> in cell B1 on the Energy balance tab
7. Open each XLS
    a. Go to Data/Edit Links and change the references from EB_Starter to the EB_<country>, as well as any other XLS linked to according to the relationship shown in Figure 1.
    b. Make sure the <country> is now reflected on the Setup sheet, so appears as the Region on each ANSWER load sheet.
    c. save each XLS.
8. Open the <country>(vXX) database & reimport EACH scenarios, specifying the <country> XLSs instead of the now missing Starter XLSs.
9. Try a test run to replicate the REFxx already in the database.
10. In ANSWER remove the old model runs, keeping the definitions --- if desired.

With that your model is now ready for customizing to your area of study.

14.2 Customizing TIMES-Starter for Your Model

The roadmap to customize the TIMES-Starter for your situation entails each of the steps listed below. All the input data templates associated with each of the steps, and how to work with them, has been described earlier, so this just serves as a sequenced recommended checklist for getting your model set up. It is recommended that this process be undertaken slowly and carefully following sequentially the steps listed below. For each step the relevant template(s) and key sheets for that action are noted.

14.2.1 Changing Units, Periods and Timeslices *{Pending}*

For now users should stick with the Units, Periods and timeslices in the TIMES-Starter. In principle all these can be adjusted, but this will be addressed in a later version of the Starter model.

14.2.2 Adding New Commodities and Processes

The TIMES-Starter, when complete, will have a wide range of commodities and processes for most every situation. However, there may be unforeseen circumstances requiring the addition of a commodity/process. To insert a new commodity/process simply copy/insert a like element on the SETUP sheet of the relevant template and adjust the $cell references to grab the right characters to properly formulate the item name and description. The process is then to add to the declaration sheet and data sheets, adjusting their reference to SETUP if/as necessary. Then to adjust the RES connectivity, on the data sheet either use the "smart" buttons to grab the input and output commodities from the declaration sheets, copy them from another process, or link them manually yourself, then complete the data requirements as appropriate. If additional parameters are needed for any item they can be freely added to the end of the associated ProcData sheet. Also, if adding an existing process with base year installed capacity to the model, it should be appropriately reflected on the BY Calibration sheet. This is valid for all sectors.

The other, perhaps simpler, approach would be to usurp an existing Commodity/Process by simply changing the way its name/description are assembled, and adjusting data as appropriate. The only downside of this approach is that you are thereby breaking the connection with the US9r source data for that item.

Caution With Respect to Changing Component Names and Adding Sub-sectors

While the templates are set up to enable the user to change the names of commodities and technologies this is **HIGHLY DISCOURAGED** since the rules that govern the many ANSWER named TechFilters and VBE Set definitions (and perhaps Table structures) are based upon the TIMES-Starter conventions!!! Therefore, while the user is certainly free to include/exclude components, special care and in-depth understanding of the TechFilters and VBE Sets governing the model is essential before embarking on such an adventure.

When introducing a new sub-sector, consideration will also need to be given to updating and/or replicating the ANSWER TechFilters and VBE Sets as well!!!

Also, note that some resources supply options in the AT_<region>_SUP template require the user to put in local prices for them to work appropriately.

14.2.3 Setup and Calibration

Model setup and calibration were discussed in the earlier in Calibration section for each sector. The points here are listed as a reminder for the steps to be undertaken.

1. Plug in your energy balance [EB_<country>(year)];
2. Adjust the periods and timeslices [LoadCalibration, then copied into EB_<country>(TimePeriods)]
3. Tailor the RES to your situation by eliminating and perhaps adding commodities/process not of interest/relevant or missing [SUP/BY/NT_<sector>(SETUP)];
4. Adjust the Calibration sheets, and
5. Run for 1 period refining the calibration by adjusting the EB and Calibration sheets.

14.2.4 Ready the Reference Scenario

Preparing the Reference Scenario was discussed in the earlier in Section 10. The points here are listed as a reminder of the steps to be undertaken, but refer to said section for specifics.

1. Adjust the energy price prices and potential/physical limits on resources and electricity/gas infrastructure [SUP(SupplyPrice/Potential+Grid&Pipeline)]
2. Adjust the demand drivers [Demand-REF(drivers)];
3. Introduce and forces operations [REF_BOUNDLO(ForceOp), and all known coming new builds (and NCAP_BND in the appropriate workbook, NT-PP in particular) ;
4. Review and adjust the Reference guidance mechanisms (fuel switching & rate of new technology penetration controls, as described in Section 10) [UC_*];
5. Introduce all known/on the books future policies [REF_POL(Policies)];
6. Run and refine the Reference scenario.
7. Make any necessary adjustments to the VBE SnT (and AXLS), (although this is likely not necessary unless names of commodities/technologies have been changed.

14.2.5 Try some Policy Scenarios

Trying policy runs was discussed in the earlier in Section 11. The points here are listed as a reminder of the steps to be undertaken, but refer to said section for specifics.

1. Paste your Reference scenario values into the standard policy scenario templates provided (e.g., CO2/EE/RE targets), and adjust the targets as desired.
2. Import the updated scenario files and run the scenarios.
3. Assess the model behavior in VBE and the AXLS.

14.3 Handling More than one Region *{Down the Road}*

In principle the design of the Starter model template will readily support the replication of the templates (or sheets in the templates) to enable multi-region models to be assembled.

However, for now users should stick with the single region model, but this will be addressed in a later version of the Starter model by creating a 2-region version of TIMES-Starter.

15 Some Advanced TIMES Features *{VFE DemoS examples – Down the Road}*

TIMES is also support by the VEDA Front-End (VFE) model management platform. The training course developed by ETSAP for VFE has a set (more sophisticated) process descriptions and model techniques that can be readily introduced to the TIMES-Starter platform, as a 2nd tier (intermediate) set of scenarios to demonstrate the implementation of each of these with the ANSWER-TIMES and TIMES-Starter environment.

Among the candidate features are:

- CHPs pass-out turbines;
- Lumpy (Discrete) investments / retirement;
- Storage technologies;
- UC growth constraint + UC total;
- Elastic demands;
- Stochastics, and

- Many others.