ITEMS
Industrial Technology And Energy Modeling System

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ITEMS

MODEL CHARACTERISTICS

- COVERAGE - Eleven industrial sector modules
- FUELS - Twenty including auxiliary services
  - Industry specific
- EMISSIONS - Ten slots, CO_2 only universal one
- YEARS - Calibrate to MECS - 1991
  - Annual - twenty increments (1991-2011)
  - Increments adjusted to cover longer periods
- SOFTWARE - Program written in APL
  - Data analysis, scenario development and results all in spreadsheets (now use Lotus 1-2-3, Version 5)

HOW THE MODEL WORKS

- ITEMS Overview
  - Product demand drives process energy service demand
  - Service requirements give rise to auxiliary demand
  - Old stocks retire
  - New stock acquired to meet demand
  - Market share calculations based on costs
    - Capital
    - O&M
    - Fuel

MODEL COMPONENTS

- Engineering process flow model (Figure 1)
- Auxiliary process components (Figure 2)
- Technology characteristics file with base energy consumption by fuel type (Figure 3)
- Industry output forecast (Figure 4)
- Fuel price forecast (Figure 5)
- Financial information (Figure 6)

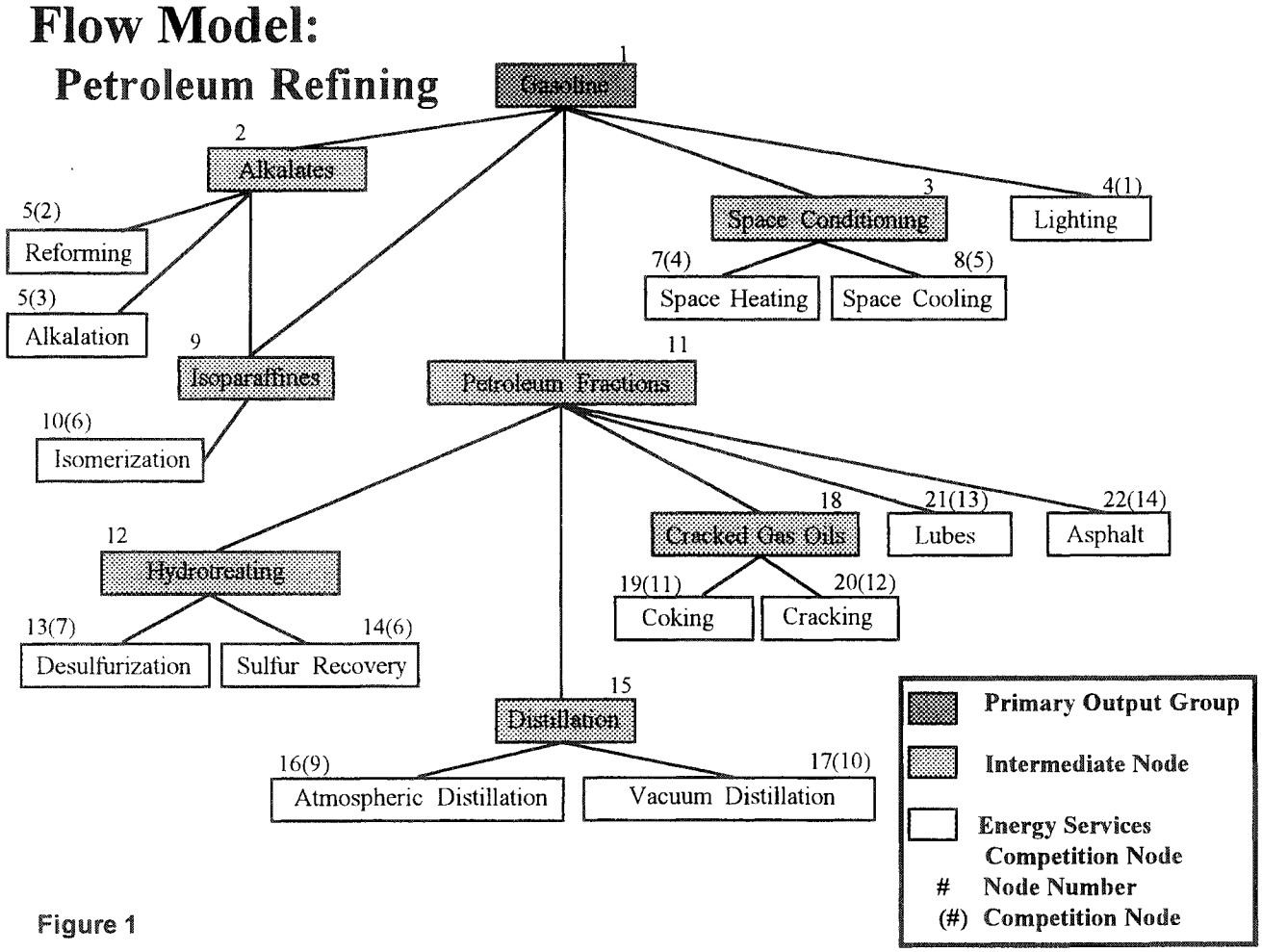


Figure 1

Auxiliary Process Components

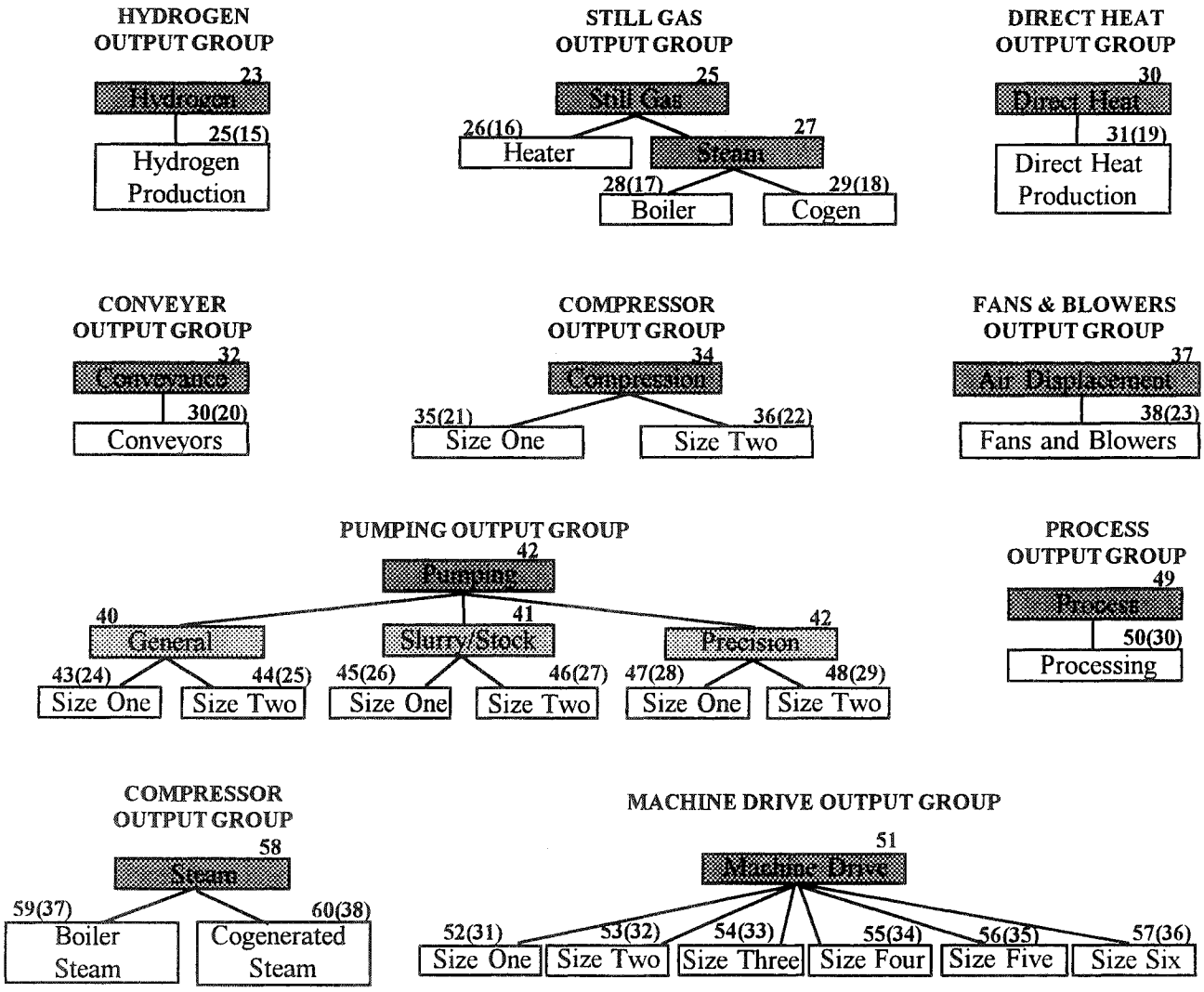


Figure 2

Technology Characteristics File

Table 1: Fuel and Emissions Information

Fuels		Base Year	
No.	Name	Units	Units
Table 1 contains information on fuel use, by type, in the starting year for the model runs. This includes conventional fuels such as coal and electricity, as well as energy carriers such as heat, compression, or conveyance. Table 1 also contains emissions information for up to ten categories. The model currently contains information only for CO2 emissions.			

Table 2: Technology Connections (Component 30)

	Technologies to be competed			
Leaf No.	No. 1	No. 2	No. 3	cont.....
Table 2 contains information on the set of technologies which compete to provide a particluar service. Each service, or "leaf" is represented in the industry flow model and has an associated leaf number. The remaining columns refer to the set of technologies listed in Table 4 which compete to provide the service.				

Table 3a: Retrofit Control and Connections

Techs for	Control			Options for retrofitting			
Retrofit	R-Max	R-Min	R-Mix	No. 1	No. 2	No. 3	cont...
Table 3a contains information on technologies that are available for retrofit before before reaching the retirement age of the equipment. Specific minimun, maximum, and retrofit mix levels can be input by the user to control the extent to which retrofit is allowed for each technology. The technology option columns are use to specifiy the technologies which are allowed to compete against the technology that is open to retrofit. These technology numbers refer to the numbers in Table 4.							

Table 3b: Retrofit Costs and Benefits of Technologies

Technologies listed in No. 1-6 of Table 3a				
No.	Option	Cap C	Tax Cr	Other Cr
Table 3b contains information on the costs for each retrofit option, tax credits associated with the retrofit, and any other credits associated with the retrofit. Technologies are referenced to the technology number found in Table 4.				

Table 4: Technology Information

Technology	Technology	Base Stock	Technology Fuel and Emissions Coefficients						Material Output		SCU Weight		Capital Cost		O&M Costs		Year	Year
Number	Name		Per Unit Output						(T or GJ)		(Share of stock)				(W/o energy costs)		Avail	Unavail
				1		2												
			Type	C/P	Type	C/P	Type	cont.....	SCU 1	SCU 2	SCU 1	SCU 2	SCU 1	SCU 2	SCU 1	SCU 2		
Table 4 contains information on the specific end-use technolgies which currently are used in each industry, or which are expected to penetrate into the industry in the future. The technology number is used in Table 2 to assign each of these technologies to a particular leaf, or competition node. Each technology listed in a particular leaf competes for market share with other technologies in that node. This competition is based on economic and opterating characteristics stored in Table 4. Each technology has assigned to it up to 10 coefficients for fuel and emissions consumed or produced per unit of service demand. The table also contains capital and operating cost information, technology lifetime, and the years in which the technology becomes available or unavailable. ITEMS calculates future energy consumption and emissions by multiplying future service demands by the performance coefficients in this table.																			

Figure 3

Industry Output Forecast

FORECAST REFINERY PRODUCT SPLITS																	
						GASOLINE					ALKYLATE			PETROLEUM FRACTION				
	RATE					SPLIT					SPLIT			SPLIT				
Year	OF	OUTPUT																
	INCREASE	(m3)	ALKYLATE	ISOPARA	PET FRAC	SPACE	LIGHT		REFORM	ALKYLATE	ISOPARA		HYDROTR	DISTILL	CRACKING	LUBES	ASPHALT
1991		4.06E+08	0.743	0.110	1.908	0.017	0.0022		0.711	0.199	0.090		0.663	1.000	0.689	0.0117	0.032
1992	1.01	4.10E+08	0.738	0.110	1.908	0.017	0.0022		0.711	0.199	0.090		0.679	1.000	0.695	0.0117	0.032
1993	1.02	4.14E+08	0.734	0.109	1.908	0.017	0.0022		0.711	0.199	0.090		0.675	1.000	0.692	0.0117	0.032
1994	1.03	4.19E+08	0.730	0.108	1.908	0.017	0.0022		0.711	0.199	0.090		0.672	1.000	0.678	0.0117	0.032
1995	1.08	4.40E+08	0.699	0.104	1.908	0.017	0.0022		0.711	0.199	0.090		0.643	1.000	0.649	0.0117	0.032
1996	1.09	4.41E+08	0.701	0.104	1.908	0.017	0.0022		0.711	0.199	0.090		0.645	1.000	0.651	0.0117	0.032
1997	1.10	4.46E+08	0.696	0.103	1.908	0.017	0.0022		0.711	0.199	0.090		0.640	1.000	0.646	0.0117	0.032
1998	1.10	4.46E+08	0.700	0.104	1.908	0.017	0.0022		0.711	0.199	0.090		0.643	1.000	0.649	0.0117	0.032
1999	1.11	4.50E+08	0.696	0.103	1.908	0.017	0.0022		0.711	0.199	0.090		0.640	1.000	0.646	0.0117	0.032
2000	1.12	4.55E+08	0.693	0.103	1.908	0.017	0.0022		0.711	0.199	0.090		0.637	1.000	0.643	0.0117	0.032
2001	1.13	4.57E+08	0.694	0.103	1.908	0.017	0.0022		0.711	0.199	0.090		0.638	1.000	0.644	0.0117	0.032
2002	1.13	4.58E+08	0.696	0.103	1.908	0.017	0.0022		0.711	0.199	0.090		0.640	1.000	0.646	0.0117	0.032
2003	1.13	4.60E+08	0.696	0.103	1.908	0.017	0.0022		0.711	0.199	0.090		0.640	1.000	0.646	0.0117	0.032
2004	1.13	4.60E+08	0.698	0.104	1.908	0.017	0.0022		0.711	0.199	0.090		0.642	1.000	0.648	0.0117	0.032
2005	1.14	4.62E+08	0.699	0.104	1.908	0.017	0.0022		0.711	0.199	0.090		0.643	1.000	0.649	0.0117	0.032
2006	1.14	4.63E+08	0.701	0.104	1.908	0.017	0.0022		0.711	0.199	0.090		0.645	1.000	0.651	0.0117	0.032
2007	1.14	4.63E+08	0.705	0.105	1.908	0.017	0.0022		0.711	0.199	0.090		0.648	1.000	0.654	0.0117	0.032
2008	1.14	4.63E+08	0.708	0.105	1.908	0.017	0.0022		0.711	0.199	0.090		0.651	1.000	0.657	0.0117	0.032
2009	1.14	4.63E+08	0.712	0.106	1.908	0.017	0.0022		0.711	0.199	0.090		0.655	1.000	0.661	0.0117	0.032
2010	1.14	4.62E+08	0.713	0.106	1.908	0.017	0.0022		0.709	0.200	0.090		0.659	1.000	0.665	0.0117	0.032
2011	1.14	4.62E+08	0.713	0.106	1.908	0.017	0.0022		0.708	0.201	0.091		0.662	1.000	0.668	0.0117	0.032

AUXILIARY TECHNOLOGY EFFICIENCY LEVEL SPLIT						
SPACE CONDITIONIN	0.95	0.05				0
MACHINE DRIVE	0.01	0.09	0.4	0.3	0.2	
PUMP SPLIT	0.99	0	0.01			
GENERAL PUMP SPLI	0.3	0.7				
SLURRY STOCK SPLI	0.3	0.7				
PRECISION SPLIT	0.3	0.7				

HYDROTREATING SPLIT		DISTILLATION SPLIT		CRACKED OIL SPLIT		STEAM SPLIT	
DESULF	SULF REC	ATMOS	VACUUM	COKING	CRACKING	BOILERS	COGEN
1.000	0.016	1.000	0.508	0.155	0.845	1.000	0.000
1.000	0.016	1.000	0.508	0.154	0.846	1.000	0.000
1.000	0.017	1.000	0.507	0.153	0.847	1.000	0.000
1.000	0.018	1.000	0.507	0.152	0.848	1.000	0.000
1.000	0.019	1.000	0.488	0.152	0.848	1.000	0.000
1.000	0.020	1.000	0.492	0.151	0.849	1.000	0.000
1.000	0.021	1.000	0.490	0.150	0.850	1.000	0.000
1.000	0.021	1.000	0.495	0.149	0.851	1.000	0.000
1.000	0.022	1.000	0.496	0.149	0.851	1.000	0.000
1.000	0.023	1.000	0.495	0.148	0.852	1.000	0.000
1.000	0.024	1.000	0.499	0.147	0.853	1.000	0.000
1.000	0.026	1.000	0.502	0.146	0.854	1.000	0.000
1.000	0.027	1.000	0.505	0.146	0.854	1.000	0.000
1.000	0.028	1.000	0.509	0.145	0.855	1.000	0.000
1.000	0.029	1.000	0.512	0.144	0.856	1.000	0.000
1.000	0.030	1.000	0.517	0.144	0.856	1.000	0.000
1.000	0.032	1.000	0.522	0.143	0.857	1.000	0.000
1.000	0.033	1.000	0.527	0.142	0.858	1.000	0.000
1.000	0.035	1.000	0.532	0.141	0.859	1.000	0.000
1.000	0.036	1.000	0.538	0.141	0.859	1.000	0.000
1.000	0.038	1.000	0.544	0.140	0.860	1.000	0.000

Figure 4

Fuel Price Forecast

FUEL	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
NAT GAS	3.07	3.17	3.27	3.36	3.46	3.56	3.66	3.75	3.85	3.95	4.06	4.16	4.27	4.37	4.48	4.59	4.71	4.82	4.93
PET COKE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LS RESID	2.54	2.67	2.79	2.92	3.04	3.17	3.29	3.42	3.54	3.69	3.84	3.98	4.13	4.28	4.38	4.49	4.59	4.7	4.8
HS RESID	2.54	2.67	2.79	2.92	3.04	3.17	3.29	3.42	3.54	3.69	3.84	3.98	4.13	4.28	4.38	4.49	4.59	4.7	4.8
DIST OIL	4.87	4.91	4.95	4.99	5.04	5.08	5.12	5.16	5.2	536	5.52	5.68	5.84	6	6.13	6.26	6.39	6.52	6.65
MOTOR GAS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LPG	3.73	3.79	3.84	3.9	3.96	4.02	4.08	4.14	4.2	4.27	4.33	4.39	4.46	4.53	4.6	4.66	4.73	4.81	4.88
STILL GAS	2.46	2.53	2.61	2.69	2.77	2.85	2.92	3	3.08	3.16	3.25	3.33	3.41	3.5	3.59	3.68	3.76	3.85	3.94
COKE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HYDROGEN	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
HEAT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COAL	1.47	1.5	1.53	1.56	1.59	1.61	1.64	1.67	1.7	1.72	1.74	1.76	1.78	1.8	1.82	1.84	1.87	1.89	1.91
ELECT	14.87	14.89	14.91	14.93	14.95	14.97	14.99	15.01	15.03	15.09	15.15	15.2	15.26	15.32	15.48	15.64	15.79	15.95	16.11
STEAM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CONVEYANC	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
COMPRESSI	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
AIR DISPL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PUMPING	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PROCESS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MACH DRIV	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EMISSIONS																			
CO2	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10

Figure 5

Financial Information

TECH NUMB	TECH NAME	DEPR LIFE	METHOD	DISC. RATE	RET DISC	NON-COST
1	DIST ATM ST	0	0	0.5	0	0
2	DIST ALQC	0	0	0.5	0	0
3	DIST AMSE	0	0	0.5	0	0
4	DIST ATME H	0	0	0.5	0	0
5	DIST SPT SP	0	0	0.5	0	0
6	DIST RCP UN	0	0	0.5	0	0
7	DIST VRC UN	0	0	0.5	0	0
8	VAC STM STA	0	0	0.5	0	0
9	VAC MECH STA	0	0	0.5	0	0
10	VAC EFF EF	0	0	0.5	0	0
11	VAC HEAVY L	0	0	0.5	0	0
12	COKE VIS CO	0	0	0.5	0	0
13	COKE SVIS CO	0	0	0.5	0	0
14	DEL COKE DE	0	0	0.5	0	0
15	FLU COKE FL	0	0	0.5	0	0
16	FCC STD STA	0	0	0.5	0	0
17	FCC COB FLU	0	0	0.5	0	0
18	FCC TRB FLU	0	0	0.5	0	0
19	FCC EFF EF	0	0	0.5	0	0
20	HC STD LO S	0	0	0.5	0	0
21	HC STD MD S	0	0	0.5	0	0
22	HC STD HI S	0	0	0.5	0	0
23	HC EFF LO E	0	0	0.5	0	0
24	HC EFF MD E	0	0	0.5	0	0
25	HC EFF HI EF	0	0	0.5	0	0
26	CANMET HI C	0	0	0.5	0	0
27	CAN HIEFF C	0	0	0.5	0	0
28	CANMET LOW	0	0	0.5	0	0
29	CAN EFFLO EF	0	0	0.5	0	0
30	HYD GOLOS D	0	0	0.5	0	0
31	HYD GOHIS D	0	0	0.5	0	0

Table 3: MAX SPLIT		%/Year CHANGE
1	1	0
1	1	0
1	1	0
1	1	0
1	1	0
1	1	0
1	1	0
1	1	0
1	1	0
1	1	0
1	1	0
1	1	0
1	1	0
1	1	0
1	1	0
1	1	0
0.83	0.83	0
0	0	0
0	0	0
0	0	0
0.07	0.07	0
0.1	0.1	0
0	0	0
0	0	0
0	0	0
0	0	0
1	1	0
1	1	0
1	1	0
1	1	0
1	1	0
1	1	0

Table 4: MIN SPLIT		%/Year CHANGE
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0.82	0.82	0
0	0	0
0	0	0
0	0	0
0.069	0.069	0
0.095	0.095	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0

Figure 6

TECHNOLOGY CHARACTERIZATION

- Technology Characteristics Stored in Spreadsheet Files
  - Technology description
  - Energy and emissions per unit demand
  - Economic information
    - Capital costs
    - O & M costs
    - Equipment life

STOCK TURNOVER MODULE

- Initial stocks constructed to calibrate to base year energy use and product output
- These are assumed to be a mix of old and new and retire on straight line basis
- New stock purchases are tracked separately - these retire using a Weibull distribution
- Energy use/emissions coefficients times the stock equal energy use/emissions

MARKET SHARE MODULE

- Technologies compete on the basis of costs
  - Annualized capital costs
  - O&M costs
  - Fuel costs
- Market shares calculated using logit function - with Weibull or normal distribution
- Market share logit functions are parameterized; i.e., penetration rates ares at the analyst's discretion
- Base Case experience suggests the rule that a 15% cost differential gives an 80% market share works well

INDUSTRIES COVERED

1. Food Processing - SIC20

*2. Wood Products - SIC24

*3. Pulp and Paper - SIC26

*4. Chemicals - SIC28

*5. Petroleum Refining - SIC29

*6. Stone, Clay and Glass - SIC32

*7. Iron and Steel - SIC331

*8. Other Primary Metals - SIC33 x 6 above

9. Fabricated Metals and Equipment - SICs 34-37

10. Other Manufacturing - All Other Manufacturing

11. Non-Manufacturing Industry - Balancing Sector

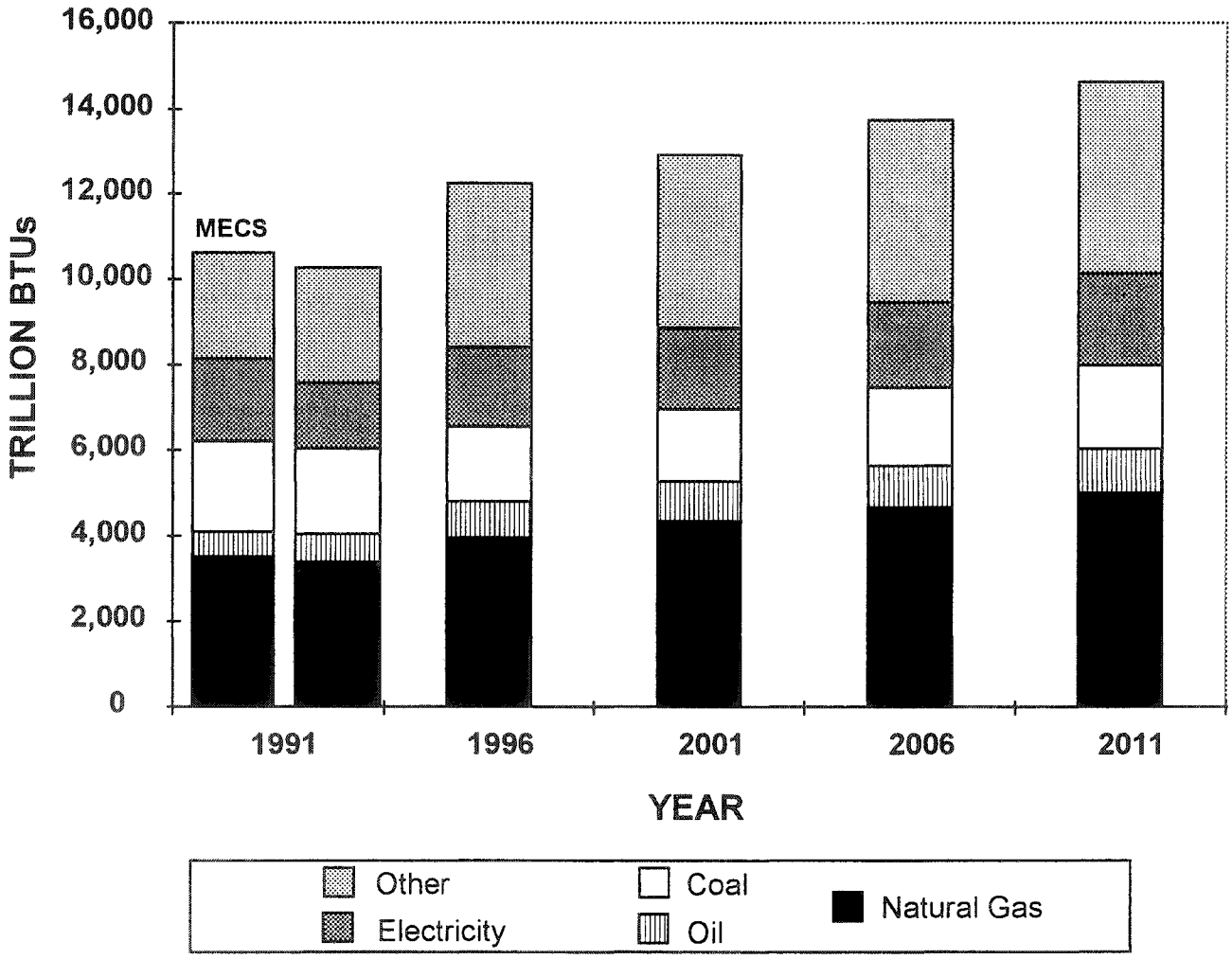
*Process flows modeled

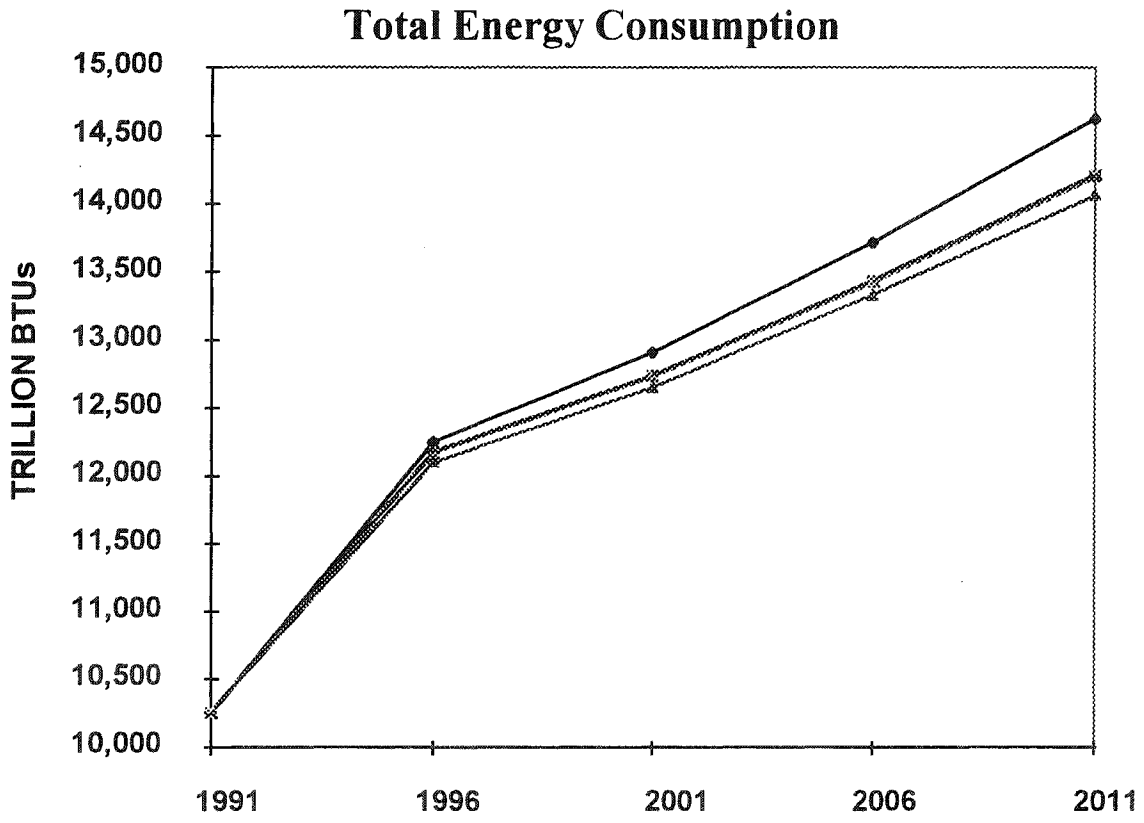
EXAMPLE SCENARIOS

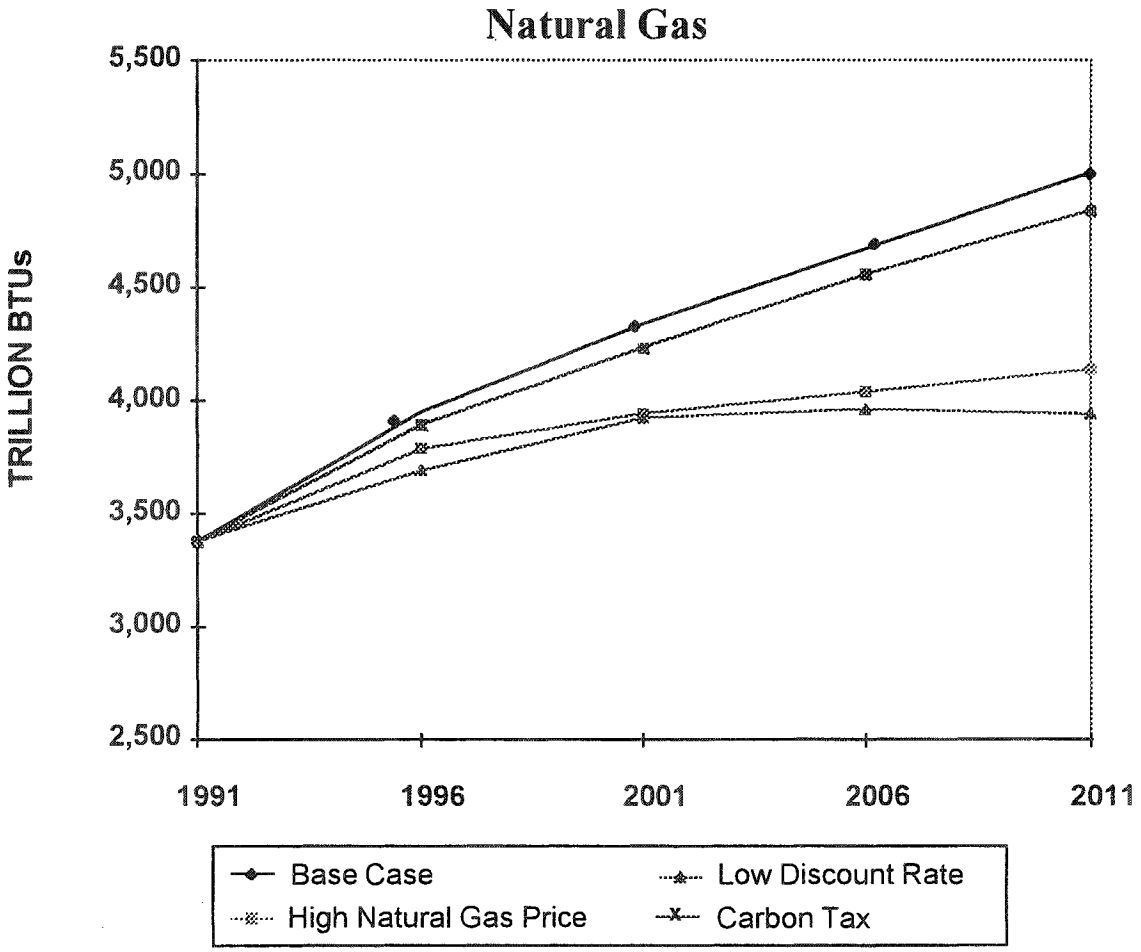
Each module was simulated for each of four scenarios.

1. **BASE CASE**: "Reasonable" Output Growth (1-3%/yr)
   Energy Prices as per 1994 AEO
   Discount Rate at .5 ~ 2-year payback
2. **HIGHER NATURAL GAS PRICES**: Same as base except:
   Natural Gas price was 20% higher
3. **LOWER DISCOUNT RATE**: Same as Base Except:
   Discount Rate at .15 ~ 5-year payback
4. **CARBON TAX**: Same as Base Case except:
   $10/ton Carbon Tax placed on CO_2 emissions

Base Case


16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
TRILLION BTUs
MECS
1991
1996
2001
2006
2011
YEAR
Other
Electricity
Coal
Oil
Natural Gas


Total Energy Consumption
TRILLION BTUs
15,000
14,500
14,000
13,500
13,000
12,500
12,000
11,500
11,000
10,500
10,000
1991
1996
2001
2006
2011


Natural Gas
TRILLION BTUs
5,500
5,000
4,500
4,000
3,500
3,000
2,500
1991
1996
2001
2006
2011
Base Case
Low Discount Rate
High Natural Gas Price
Carbon Tax