". . . simulation models were used to gain an understanding of the primary determinants of energy use in the transportation system."

The Future of Transportation Energy Use in the Philippines

by

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ABSTRACT

As the Philippines attains some progress in its program to reduce oil consumption and imports, the use of petroleum in the transportation industry will become an increasingly important factor to consider. A set of microcomputer based spread sheet simulation models were used to estimate the impact of future economic trends and conservation actions. The simulation results indicated that an economic recovery and subsequent moderate growth would also lead to increased demand for petroleum. On the other hand, economic stagnation combined with some conservation, would hold petroleum use fairly constant. Specific conservation actions, such as efficiency standards, would significantly reduce the increase in petroleum use that would occur with the resumption of economic expansion.

INTRODUCTION

A major challenge facing the Philippines is the planning of its transportation systems within the limits of the amount of petroleum products that the country is capable of importing. The transportation sector accounted for approximately 25 percent of the total national energy use in 1983 and 33 percent of national petroleum use as shown in Table 1. While transportation energy use has

Table 1. 1983 Distribution of Petroleum Energy by Sector

	Petroleum Energy	
	MMBOE	%
Industry	17.8	23.8
Transportation	24.3	32.6
Residential/Commercial	3.9	5.1
Fishing/Agriculture	4.9	6.6
Power Generation	19.9	26.6
Others	4.0	5.3
Total	74.8	100.0

Source: (Lim, 1984)

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remained virtually constant since 1975 due to adoption of conservation measures and the country's economic stagnation, it is beginning to claim a larger share in the Philippine oil market because of the success of the national program to reduce dependence on petroleum in the other sectors, particularly in power generation (Ministry of Energy, 1980). This is shown in Table 2 by the sharp decline in fuel oil use and the increasing percentage of transportation fuels between 1980 and 1984.

The importance of petroleum imports to the national economy is indicated by the oil fraction of export revenues described in Table 3. In 1983, 42 percent of the amount generated from Philippine exports was used to pay for petroleum imports. A large and growing share of the cost of imported oil is being allocated to transportation requirements.

In response to these trends, it is important to consider what the future of transportation energy use will be. If the transportation system will grow considerably in the future and remain almost entirely based on petroleum, then it will place a large and growing burden on the country's economy. If, on the other hand, transportation energy requirements remain constant and become more reliant on non-petroleum energy sources, then the burden on the economy will diminish.

Table 2. Use of Petroleum Products (in thousands of barrels)

Product	1965	%	1970	%	1975	%	1980	%	1983	%	1984	%
Transportation Fuels*												
Avgas	319		104		185		62		51		–	
Avturbo	900		1,867		2,165		2,605		2,658		2,824	
Premium Gasoline	1,669		3,653		5,124		5,866		6,206		5,954	
Regular Gasoline	8,499		11,394		10,132		5,299		2,971		2,717	
Diesel	6,976		10,749		13,227		17,428		18,879		17,090	
Subtotal	18,363	52%	27,767	49%	30,833	43%	31,260	39%	30,765	41%	28,585	46%
Other Fuels												
Fuel Oil	11,228		19,934		29,829		37,129		33,690		24,390	
Kerosene	2,413		3,245		3,154		3,179		2,569		2,269	
LPG	171		1,043		2,086		2,411		2,533		2,225	
Others	1,181		1,607		2,690		2,697		2,410		1,690	
Refining and Loss	1,963		3,160		3,533		3,283		2,853		2,479	
Subtotal	16,956	48%	28,989	51%	41,292	57%	48,699	61%	44,055	59%	33,053	54%
Total	35,319	100%	56,756	100%	72,125	100%	79,959	100%	74,820	100%	61,638	100%

*The fuels under this subheading are usually associated with transportation uses. There are, however, some non-transportation uses such as fishing, agriculture, and power generation. The bulk of this subcategory, however, is for transportation.

Source: Ministry of Energy

Table 3. Petroleum Imports and the National Balance of Trade

	1970	1980	1983
Imported Oil Cost (Million $'s)	126	2516	2116
Oil as a Fraction of Imports (%)	10.4	30.3	28.3
Oil as a Fraction of Exports (%)	11.9	38.4	42.3
Balance of Trade (Million $'s)	–148	–1740	–2482

Source: (Lim, 1984)

METHODOLOGY

A series of modular, special purpose simulation models of transportation energy use were constructed to address the question of the future of transportation energy use in the Philippines (Hanson and Lopez, 1985). Because the models were to be used in a seminar at the National Engineering Center (NEC) at the University of the Philippines, they were developed on Visicalc spreadsheets on Radio Shack TRS-80 Computers.* The purpose of the models was to gain an understanding of the primary determinants of energy use in the transportation system. The focus of the inquiry was on measures that could alter future trends in energy use. Attempts to forecast the future were not emphasized. Management of transportation energy demand is viewed as a more productive area of inquiry (Hanson and Foell, 1981; Hanson, 1985).

Figure 1 provides a description of the elements of the automobile and motorcycle, public utility jeepney, and the bus models. The boxes with no arrows entering are model elements that are

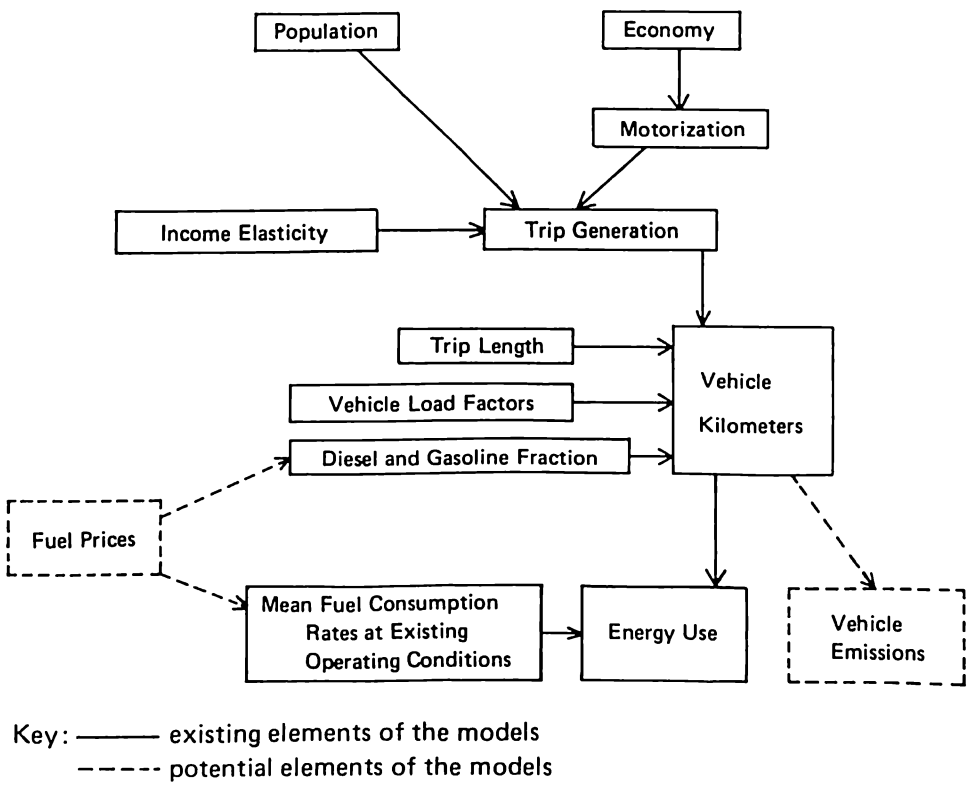

Figure 1. Simulation Models by Mode

the main determinants of energy use. Some model elements such as population and economy are not likely to be influenced by transportation energy policy reasons. Other elements, such as mean fuel consumption rates, could be greatly influenced by altering the characteristics of vehicles permitted into the Philippine vehicle fleet either by import or domestic assembly (Gimenez, 1985; Ocampo, 1985). Differential fuel prices between gasoline and diesel have significantly increased the

*The seminar was entitled "Seminar on Energy Use in Transportation", November 11-29, 1985. Copies of the spreadsheet models can be obtained from the National Engineering Center at the University of the Philippines, Diliman, Quezon City, Philippines. Visicalc is a Registered Trademark of VisiCorp.

fraction of diesel engines in bus and truck fleets. While price elasticities are not directly incorporated in the models, price effects are indirectly incorporated by assuming high fractions of diesel engines and higher fuel economies.*

Model elements with arrows entering and leaving are intermediary variables, for example passenger trips and vehicle kilometers. Model elements showing only arrows entering are energy use, the focus of this inquiry, and potentially, emissions.

Table 4 shows the automobile and motorcycle model implemented for one set of conditions. Important features of the spreadsheet include the regional breakdown for the thirteen Philippine regions across the spreadsheet. From the spreadsheet, it can be noted that each of the key exogenous variables is explicitly shown, including: population growth rates, motorization levels, income growth per capita, income elasticity of trip making, load factors (people per vehicle), mean fuel consumption rates (kilometers per liter), and trip lengths. Space does not permit the showing of the other models; however, their structure is similar.

The models were assembled using available data (Ministry of Transportation and Communications, 1984 and 1984A) and considerable judgment. Data were reasonably adequate for population and vehicle registration by region, and for energy use on a national basis; however, information for intermediary parameters such as trip rates, load factors, and fuel economy was often lacking. While seminar participants at NEC provided considerable help in refining the judgments used, the analysis should be regarded as an initial effort to be improved on in subsequent analysis.

CRITICAL TRENDS AND POINTS OF INFLUENCE

Future energy use in the transportation system is dependent on a small number of critical variables of which only some may be altered by transportation policy. Population and economic growth are the primary driving forces in the system, but these are not influenced by transportation energy policy. Fuel efficiencies, modal distributions, load factors, trip making levels, and trip lengths are subject, to various degrees, to public policy input. The simulation, spreadsheet models were used to evaluate the consequences of varying economic growth rates and policies that would improve fuel efficiency in terms of kilometers per liter of fuel.

RESULTS

To distinguish the influences of economic growth and conservation on energy use, three scenarios were considered.

Scenario A assumed a slowly growing economy from 1980 to 1990, economic recovery at moderate levels of growth after 1990, and little change in the energy efficiency of the transportation system. The economic growth rate in terms of real pesos averages two percent per year from 1980 to 1990, which is less than the population growth rate. The economy is assumed to improve from 1990 to 2000, growing at an average rate of 4.2 percent per year.

Scenario B, while assuming population and economic growth rates identical to scenario A, incorporated a set of conservation measures. Fuel efficiency of cars was assumed to have improved from 10 kilometers per liter in 1980 to 15 kilometers per liter by the year 2000. The jeepney population would have been dominated by the more fuel efficient diesel engine types with the fuel economy improving from 8 kilometers per liter to 10. Buses fuel efficiency would have improved from 1.8 kilometers per liter to 2.5. Truck freight efficiency also would have improved by 20 percent in terms of energy required per ton-kilometer by the year 2000.

Scenario C incorporated the very modest conservation measures in Scenario A and a continuing stagnant economy, with the economy growing after 1990 at 1.2 percent per year. This scenario is included to demonstrate the importance of economic growth trends in determining future transportation energy use.

*Memory restrictions in the TRS-80 microcomputer permitted the inclusion of income elasticities only in the spreadsheets.

Table 4. Automobile and Motorcycle Simulation Model (Scenario A)*

REGION	ONE	TWO	THREE	FOUR	FIVE	SIX	SEVEN
POPULATION (1000'S)							
1975	3269	1933	4210	5214	3194	4146	3387
1980	3541	2216	4803	6119	3477	4526	3787
GRW/YR	1.016	1.028	1.027	1.033	1.017	1.018	1.023
1990	4155	2912	6251	8428	4120	5394	4734
GRW/YR	1.011	1.019	1.019	1.023	1.012	1.012	1.016
2000	4648	3529	7523	10555	4642	6100	5538
MOTORIZATION							
CARS/1000							
1983	3.16	1.24	8.03	3.92	0.98	2.78	4.37
MC/1000							
1983	6.59	4.89	8.04	4.16	3.37	3.39	5.96
TRIPS (1000'S)							
	1980					1975	
CARS	28 = AVE TRIP/PERSON/YR					1.014 = INC-EXP	
	0.99 = INCOME-EXP GROWTH/YR 80-90					2 = ELASTICITY	
	2 = ELASTICITY 80-90					24 = TRIPS 75	
1975	32972	7635	107917	65210	9998	36772	47247
1980	41043	10059	141482	87943	12507	46130	60706
1990	39388	10813	150614	99066	12122	44963	62072
2000	53766	15987	221173	151402	16663	62050	88598
MC	6 = AVE TRIP/PERSON/YEAR						
1975	23782	10446	37380	23927	11875	15505	22279
1980	25761	11975	42645	28080	12928	16926	24910
1990	30227	15738	55505	38673	15320	20171	31141
2000	33814	19070	66799	48438	17259	22813	36428
LOAD FACTORS		CARS:	1980 2.4 = CAR LOAD (AVE)				MC 1.5
MILAGE FACTORS		CARS:	1980 8 = KPL (KILOM/LITER)				MC 20
DISTANCE FACTORS		CARS:	1980 10 = KPT (KILOM/TRIP)				MC 8
PRIVATE VEHICLE FUEL USE (MMBOE'S)							
CARS							
1975	0.13	0.03	0.41	0.25	0.04	0.14	0.18
1980	0.13	0.03	0.45	0.28	0.04	0.15	0.19
1990	0.10	0.03	0.38	0.25	0.03	0.11	0.16
2000	0.15	0.04	0.61	0.42	0.05	0.17	0.25
MC							
1975	0.04	0.02	0.06	0.04	0.02	0.03	0.04
1980	0.04	0.02	0.07	0.05	0.02	0.03	0.04
1990	0.05	0.03	0.09	0.06	0.02	0.03	0.05
2000	0.05	0.03	0.11	0.08	0.03	0.04	0.06
TOTAL							
1975	0.16	0.05	0.47	0.29	0.06	0.16	0.22
1980	0.17	0.05	0.52	0.32	0.06	0.17	0.23
1990	0.15	0.05	0.47	0.31	0.06	0.15	0.21
2000	0.20	0.08	0.72	0.50	0.07	0.21	0.30

EIGHT	NINE	TEN	ELEVEN	TWELVE	SUBTOTL EXCL NCR	NCR	TOTAL INCL NCR
2600	2048	2314	2715	2070	37100	4570	41670
2800	2529	2759	3347	2271	42175	5926	48101
1.015	1.043	1.036	1.043	1.019		1.053	
3247	3856	3922	5087	2733	54840	9964	64805
1.010	1.030	1.025	1.030	1.013		1.037	
3603	5191	5024	6831	3113	66298	14377	80675
0.57	0.84	1.73	2.83	1.20	3.07	40.06	7.63
3.13	5.27	6.15	6.04	2.96	5.07	8.03	5.43
		1990			2000		
GRW 80-75	23	= TRIPS 90			28 = TRIPS		
80-75	1.01	= INC GRW 90-2000					
	2	= ELASTICITY 90-2000					REGIONS SUMMATION
4709	5462	12779	24527	7961	363189	584571	947760
5828	7751	17509	34746	10037	475740	871088	1346828
5528	9667	20358	43189	9881	507662	1198001	1705662
7484	15877	31818	70768	13732	749319	2109070	2858389
8987	11907	15705	18093	6753	206640	40533	247173
9679	14704	18726	22305	7409	236046	52560	288606
11225	22422	26620	33897	8917	309856	88379	398235
12455	30182	34097	45520	10156	377031	127513	504544
ALL YEARS		1975		1990		2000	
=MC LOAD	2.35	= CAR LOAD	2.4	= CAR LOAD	2.4	= CAR LOAD	
ALL YEARS		1975		1990		2000	
=MC KPL	6.5	= CAR KPL	10	= CAR KPL	11	= CAR KPL	
ALL YEARS		1975		1990		2000	
=MC KPT	9.5	= CAR KPT	10	= CAR KPT	12	= CAR KPT	
0.02	0.02	0.05	0.09	0.03	1.38	2.22	3.59
0.02	0.02	0.06	0.11	0.03	1.51	2.77	4.28
0.01	0.02	0.05	0.11	0.03	1.29	3.04	4.33
0.02	0.04	0.09	0.20	0.04	2.08	5.85	7.92
0.01	0.02	0.03	0.03	0.01	0.34	0.07	0.40
0.02	0.02	0.03	0.04	0.01	0.38	0.09	0.47
0.02	0.04	0.04	0.06	0.01	0.50	0.14	0.65
0.02	0.05	0.06	0.07	0.02	0.61	0.21	0.82
0.03	0.04	0.07	0.12	0.04	1.71	2.28	4.00
0.03	0.05	0.09	0.15	0.04	1.89	2.85	4.75
0.03	0.06	0.10	0.16	0.04	1.79	3.19	4.98
0.04	0.09	0.14	0.27	0.05	2.69	6.05	8.74

*The listing of the computer program of the "Automobile and Motorcycle Simulation Model (Scenario A)" is available upon request from: The Managing Editor, *Philippine Engineering Journal,* Rm. 112, National Engineering Center, U.P. Diliman, Quezon City, Philippines.

Table 5 summarizes the energy results of these three scenarios. Scenario A demonstrates that if the Philippine economy recovers from its severe current slump to register a low level of growth from 1980 to 1990, a modest increase in transportation energy use would occur, that is, from 26 million barrels to 31 million barrels in 1990. A moderate growth rate from 1990 to 2000 would result in a substantial growth from 31 million barrels in 1990 to 47 million barrels in 2000.

Scenario B suggests that a deliberate conservation program oriented towards improving vehicle efficiency could cut the growth in energy use from 1990 to 2000 by half. Such a program is not predicated on any changes in travel behavior or land use patterns. For example, the further expansion of the LRT (light rail transit) system in Metro Manila would significantly alter travel patterns, primarily from buses to LRT. Expansion of the LRT or specific measures to limit the geographic extent of Metro Manila are not considered in Scenario B.

Table 5. Transportation Energy Use Scenario Results
(in millions of barrels)

			Scenario A		Scenario B		Scenario C	
	1975	1980	1990	2000	1990	2000	1990	2000
Gasoline	13.2	11.1	8.9	13.0	8.8	10.5	8.9	10.2
Diesel	9.5	12.9	18.6	29.2	17.9	23.8	18.6	22.2
Bunker Fuel	.5	.8	1.0	1.4	1.0	1.4	1.0	1.4
Aviation Fuels	1.3	1.5	2.4	3.8	2.4	3.8	2.4	3.8
	24.5	26.3	30.9	47.4	30.1	39.5	30.9	37.6

Scenario C demonstrates how influential economic growth is in determining future transportation demands. With slow economic growth, transportation energy requirements increase only modestly without the conservation included in Scenario B. Conversely, economic growth rates, similar to those envisioned by the 1983-1987 five-year plan, would result in large increases in transportation energy use, considerably above those in Scenario A.

POLICY IMPLICATIONS

In the light of the critical role which transportation plays in petroleum import requirements, prudent policy should deliberately move towards continued improvement in transportation energy efficiency. Automobiles, jeepneys, and trucks must be the primary targets of conservation measures because of their large share in energy use. Programs to improve efficiency, including vehicle efficiency standards and economic incentives to promote public transportation and limit private vehicles, should be carefully considered. The implications of the continued expansion of Metro Manila and infrastructure investments such as the LRT, exclusive public transit lanes, and bicycle lanes, should be carefully considered and experimented with. Active energy management in transportation can serve to sustain the considerable progress already achieved in reducing oil imports.

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