TABLE III-9. FEEDSTOCK COST CEILING PROJECTIONS, 1990 START

Operation Start Date = 1990

TPD CAPACITY	PLANT FACTOR %	1985 PRODUCT VALUE,$/GAL	1985 GAS COST,$/$10^6$Btu	Feedstock Cost Ceiling--1985 Dollars Per Dry Ton											
			Feedstock Moisture Content:	20%				35%				50%			
			Yield (Gal/Dry Ton):	40	60	80	100	40	60	80	100	40	60	80	100
500	50	1.43	5.96	(79.85)	(57.11)	(34.37)	(11.63)	(95.83)	(73.33)	(50.83)	(28.33)	(120.89)	(98.53)	(76.17)	(53.81)
500	50	1.75	7.30	(63.90)	(35.43)	(6.95)	21.53	(81.90)	(53.03)	(25.52)	2.67	(110.31)	(82.29)	(54.27)	(26.25)
500	50	2.00	8.34	(51.87)	(19.07)	13.74	46.54	(71.39)	(37.72)	(6.24)	26.06	(102.33)	(70.04)	(37.75)	(5.46)
500	70	1.43	5.96	(36.97)	(13.52)	9.94	33.39	(50.93)	(27.70)	(4.47)	18.75	(73.04)	(49.95)	(26.86)	(3.77)
500	70	1.75	7.30	(11.41)	14.57	40.56	66.54	(36.36)	(7.49)	21.05	49.75	(60.18)	(32.19)	(4.20)	23.79
500	70	2.00	8.34	7.87	35.76	63.66	91.55	(25.36)	7.76	40.31	73.14	(50.47)	(18.79)	12.90	44.58
500	90	1.43	5.96	(12.52)	11.12	34.75	58.39	(25.36)	(1.94)	21.48	44.90	(45.83)	(22.35)	0.74	24.02
500	90	1.75	7.30	4.07	33.23	62.38	91.55	(10.79)	18.12	47.00	75.90	(34.61)	(5.88)	22.85	51.58
500	90	2.00	8.34	16.58	49.91	83.23	116.56	0.20	33.26	66.26	99.29	(26.15)	6.69	39.53	72.37
1000	50	1.43	5.96	(40.45)	(16.82)	6.17	28.84	(54.94)	(31.78)	(8.99)	13.68	(75.05)	(55.35)	(32.57)	(9.90)
1000	50	1.75	7.30	(22.98)	6.57	35.35	63.74	(39.60)	(10.62)	17.91	46.31	(65.02)	(37.81)	(9.28)	19.12
1000	50	2.00	8.34	(11.34)	22.16	54.80	87.01	(29.37)	3.49	35.85	68.07	(58.34)	(26.12)	6.25	38.46
1000	70	1.43	5.96	(8.03)	15.93	39.26	62.29	(20.92)	2.59	25.73	48.76	(41.62)	(18.58)	4.56	27.59
1000	70	1.75	7.30	9.44	39.31	68.44	97.19	(5.58)	23.75	52.63	81.39	(29.81)	(1.04)	27.85	56.60
1000	70	2.00	8.34	21.09	54.90	87.89	120.46	4.65	37.85	70.57	103.14	(21.94)	10.65	43.37	75.94
1000	90	1.43	5.96	9.98	34.12	57.65	80.88	(2.01)	21.67	45.03	68.24	(21.40)	1.84	25.18	48.42
1000	90	1.75	7.30	27.45	57.51	86.60	115.78	13.33	42.83	71.40	100.87	(9.59)	19.38	49.00	77.43
1000	90	2.00	8.34	39.10	73.10	106.28	139.04	23.55	56.94	89.86	122.63	(1.71)	31.07	64.00	96.77

TABLE III-10. FEEDSTOCK COST CEILING PROJECTIONS, 1995 START

Operation Start Date = 1995

				Feedstock Cost Ceiling--1985 Dollars Per Dry Ton											
Feedstock Moisture Content:				20%				35%				50%			
Yield (Gal/Dry Ton):				40	60	80	100	40	60	80	100	40	60	80	100
TPD CAPACITY	PLANT FACTOR %	1985 PRODUCT VALUE, $/GAL	1985 GAS COST, $/10^6Btu												
500	50	1.43	5.96	(77.76)	(53.00)	(28.23)	(3.47)	(96.59)	(72.10)	(47.61)	(23.12)	(126.17)	(101.92)	(77.66)	(53.41)
500	50	1.75	7.30	(58.57)	(27.74)	3.10	33.93	(79.96)	(49.90)	(18.96)	11.54	(113.80)	(83.57)	(53.34)	(23.12)
500	50	2.00	8.34	(44.67)	(9.44)	25.78	61.01	(67.92)	(33.83)	1.79	36.64	(104.84)	(70.29)	(35.73)	(1.18)
500	70	1.43	5.96	(31.83)	(6.64)	18.55	43.74	(48.44)	(23.52)	1.41	26.33	(74.83)	(50.12)	(25.42)	(0.71)
500	70	1.75	7.30	(12.64)	18.62	49.88	81.14	(31.82)	0.95	30.06	61.00	(64.46)	(31.77)	(1.10)	29.58
500	70	2.00	8.34	1.26	36.91	72.57	108.22	(19.78)	15.39	50.81	86.10	(53.50)	(18.49)	16.51	51.52
500	90	1.43	5.96	(6.31)	19.12	44.45	69.97	(21.70)	3.67	28.63	53.80	(46.31)	(21.35)	3.61	78.57
500	90	1.75	7.30	12.88	44.38	75.88	107.37	(5.08)	26.34	59.85	92.31	(31.57)	0.67	32.91	65.14
500	90	2.00	8.34	26.78	62.67	98.57	134.46	6.96	42.90	82.45	120.20	(20.89)	16.62	54.12	91.63
1000	50	1.43	5.96	(35.38)	(9.97)	14.66	38.89	(52.66)	(28.32)	(3.48)	20.73	(80.26)	(56.02)	(31.67)	(7.43)
1000	50	1.75	7.30	(15.20)	16.74	47.72	78.22	(35.18)	(4.44)	26.70	57.19	(67.25)	(36.74)	(6.08)	14.43
1000	50	2.00	8.34	(2.29)	33.81	68.86	103.37	(24.00)	10.83	46.00	80.50	(58.93)	(24.41)	10.28	44.80
1000	70	1.43	5.96	(1.56)	24.26	49.32	74.00	(17.07)	7.84	32.98	57.67	(42.04)	(17.35)	7.44	32.13
1000	70	1.75	7.30	18.62	50.97	82.39	113.33	0.41	31.72	63.17	94.13	(29.03)	1.93	33.04	63.99
1000	70	2.00	8.34	31.53	68.04	103.53	138.48	11.59	46.99	82.47	117.44	(20.71)	14.26	49.40	84.36
1000	90	1.43	5.96	17.23	43.28	68.58	93.50	2.70	27.93	53.24	78.18	(20.81)	4.13	29.18	54.11
1000	90	1.75	7.30	37.41	69.99	101.64	132.84	20.18	51.81	83.43	114.63	(7.80)	23.42	54.77	85.97
1000	90	2.00	8.34	50.32	87.06	122.78	157.99	31.36	67.08	102.73	137.94	0.52	35.75	71.13	106.34

TABLE III-11. PROJECTED MINIMUM FEASIBLE PLANT PERFORMANCE LEVELS -- $8/TON FEEDSTOCK CRITERION[1]

Middle Fuel Price Scenario ($1.75/gallon 1985 product value)

	Nominal Plant Characterization	Minimally Feasible Combinations				
		a	b	c	d	e
Plant Capacity	500 TPD	1000 TPD	1000 TPD	500 TPD	500 TPD	1000 TPD
Plant Factor	70%	70%	50%	90%	50%	90%
Plant Yield	70 GPT	50 GPT	70 GPT	50 GPT	100 GPT	40 GPT

High Fuel Price Scenario ($2.00/gallon 1985 product value)

	Pessimistic Plant Characterization	Minimally Feasible Combinations				
		a	b	c	d	e
Plant Capacity	500 TPD	500 TPD	500 TPD	1000 TPD	1000 TPD	1000 TPD
Plant Factor	60%	50%	90%	50%	70%	90%
Plant Yield	60 GPT	90 GPT	40 GPT	60 GPT	40 GPT	30 GPT

Low Fuel Price Scenario ($1.43/gallon 1985 product value)

	Optimistic Plant Characterization	Minimally Feasible Combinations				
		a	b	c	d	e
Plant Capacity	1000 TPD	1000 TPD	1000 TPD	500 TPD	500 TPD	500 TPD
Plant Factor	90%	70%	50%	90%	70%	50%
Plant Yield	80 GPT	60 GPT	90 GPT	70 GPT	90 GPT	n/a

[1]Minimal feasibility criterion is a 1985 start 20% moisture feedstock cost ceiling of $8 per ton, which could make 10 million tons potentially available in 1985.

(2) The 10 mile one-way haul distance associated with the RDF supply curve may be optimistic. Though the typical output RDF capacity of a single municipal resource recovery plant is at least 1000 TPD (Reference 6), it is conceivable that the RDF conversion plant would be located between two or more such recovery plants as part of its business strategy. If the average haul distance for RDF is doubled to twenty miles, the resulting delivered cost increase in 1985 is $3.50 per day equivalent ton (Reference 30).

(3) The above two adjustments would together shift the RDF supply curve by a $6 per ton increase in delivered RDF cost in 1985. The minimal feasibility criterion specified in Table III-11, then, would change from $8 per ton to a $14 per ton feedstock cost ceiling for RDF conversion in 1985.

Minimum plant performance levels are projected in Table III-12 for this $14 per ton criterion. Under the Middle Fuel Price Scenario, it can be seen that the Nominal Plant Characterization (combination f) still meets the criterion. In fact, only nine of the 18 minimum feasibility combinations change in moving from the $8 per ton criterion to the $14 per ton criterion. This apparently weak sensitivity is due partially to the way in which the minimum feasibility combinations were determined (without interpolation between parameter decades), and partially because the plant economy improves so dramatically over the range of uncertainty in performance characteristics.

TABLE III-12. PROJECTED MINIMUM FEASIBLE PLANT PERFORMANCE LEVELS -- $14/TON FEEDSTOCK CRITERION

Middle Fuel Price Scenario ($1.75/gallon 1985 product value)

	Minimally Feasible Combinations					
	a	b	c	d	e	f
Plant Capacity	1000 TPD	1000 TPD	500 TPD	500 TPD	1000 TPD	500 TPD
Plant Factor	70%	50%	90%	50%	90%	70%
Plant Yield	50 GPT	70 GPT	60 GPT	n/a	40 GPT	70 GPT

High Fuel Price Scenario ($2.00/gallon 1985 product value)

	Minimally Feasible Combinations					
	a	b	c	d	e	f
Plant Capacity	500 TPD	500 TPD	1000 TPD	1000 TPD	1000 TPD	500 TPD
Plant Factor	50%	90%	50%	70%	90%	70%
Plant Yield	90 GPT	50 GPT	70 GPT	50 GPT	40 GPT	60 GPT

Low Fuel Price Scenario ($1.43/gallon 1985 product value

	Minimally Feasible Combinations					
	a	b	c	d	e	f
Plant Capacity	1000 TPD	1000 TPD	500 TPD	500 TPD	500 TPD	1000 TPD
Plant Factor	70%	50%	90%	70%	50%	90%
Plant Yield	70 GPT	100 GPT	70 GPT	90 GPT	n/a	50GPT

Note: Minimal feasibility criterion is a 1985 start 20 percent moisture feedstock cost ceiling of $14 per ton, representing a $6 per ton shift in the feedstock supply curve shown in Chapter II.

IV. PROJECTED IMPACTS OF THE ASU WASTE CONVERSION PROCESS

This chapter projects the potential petroleum savings and cost impacts of the ASU process assuming pessimistic, nominal, and optimistic performance levels. Table IV-1 defines these plant performance levels. The nominal performance level characteristics are selected as one possible set which leads to a minimally feasible 1985 feedstock cost ceiling under the middle fuel price scenario. The optimistic plant performance levels are selected as one possible set which exceeds the minimally feasible 1985 feedstock cost ceiling under the low fuel price scenario. Pessimistic plant performance levels are chosen as a set which just fails to meet the minimally feasible 1985 feedstock cost ceiling (see Table III-11, previous chapter).

Potential nationwide petroleum saving and net energy impacts of these characteristic plant/fuel price scenario combinations are projected in Tables IV-2, IV-3, and IV-4. The market penetration fractions appearing in these tables are determined separately for RDF, agricultural residue, and wood conversion markets using the Bass model diffusion curve shown in Figure IV.1 (Reference 31). The Bass equation coefficients were chosen arbitrarily but fall within the range of specifications found in the literature on innovative industrial technologies (e.g., fuel cells, Reference 31).

The estimated purchased gas energy in Tables IV-2, IV-3, and IV-4 is obtained from the process energy balance discussed in Chapter III as tabulated in Table IV-5. Purchased electricity is taken from the plant O&M cost analysis and expressed as its primary energy equivalent. Feedstock production energy is estimated as shown in Table IV-6.

Projected economic impacts of the three test implementation cases are shown in Table IV-7. The potential cost benefit of the public investment in the ASU process is extremely favorable, so long as progress continues toward these commercial plant performance levels.

No potential adverse environmental issues associated with the ASU process are believed capable of hindering the technology's commercialization with proper planning. The 1980 Environmental Development Plan for the DOE Office of Industrial Programs identifies (1) local aquatic ecosystem and water quality impacts, and (2) solid waste disposal as the primary environmental concerns associated with the process. Best Available Technology standards prescribed by the Environmental Protection Agency (EPA) for some refinery contaminants may apply. The EPA Hazardous Waste Management System may apply to nonregenerable spent catalysts, process vessel sludges and scale, and storage tank sediments. DOE plans to perform the necessary characterization, measurement, and monitoring research as the RD&D project matures. Potential national environmental impacts can not be projected with any degree of confidence at this stage of the project.

TABLE IV-1. CHARACTERISTIC PLANT ASSUMPTIONS

<u>Nominal Plant Characteristics</u>

Capacity:	500 TPD dry feedstock equivalent
Plant Factor:	70 percent
Plant Yield:	70 gallons light heating oil per ton dry feedstock equivalent

<u>Optimistic Plant Characteristics</u>

Capacity:	1000 TPD dry feedstock equivalent
Plant Factor:	90 percent
Plant Yield:	80 gallons light heating oil per ton dry feedstock equivalent

<u>Pessimistic Plant Characteristics</u>

Capacity:	500 TPD dry feedstock equivalent
Plant Factor:	60 percent
Plant Yield:	60 gallons light heating oil per ton dry feedstock equivalent

TABLE IV-2. PROJECTED IMPACTS -- NOMINAL PLANT CHARACTERISTICS[1] AND MIDDLE FUEL PRICE SCENARIO[2]

	Feedstock Cost Ceiling[7] 1985 $/dry ton			Available Feedstock 10^6 dry tons/year			Market Penetration Fraction--Units in Use[3]			Fuel Oil Produced[4] 10^{12} Btu/year			Gas Purchased[5] 10^{12} Btu/year			Electricity Purchased 10^{12} Btu/year			Feedstock Production Energy 10^{12} Btu/year			Net Energy Balance[6] 10^{12} Btu/year			
Year	RDF	Agr-Res.	Wood	RDF	Agr-Res.	Wood	RDF	Agr-Res.	Wood	RDF	Agr-Res.	Wood	RDF	Agr-Res.	Wood	RDF	Agr-Res.	Wood	RDF	Agr-Res.	Wood	RDF	Agr-Res.	Wood	Total
1985	13.55	(0.19)	(21.69)	40.0	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
1990	27.57	6.78	(18.20)	71.5	0.0	0.0	0.08	0.0	0.0	55.5	0.0	0.0	1.7	0.0	0.0	1.4	0.0	0.0	4.0	0.0	0.0	48.4	0.0	0.0	48.4
1995	34.25	15.51	(16.44)	80.0	6.0	0.0	0.40	0.05	0.0	310.2	2.9	0.0	9.6	0.5	0.0	8.0	0.1	0.0	22.4	0.8	0.0	270.2	1.5	0.0	271.7
2000	34.25	15.51	(16.44)	86.0	8.0	0.0	0.73	0.33	0.0	608.6	25.6	0.0	18.8	4.2	0.0	15.7	0.7	0.0	43.9	6.9	0.0	530.2	13.8	0.0	544.0

NOTES:

1 500 TPD, 70 percent plant factor, and 70 gallons per ton yield.
2 In 1985, product value is $1.75/gallon and gas cost is $7.30/$10^6$ Btu (1985 dollars). Annual price escalators are 10.5% and 12.9%, respectively.
3 Assumes RDF plant introduction in 1987; agri-residue plant introduction in 1993. It should be recognized that the Bass diffusion curve was specified arbitrarily and that other, conceivably competing, innovative uses for feedstocks were ignored (see text).
4 At 138,500 Btu/gallon.
5 This supplemental heat requirement could be met alternatively by scaling up the system to accept more biomass.
6 Net Energy Balance = Fuel Oil Produced - (Gas Purchased + Electricity Purchased + Feedstock Production Energy).
7 Operating plant inventories in 1985, 1990, and 1995 are represented by leveled cost analyses for plants coming on line in those years. The inventory in 2000 is represented by the 1995 plant start leveled cost analysis.

TABLE IV-3. PROJECTED IMPACTS -- OPTIMISTIC PLANT CHARACTERISTICS AND LOW FUEL PRICE SCENARIO

	Feedstock Cost Ceiling[7] 1985 $/dry ton			Available Feedstock 10^6 dry tons/year			Market Penetration Fraction--Units in Use[3]			Fuel Oil Produced[4] 10^{12} Btu/year			Gas Purchased[5] 10^{12} Btu/year			Electricity Purchased 10^{12} Btu/year			Feedstock Production Energy 10^{12} Btu/year			Net Energy Balance[6] 10^{12} Btu/year			
Year	RDF	Agr-Res.	Wood	RDF	Agr-Res.	Wood	RDF	Agr-Res.	Wood	RDF	Agr-Res.	Wood	RDF	Agr-Res.	Wood	RDF	Agr-Res.	Wood	RDF	Agr-Res.	Wood	RDF	Agr-Res.	Wood	Total
1985	48.35	37.84	21.35	72.0	5.0	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
1990	57.65	45.01	25.18	76.0	57.0	0.0	0.08	0.08	0.0	67.4	50.5	0.0	5.2	9.7	0.0	1.5	1.2	0.0	4.3	11.9	0.0	56.4	27.7	0.0	84.1
1995	68.58	53.24	29.18	82.0	78.0	0.0	0.40	0.40	0.0	363.4	345.7	0.0	27.9	66.1	0.0	8.2	8.1	0.0	23.0	81.1	0.0	304.3	190.4	0.0	494.7
2000	68.58	53.24	29.18	90.0	85.0	0.0	0.73	0.73	0.0	728.0	687.5	0.0	55.8	131.5	0.0	16.4	16.1	0.0	46.0	161.3	0.0	609.8	378.6	0.0	988.4

NOTES:

1 1000 TPD, 90 percent plant factor, and 80 gallons per ton yield.
2 In 1985, product value is $1.43/gallon and gas cost is $5.96/$10^6$ Btu (1985 dollars). Annual price escalators are 10.5% and 12.9%, respectively.
3 Assumes RDF agri-residue plant introduction in 1987. It should be recognized that the Bass diffusion curve was specified arbitrarily and that other, conceivably competing, innovative uses for feedstocks were ignored (see text).
4 At 138,500 Btu/gallon.
5 This supplemental heat requirement could be met alternatively by scaling up the system to accept more biomass.
6 Net Energy Balance = Fuel Oil Produced - (Gas Purchased + Electricity Purchased + Feedstock Production Energy).
7 Operating plant inventories in 1985, 1990, and 1995 are represented by leveled cost analyses for plants coming on line in those years. The inventory in 2000 is represented by the 1995 plant start leveled cost analysis.

TABLE IV-4. PROJECTED IMPACTS -- PESSIMISTIC PLANT CHARACTERISTICS[1] AND HIGH FUEL PRICE SCENARIO[2]

	Feedstock Cost Ceiling[7] 1985 \$/dry ton			Available Feedstock 10^6 dry tons/year			Market Penetration Fraction--Units in Use[3]			Fuel Oil Produced[4] 10^{12} Btu/year			Gas Purchased[5] 10^{12} Btu/year			Electricity Purchased 10^{12} Btu/year			Feedstock Production Energy 10^{12} Btu/year			Net Energy Balance[6] 10^{12} Btu/year			
Year	RDF	Agr-Res.	Wood	RDF	Agr-Res.	Wood	RDF	Agr-Res.	Wood	RDF	Agr-Res.	Wood	RDF	Agr-Res.	Wood	RDF	Agr-Res.	Wood	RDF	Agr-Res.	Wood	RDF	Agr-Res.	Wood	Total
1985	(5.93)	(21.50)	(46.52)	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
1990	8.35	(14.98)	(44.42)	15.0	0.0	0.0	0.08	0.0	0.0	10.0	0.0	0.0	(0.3)	0.0	0.0	0.3	0.0	0.0	0.8	0.0	0.0	9.2	0.0	0.0	9.2
1995	13.74	(9.22)	(44.39)	47.5	0.0	0.0	0.40	0.0	0.0	157.9	0.0	0.0	(4.6)	0.0	0.0	4.8	0.0	0.0	13.3	0.0	0.0	144.0	0.0	0.0	144.4
2000	13.74	(9.22)	(44.39)	52.0	0.0	0.0	0.73	0.0	0.0	315.4	0.0	0.0	(9.1)	0.0	0.0	9.5	0.0	0.0	26.6	0.0	0.0	288.4	0.0	0.0	288.4

NOTES:

1 500 TPD, 60 percent plant factor, and 60 gallons per ton yield.
2 In 1985, product value is \$2.00/gallon and gas cost is \$8.34/10^6 Btu (1985 dollars). Annual price escalators are 10.5% and 12.9%, respectively.
3 Assumes RDF plant introduction in 1987. It should be recognized that the Bass diffusion curve was specified arbitrarily and that other, conceivably competing, innovative uses for feedstocks were ignored (see text).
4 At 138,500 Btu/gallon.
5 This supplemental heat requirement could be met alternatively by scaling up the system to accept more biomass.
6 Net Energy Balance = Fuel Oil Produced - (Gas Purchased + Electricity Purchased + Feedstock Production Energy).
7 Operating plant inventories in 1985, 1990, and 1995 are represented by leveled cost analyses for plants coming on line in those years. The inventory in 2000 is represented by the 1995 plant start leveled cost analysis.

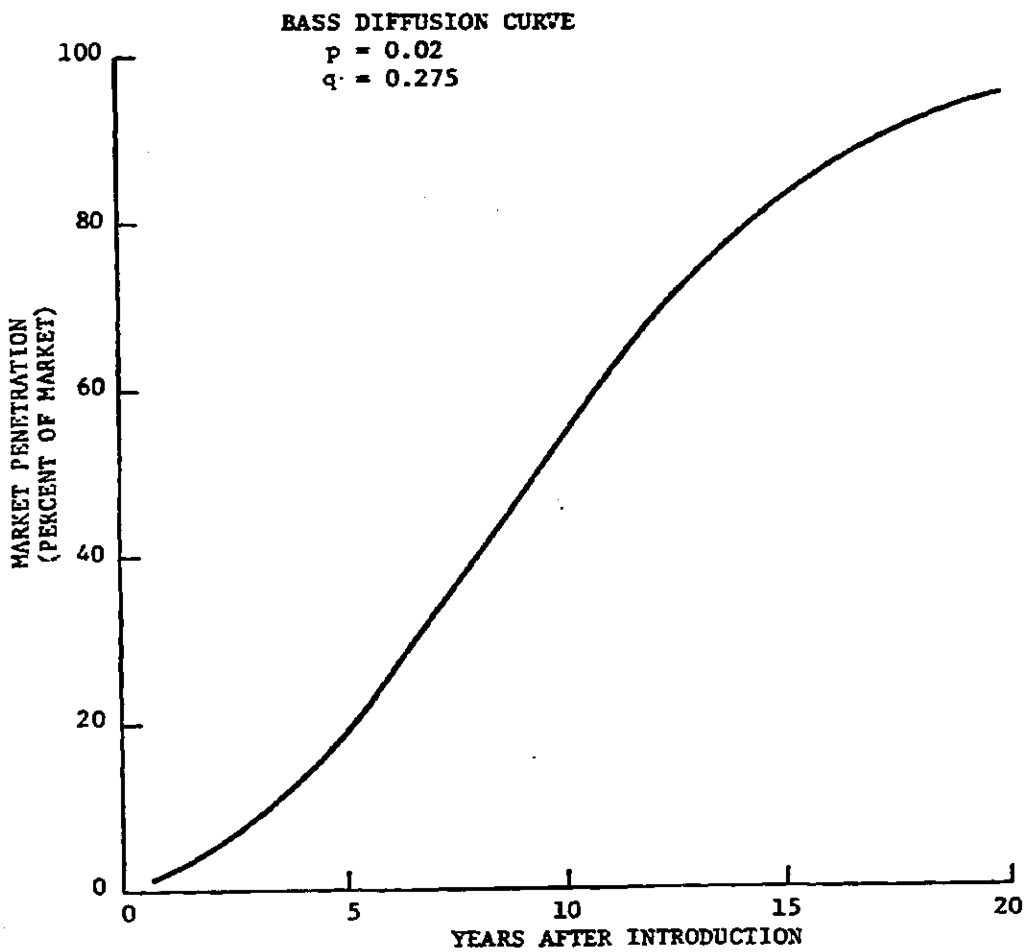

Figure IV.1. Bass Model Diffusion Curve Used to Project Technology Impacts

TABLE IV-5. SURPLUS HIGH BTU GAS

Plant Yield (gallons/dry ton)	10^6 Btu per dry ton feedstock			
	40	60	80	100
Feedstock Moisture Content				
0%	2.43	1.33	0.24	(0.84)
20%	1.33	0.24	(0.85)	(1.94
35%	0.0	(1.04)	(2.12)	(3.21)
50%	(1.98)	(3.07)	(4.15)	(5.25)

TABLE IV-6. IMBEDDED ENERGY CONTENT OF FEEDSTOCKS

Feedstock	Production Energy (10^6Btu/dry ton)
RDF	0.7
Agricultural residue	2.6[1]
Wood	0.6

[1] Takes into account replacement of fertilizer energy value.

Source: Reference 1.

TABLE IV-7. PROJECTED ECONOMIC IMPACTS

Year	Feedstock Converted 10^6 Tons/Year	Net Fuel Energy Produced 10^{12} Btu/year	Number Plants in Operation[1]	Cumulative Capital Investment[2] 10^6 1985 $	Annual Value of Net Fuel Energy Produced[3] 10^6 1985 $	Cumulative Value of Net Fuel Energy Produced 10^6 1985 $	Plant Characteristics and Fuel Price Assumptions
1985	0.0	0.0	0.0	0.0	0.0	0.0	Nominal Plant Characteristics and Middle Fuel Price Scenario
1990	5.7	48.4	45	1725.8	1006.0	1006.0	
1995	32.3	271.7	259	9932.6	9304.1	10310.1	
2000	65.4	544.0	512	19635.2	30689.8	40999.9	
1985	0.0	0.0	0.0	0.0	0.0	0.0	Optimistic Plant Characteristics & Low Fuel Price Scenario
1990	10.6	84.1	32	1867.8	1428.5	1428.5	
1995	64.0	494.7	195	11382.2	13842.8	15271.3	
2000	127.8	988.4	389	22705.9	45564.5	60835.8	
1985	0.0	0.0	0.0	0.0	0.0	0.0	Pessimistic Plant Characteristics & High Fuel Price Scenario
1990	1.2	9.2	11	423.3	218.6	218.6	
1995	19.0	144.4	174	6695.5	5651.2	5869.8	
2000	38.0	288.4	347	13352.6	18594.4	24464.2	

1 Determined by assumed average plant capacity and plant factor.
2 Based on total capital requirement per plant in 1985.
3 Taken as Net Fuel Energy Produced x the assumed product value in 1985.

The $6 per ton test increment in projected 1985 RDF feedstock costs (discussed in Chapter III) can also be examined for its effect on the potential national impacts of the ASU process. Under the middle fuel price scenario, and with this $6 per ton cost increase, the nominal performance level plant projected national net energy balance is as follows:

	Net Energy Balance 10^{12} Btu/Year		
Year	RDF	Agr-Res	Total
1985	0.0	0.0	0.0
1990	42.6	0.0	42.6
1995	246.6	0.0	246.6
2000	505.5	0.0	505.5

Comparable test increases in 1985 agricultural residue costs would be $9.20/ton for imbedded energy at a $0.50/gallon oil price increase, plus $7.80/ton to represent a doubling of the assumed average haul distance to 60 miles. With this $17.60/ton shift in the supply curve for agricultural residue, none is economically available under the nominal plant performance and middle fuel price assumptions.

The net energy difference associated with the feedstock cost test increment ($6/ton RDF) is 5.8, 25.1, and 38.5 trillion Btu in 1990, 1995, and 2000, respectively. While these numbers are large, they represent decreases in the original projections of only 12, 9, and 7 percent, respectively.

There are plant economic trade-offs implicit in the relationship between feedstock costs and plant factor. It is expected, for example, that a very highly processed RDF is consistent with a high plant factor. The existence of these obvious trade-offs are the reason that feedstock cost ceilings are mapped extensively over the ranges of key parameters in Chapter III. The economic feasibility of individual plants and their feedstock supply-limited potential national impacts can be determined immediately for a large number of plant performance level combinations by using these results.

V. REFERENCES

1. "The Report of the Alcohol Fuels Policy Review," U.S. Department of Energy, Assistant Secretary for Policy Evaluation, Washington, D.C., June 1979. DOE/PE-0012.

2. "Annual Report to Congress, 1979," U.S. Department of Energy, Energy Information Administration, (Volume Three). DOE/EIA-0173 (79)/3.

3. Mittelhauser Corporation, "Preliminary Economic Assessment of Two Facilities Using the Arizona State University Flash Pyrolysis Method for Conversion of Cellulosic and Waste Polymer Materials to a Light Heating Oil Product," Prepared for Argonne National Laboratory, Argonne, Illinois, February 15, 1980.

4. Third International Symposium on Alcohol Fuels Technology, Conference Proceedings, Mary 29-31, 1979, Asilomar, California, U.S. Department of Energy, Assistant Secretary for Conservation and Solar Energy, Washington, D.C., April 1980. CONF-790520.

5. Proceedings of the DOE Residue and Waste Fuels Utilization Program Contractor Review Meeting, Conference September 25-26, 1979, Washington, D.C., U.S. Department of Energy, Assistant Secretary for Conservation and Solar Energy, December 1979. CONF-790987.

6. M.L. Renard, "Refuse-Derived Fuel (RDF) and Densified Refuse-Derived Fuel (d-RDF," National Center for Resource Recovery, Washington, D.C., June 1978. RM77-2.

7. J.L. Jones, et al, "A Comparative Economic Analysis of Alcohol Fuels Production Options," SRI International, Menlo Park, California, 1979.

8. "Executive Briefing Report--Waste to Energy Systems," U.S. Environmental Protection Agency, Environmental Research Information Center, June 14, 1979.

9. Nowacki, Perry, Coal Liquefaction Processes, Noyes Data Corporation, Park Ridge, New Jersey, 1979.

10. Reed, R.J. (Editor), North American Combustion Handbook, 2d Ed, North American Manufacturing Company, Cleveland, Ohio, 1978. ISBN 0-9601596-1-4.

11. Technical and Economic Evaluations of Biomass Utilization Processes, Technical Report No. 1, Prepared for the United States Department of Energy , Biomass Energy Systems Branch, by SRI International, Menlo Park, California, September 1980.

12. The Bio-Energy Directory, 2d Ed., The Bio-Energy Council, Washington, D.C., 1980.

13. Plant Design and Economics for Chemical Engineers, 2d Ed., Peters and Timmerhaus, McGraw-Hill Book Company, New York, 1968.

14. Kuester, James L., "Conversion of Cellulosic and Waste Polymer Material to Gasoline," Interim Report No. COO-2982-1 thru 58, Alternative Materials Utilization Branch, Division of Industrial Energy Conservation, U.S. Department of Energy Contract No. EY-76-S-02-2982, March 28, 1979.

15. Kuester, James L., "Fluidized Bed Pyrolysis to Gases Containing Olefins," Specialist's Workshop on Fast Pyrolysis of Biomass, Copper Mountain, Colorado, October 19-22, 1980.

16. Kuester, James L., "Liquid Hydrocarbon Fuels from Biomass," Symposium on Biomass as a Fossil Fuel Source, Joint Meeting of the American Chemical Society and Chemical Society of Japan, Honolulu, Hawaii, April 1-6, 1979.

17. Kuester, James L., "Conversion of Cellulosic Wastes to Liquid Fuels," Presented at the Engineering Foundation Conference on Municipal Solid Waste as a Resource, The Problems and the Promise, Henniker, New Hampshire, July 22-27, 1979.

18. Kuester, James L., "Conversion of Cellulosic and Waste Polymer Material to Gasoline," Presented at the Thermal Conversion of Solid Waste and Biomass Symposium, American Chemical Society, Washington, D.C., September 9-14, 1979.

19. Chemical Engineers' Handbook, 5th Ed., Perry and Chilton, McGraw-Hill Book Company, New York, New York, 1973.

20. Private Communication, R.M. Gould, Mobil Research and Development Corporation, to JoAnne Wade, February 12, 1981.

21. Site Visit to Arizona State University, Cellulosic Waste Conversion Pilot Plant Facility, December 4, 1980. E. Lynch, J.L. Kuester, J.E. Reed, J. Wade and B. Cranford in attendance.

22. "Operations of the Biomass Liquefaction Facility," A Wood-to-Oil Process Development Unit, Wheelabrator Cleanfuel Corporation, Albany, Oregon.

23. "A Vertical-Bed Pyrolysis System," Jones, Jerry L. and Radding, Shirley B., editors, ASC Symposium Series, No. 76, Solid Wastes and Residues, American Chemical Society, 1978.

24. "Pyrolytic Oils, Characterization and Data Development for Continuous Processing," United States Environmental Protection Agency, Municipal Environmental Research Laboratory, Cincinnati, Ohio, August, 1980.

25. "Coal Gasification Technology," Citations from the American Petroleum Institute Data Base, National Information Service, Springfield, Virginia, 1979-March 1980.

26. "Fluidized Bed Combustion," Volume 1, Citations from the Engineering Index Data Base, National Technical Information Service, Springfield, Virginia, 1970-1976.

27. "Fluidized Bed Combustion," Volume 2, Citations from the Engineering Index Data Base, National Technical Information Service, Springfield, Virginia, 1977-March 1980.

28. "Synthetic Fuels from Municipal, Industrial and Agricultural Wastes," Citations from the NTIS Data Base, National Technical Information Service, Springfield, Virginia, 1964-June 1980.

29. "Coal Liquefaction Technology," Citations from the American Petroleum Institute Data Base, National Technical Information Service, Springfield, Virginia, 1979-March 1980.

30. Joseph L. Pavoni, et al, Handbook of Solid Waste Disposal, Van Nostran Reinhold Company, New York, 1975.

31. W.R. Mixon, et al, "Market Assessment of Fuel Cell Total Energy Systems," ORNL/CON-36, March 1979.

APPENDIX A

ARIZONA STATE UNIVERSITY
PROJECT SUMMARY

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PROJECT SUMMARY

A. BACKGROUND

Due to the energy problems caused by decreases in energy availability and supply, and associated price increases, alternative energy sources are under investigation by the Federal governemnt and private industry. To reduce this country's dependence on imported oil, keep energy dollars within the United States, provide a lower cost alternative to petroleum-based fuels and ensure continuity of supply, new oil substitute processes must be developed.

As a substitute for petroleum, the concept of fuels and chemical feedstocks from wastes and direct biomass sources presents a viable alternative. While coal offers an intermediate solution, the supply is finite with considerable detrimental environmental side effects existing in both the collection and conversion steps. Cellulosic sources do not suffer from significant environmental problems in their collection or processing, and with the present direct biomass sources, the supply is enormous and renewable. Although the cost of collection may be incrementally greater than that of more traditional energy sources, with the depletion of the fossil feedstocks, there will be no other source for liquid fuels.

Waste sources (industrial, municipal) present a promising outlook for satisfying an increasing portion of future energy demands. Technologies for processing waste energy sources are numerous and varied (References 12 and 28). In many areas municipal sources (refuse, sludge) are collected (taking advantage of an existing collection system), and separated, with the organics being used as a solid fuel. While the resulting solid fuel has the heating quality of a low grade coal (8000 Btu/lb maximum), and the technology is comparably well developed, environmental restrictions in many areas prohibit the burning of solid fuels. Other technologies, both biological and thermal, for fuel products from waste organics (biomass) are currently in different research, design and development stages. Biological routes include: 1) anaerobic digestion to produce methane; 2) aerobic digestion to produce compost; and 3) hydrolysis routes to produce glucose and various derivatives. Although the aforementioned biological conversions all take place at relatively low temperatures, they have major inherent disadvantages with respect to processing times (weeks) and control sensitivity (destruction of the biological mechanism by minor changes in process conditions).

Thermal conversion is a process in which the biomass is decomposed at elevated temperatures with or without the presence of oxygen. With sufficient oxygen, complete combustion takes place. In an oxygen starved