Table 5.2: Summary of Forintek Integrated Process Model non-zero constraint activities

Constraint	Activity	Types of Constraint	RHS	Explanation
ASPAVAIL	195.00	=	195	This constraint limits the amount of aspen wood available for the bioconversion process.
SEACAPAC	195.00	>	0	This indicates that in the steam treatment process, the input cannot exceed its capacity. At present, there is unlimited capacity which is indicated by the > sign.
H2SO4CAP	185.46	>	0	This constraint limits the amount of aspen wood which can be pretreated with sulfuric acid to the sulfuric acid pretreatment capacity.
STM15REQ	-34.80	<	0	This implies that the consumption of 15 PSIG steam is less than its production. Thus a surplus of 34.80 mmlb of steam.
FURLIMIT	15.08	>	0	It indicates the number (tons/day) of coproduct, furfural, produced.
BDLLIMIT	45.57	>	0	Similiar explanation for butanediol.
ETHLIMIT	9.11	>	0	Similiar explanation for ethanol.
CHF1INHB	168.77	>	0	This total indicates both SEA & inhibitors. At present, there is no removal of inhibitors performed. This is due to the inability to identify specific inhibitors from each other.
CHF1CAPC	506.31	>	0	This indicates the amount of capacity required in CHF1 process to convert 168.77 tons of SEA to 45.57 tons of butanediol and 9.11 tons of its coproduct, ethanol.
XYASEBAL	455.44	>	0	This amount of xylanese enzymes were produced but not used. This is because there was no input sent to CHF2 process.
ENPRDCAP	32.13	>	0	To produce the required amount of enzymes this amount of capacity is required.

Table 5.3: List of Symbols for Non-zero Variables in the Optimal Solution.

ASSPURCH : Aspen wood purchased (TONS).

SEEJ4F6N : Steam explosion at 180 seconds retention time, 470 PSIG pressure (240 c), Forintek chip size, green, no pretreatment (TONS).

SEE63F62 : Steam explosion at 80 seconds retention time, 322 PSIG pressure (220 c), Forintek chip size, green, with .2% sulfuric acid pretreatment (TONS).

SE63F62T : The SEA (steam exploded aspen) from above activity, SEE63F62 is send directly to a CHF (combined hydrolysis and fermentation) process (TONS).

H1D12N3B : The CHF of the total SEA stream to produce 2,3-butanediol with an enzyme loading of 10 FPU/G, a substrate concentration of 2% , no inhibitors removal, a 3 days residence time and a batch process (TONS).

SEATOTAL : The totals of SEA produced under different steam explosion condition prior to transfer to CHF processes (TONS).

EPE4SBSS : Enzyme production with the SEA material. The enzyme production has a four day residence time, standard aeration and agitation, a batch process, standard temperature and standard PH (TONS).

BDLRECOV : The recovery of end product, 2,3-butanediol (TONS).
BDLSALE : The sales of 2,3-butanediol (TONS).
ETHRECOV : The recovery of end product, ethanol (TONS).
ETHSALE : The sales of ethanol (TONS).
LIGRECOV : The recovery of coproduct, lignin (TONS).
LIGFUEL : The sales of lignin as fuel (TONS).
FURRECOV : The recovery of coproduct, furfural (TONS).
FURSALE : The sales of furfural (TONS).
POWERPUR : Power purchase (KWH).
CWPURCH : Cooling water purchase (MMGAL).
PWPURCH : Process water purchase (MMGAL).
STM200PU : Purchase 200 PSIG steam (MMLB).
STM600PU : Purchase 600 PSIG steam (MMLB).
ENMEDIUM : Enzyme production medium purchase (TONS).
FERMED : Fermentation medium purchase (TONS).

5.3 SENSITIVITY ANALYSIS

In order to get significant results from the simulated model, accurate data is necessary. However, collection of accurate data, even if possible, can be costly, and we are sometimes forced to use data of doubtful quality. Since there is always some uncertainty in the data, it is useful to know over what range and under what conditions the components of a particular solution remain unchanged. Further, the sensitivity of a solution to changes in the data gives us insight into possible technological improvements in the process being modelled. For instance, it might be that the available resources are not balanced properly and the primary issue is not to resolve the most effective allocation of these resources, but to investigate what additional resources should be acquired to eliminate possible bottlenecks. Sensitivity analysis can also give guidance in identifying which particular pieces of information or coefficient values require greater care in their estimation. For instance, if it is quite obvious from the solution that the production of certain products are unprofitable, then little effort should be taken in trying to accurately estimate their costs. Thus, time and resources should not be wasted in attempting to accurately estimate parameters, if modest errors in those parameters, would have little effect on the recommended solution. Sensitivity analysis provides an invaluable tool for addressing such issues.

Many linear-programming packages can supplement the solution report with a range or sensitivity analysis report which indicates

the amounts by which individual righthand-side or objective function coefficients can be changed without affecting the 'basis' of the optimal solution.

The sensitivity analysis can be divided into two parts: cost analysis and marginal analysis. The former refers to the range over which an individual coefficient of an objective function may vary, without changing the basis associated with an optimal solution. These are the ranges on the objective-function coefficients over which the values of the decision variables in an optimal solution will remain unchanged. The latter refers to the range over which an individual righthand-side value may vary, again without changing the basis associated with an optimal solution. These are the ranges on the righthand-side values over which the values of the shadow prices and reduced costs will remain unchanged.

These analyses, cost analysis and marginal analysis, will be presented in the following two sections, respectively.

5.3.1 COST ANALYSIS

Changes made to a coefficient may require resolving the whole problem. This may take a considerable amount of computer time. Fortunately, methods have been developed to determine effects of single coefficient changes without resolving the whole problem. This section provides such an analysis.

A summary of the cost analysis is included in Table 5.4. The table includes: the variable current activity value, its reduced cost rate, its stable cost range values, by specifying the upper and lower limits which the variable can assume before the whole problem has to be re-solved, and the particular variables that will be affected at these limits. The summary is obtained by analyzing each box of the cost analysis print-out, included in Appendix B, and selecting the most sensitive variables (those with narrow and meaningful ranges). For example, the first variable in Table 5.4, SEEJ4FGN, has a range of 79.23 to -19.59. The upper limit, 79.23, of this range does not make economic sense in that it is a positive cost. Therefore, we can reduce the upper limit to zero which is denoted by an 'X' in the table, thereby narrowing the variable's range and increasing its sensitivity. The allowable range now indicates that, $-19.59 \leqslant \text{SEEJ4FGN} + \Delta \leqslant 0.00$, where Δ represents a small change in cost, in order for the basis optimal solution to remain unchanged.

The reduced cost is the cost that will bring to a positive value a variable that is currently zero. For instance, the sixth variable STM15PUR of Table 5.4, is currently at zero. If it is

forced to increase by 1 mmlb, that is, if STM15PUR is forced to be used, then the objective function will decrease by $4.50. It can be thought of as the opportunity costs associated with diverting resources away from the optimal production mix. Increasing the nonnegativity constraint by a small amount for the basis variable will not affect the optimal solution. This is illustrated by the remaining basis variables in Table 5.4 which currently have zero reduced cost rates.

Cost analysis, in addition to providing a stable cost range for the variables, also provides fragmented information on which variables may change if their cost values change to the upper or lower limits. For example, when the cost value of the SEEJ4FGN variable reaches the upper bound, the variable SEJ4FGNT will be affected, as will the EPF4SBSS variable, when the lower bound is reached. Although, there are only, at maximum, two variables indicated in the 'Variable to Change' column (for upper and lower limits), in some cases, there may be other variables that may be affected, in addition to the ones indicated, if changes are made to the current cost value of the variable in the 'Variable' column. The LP83 package can only indicate a maximum of two variables to change. If users are interested in any particular variables, they can pursue them in greater detail by making changes to the current cost of the variables that will have an affect on the variables of interest.

Of all the variables in the cost analysis, Table 5.4 includes the ones that should be paid very close attention to.

Table 5.4: Summary of Cost Analysis

Variable	Activity	Reduced cost	Stable Cost Range Upper	Current	Lower	Variable to Change Upper	Lower	Explanation
SEEJ4F6N	9.54	0.00	X	-3.68	-19.59	SEJ4F6NT	EPF4SBSS	Its current activity value is 9.54 tons and its reduced cost rate is zero. Its current cost is $3.68. Its lowest cost is $0.00 and its most expensive is $19.59. Therefore, changes to the cost within this range will not affect the current basis optimal solution, but the objective function value will change. At a cost of $19.59, EPF4SBSS will be affected.
SEE63F62	185.46	0.00	X	-3.68	-47.37	EPF4SBSS	W1EE3F62	Similar explanation as above.
POWERPUR	16,813.31	0.00	X	-0.05	-1.71	EPF4SBSS	CHF2CAPC	Its current activity value is 16,813.31 kwh and its reduced cost rate is zero. Its current cost is $0.05. Its lowest cost is $0.00 and its most expensive is $1.71. Changes to the cost within this range will not affect the current basis optimal solution, but the objective function value will change. At a cost of $1.71, CHF2CAPC will be affected.
CWPURCH	2855.34	0.00	X	-0.07	-20.83	EPF4SBSS	W1E63F62	Similar explanation as POWERPUR above.
PWPURCH	481.41	0.00	X	-0.65	-39.79	EPF4SBSS	H3B52N5B	Similar explanation as POWERPUR above.
STM15PUR	0.00	4.50	0.00	-4.50	$$$	+	$$$	Its current activity value is at zero, and if it were forced to increase by 1 mmlb, then the objective function will decrease by $4.50. Its current cost is $4.50. Its lowest cost is $0.00 and since no 15 PSIG steam is utilized in the bioconversion, its highest cost is unbounded.
STM200PU	1,072.81	0.00	$$$	-4.80	-56.54	$$$	W1E63F62	Its current activity value is 1,072.81 mmlb and its reduced cost rate is zero. Its current cost is $4.80. Its lowest cost is $0.00 and its most expensive is $56.54. Changes to the cost within this range will not affect the current basis optimal solution, but the objective function value will change. At a cost of $56.54, W1E63F62 will be affected.
FURSALE	15.08	0.00	1,609.27	1,320.00	324.50	EPF4SBSS	W1ED4FAN	Its current activity value is 15.08 tons and its reduced cost rate is zero. Its current sales price is $1320.00. The upper and lower limits are $1,609.23 and $324.50, respectively. Changes made to the sales price within this range will not affect the current basis optimal solution, but the objective function value will change. At the limits, EPF4SBSS and W1ED4FAN will be affected.
ETHSALE	9.11	0.00	857.18	540.00	X	H3E21N4B	H1B12N5B	Similar explanation as FURSALE. Note that the stable cost range is between the value 0.00 and 857.18.
BDLSALE	45.57	0.00	927.14	760.00	696.37	W1E63F62	H1B12N5B	Similar explanation as FURSALE.
BUTSALE	0.00	0.00	810.41	720.00	538.86	H1B12N5B	W1E63F62	Similar explanation as FURSALE. Note that the variable has both a zero value and a zero reduced cost which indicates that alternate optima may exist.
ACTSALE	0.00	0.00	811.79	640.00	292.81	H1B12N5B	W1E63F62	Similar explanation as FURSALE.

'X' indicates a zero value which represents the economic bounds.
'$$$' represents unbounded ranges.
'+' indicates that there is more than one variable affected.

For illustrative purposes, the coefficient of SEEG3FG2 variable, the second row of Table 5.4, was changed from -3.68 to -43.68, increasing the cost by about twelve times. According to the Cost Analysis table, the profit will decrease by $7418.40 (40 * 185.46) and the basic solution remains unchanged, since the change is within its allowable range. The test run, included in Appendix C, confirms our prediction. The profit has decreased to $41,800.40 per day and the basic solution is not affected. Although the cost of choosing SEEG3FG2 has increased twelve times in this case, it is still optimum to continue using this more expensive activity rather than choosing another alternative.

5.3.2 MARGINAL ANALYSIS

Of equal importance to cost analysis, it is often valuable to know what will happen to the optimal solution if single righthand-side (RHS) values change. We would like to determine the effects of these changes without solving the whole problem. This section provides such an analysis, and is referred to as marginal analysis.

A summary of the marginal analysis is included in Table 5.5. The table includes: the constraint current RHS value, its 'shadow price', its stable RHS range values, by specifying the upper and lower limits which the RHS value can assume before the whole problem has to be re-solved, and the particular variables that will be affected when the RHS value reaches these limits. The summary is obtained by analyzing each box of the marginal analysis print-out, included in Appendix B, and selecting the constraints that have meaningful ranges. The order of constraints in Table 5.5 have been re-arranged.

Explanation of Table 5.5:

The first constraint, ASPAVAIL, has a current RHS value of 195 tons and its shadow price is $252.40/ton. The shadow price associated with a particular constraint is defined as the change in the optimal value of the objective function per unit increase in the RHS value for that constraint, all other problem data remaining unchanged. Thus for ASPAVAIL, the shadow price indicates that with a unit increase in its current RHS, the objective

function value will increase by $252.40. The constraint has a range from unbounded (upper limit) to zero (lower limit). This upper limit indicates that there is no restriction on aspen availability, thus unbounded profit. The lower limit is to purchase none, which results in no product recovery, therefore forcing the variable STM200PU to its limit, and no profit contribution.

The second constraint, H2SO4REQ, currently has a RHS value of zero. Its shadow price indicates that for a unit increase in the RHS value, the objective function will increase by $52.34. The upper limit is the amount of sulfuric acid required for the process which equals to the amount purchased, and thus no slack. At the limit, the objective function value is equal to $49,335.30, and H2SO4PUR is forced to its limit. There is no restriction on its lower limit, that is, there is no restraint on the slack. Similar explanations apply to constraints POWERREQ, COWATREQ, PRWATREQ, ST200REQ, ST600REQ, FERMEDRQ and ENMEDREQ, except that, the shadow price of constraint FERMEDRQ is zero. This is due to the zero cost assigned to the FERMED variable in the objective function.

The ASPENBAL constraint currently has a RHS value of zero. The shadow price indicates that for a unit increase in its RHS value, the objective function will decrease by $267.40. Its upper limit is the aspen wood purchased. If none is used in the process then the loss incurred will be the amount spent to purchase the wood, $2,925.00. There is no product recovery and thus STM200PU is forced to its limit. It makes no sense to look at the lower limit since

one cannot use more input than was purchased. Similar explanations apply to constraints BUTANBAL and ACTONBAL.

The FURBALAN constraint currently has a RHS value of zero. Its shadow price indicates that for a unit increase in the RHS value, the objective function value will decrease by $1,274.69. Small increases in the RHS value indicates that there is some furfural produced in the steam treatment process that has not been recovered which may impede the subsequent fermentation process. Its upper limit is the amount of furfural that can be recovered/extracted from the steam treatment process. If no furfural can be recovered from the process, FURRECOV is forced to its limit and the objective function value will decrease to $30,002.44. There is no sense in looking at the lower limit since we cannot recover more furfural than was actually produced. Similar explanations apply to constraints BDIOLBAL, ETNOLBAL and LIGNINBA, except that LIGNINBA has a positive shadow price.

The PETROBAL constraint currently has a RHS value of zero. Its shadow price indicates that for a unit increase in the RHS, the objective function will decrease by $899.81. Small increases in the RHS value indicates that less pentosans is used in the CHF2 process, thus producing lesser amounts of end product and coproducts, than is possible under the water extraction process. Its upper limit is the excess pentosans (slack) produced that is not used up in the CHF2 process. At this limit, the objective function value is $35,546.50, and BDLRECOV is forced to its limit, since no pentosans is converted to butanediol. It makes no sense to look at the lower limit or a negative RHS value since this

implies that the CHF2 process uses up more pentosans than there actually is. A similar explanation applies for the HEXPENBA constraint.

The SEATOTAL constraint currently has RHS value of zero. Its shadow price indicates that for a unit increase in its RHS value, the objective function will decrease by $198.31. This is because less steam exploded material (SEW) is recovered and thus less is sent to the CHF1 process. The maximum amount of SEW not recovered in the steam treatment process is 117.45 tons. At this limit, the objective function value will be $14,029.42, and there will be no product recovery. Thus the variable ETHRECOV is forced to its limit. It does not make sense to look at the negative range since we cannot have a total of SEW greater than was actually produced.

The CLASEBAL constraint currently has a RHS value of zero. Although its shadow price indicates that for a unit increase in the RHS value, the objective function will increase by $1.98, it makes no sense to look at a positive RHS value, since this implies that more enzyme is consumed in the CHF1 and CHF2 processes than is produced. The lower limit indicates the amount of slack, more enzyme produced than required. At this limit the objective function value has decreased from its current value to $29,510.40, and the STM15REQ constraint is forced to its limit. The objective function value will increase if the extra quantity of enzyme produced can be sold.

The FURSALES constraint currently has a RHS value of zero. Its shadow price indicates that with a unit increase in the RHS value, which implies that recovery of furfural is greater than its sales,

the objective function value will decrease by $1,320.00. Its upper limit is the amount of furfural that can be recovered. With the constraint RHS value equal to this limit, all recovered furfural cannot be sold and thus the objective function value will decrease from its current value to $29,319.39. Therefore, the FURLIMIT constraint which specified unlimited sales will be forced to its limit. There is no sense in looking at its lower limit since we cannot sell more than we can produce. Similar explanations apply to constraints BTDLSALE, ENOLSALE and LIGNSALE.

The CHF2CAPC constraint currently has a RHS value of zero which indicates an unlimited restriction on the CHF2 process capacity. With a unit increase in the RHS value, the objective function will decrease by $138.31 since the new RHS value now puts a restriction on the CHF2 process capacity. The maximum process capacity under this restriction is 76 tons/day. At this limit, the objective function value will be $38,707.65, and the variable CHF1INHB will be forced to its limit since less or no CHF1 and CHF3 processes will be utilized if CHF2 is. It makes no sense to look at negative RHS values since linear programming assumes nonnegative values for the variables or activities in the problem. Thus the LHS value for the CHF2CAPC constraint will always be greater than a zero value.

This type of information is very valuable to decision makers. It can help them to determine whether or not to change policy when any of the limited resources like the capacity constraints, the RHS values, change.

Table 5.5: Summary of marginal analysis

Constraint	RHS	Shadow price	Upper limit	New optimal	Forced to limit	Lower limit	New optimal	Forced to limit
ASPAVAIL =	195.00	252.40	$$$	$$$	$$$	0.00	0.00	STM200PU
H2SO4REQ =	0.00	52.35	2.23	49,335.30	H2SO4PUR	$$$	$$$	$$$
POWERREQ =	0.00	0.05	16,813.00	49,992.23	POWERPUR	$$$	$$$	$$$
COWATREQ =	0.00	0.07	2,855.34	49,427.26	CWPURCH	$$$	$$$	$$$
PRWATREQ =	0.00	0.65	481.41	49,531.73	PWPURCH	$$$	$$$	$$$
ST200REQ =	0.00	4.80	1,072.81	54,368.31	STM200PU	$$$	$$$	$$$
ST600REQ =	0.00	5.00	74.10	49,589.31	STM200PU	$$$	$$$	$$$
FERMEDRQ =	0.00	0.00	16.88	49,218.81	FERMED	$$$	$$$	$$$
ENMEDREQ =	0.00	16.38	8.68	49,360.91	ENMEDIUM	$$$	$$$	$$$
ASPENBAL =	0.00	-267.40	195.00	-2,925.00	STM200PU	$$$	$$$	$$$
BUTANBAL =	0.00	-674.69	118.02	-30,408.94	STM200PU	$$$	$$$	$$$
ACTONBAL =	0.00	-594.69	118.02	-20,967.26	STM200PU	$$$	$$$	$$$
FURBALAN =	0.00	-1,274.69	15.08	30,002.44	FURRECOV	$$$	$$$	$$$
BD1OLBAL =	0.00	-714.69	45.57	16,652.05	BDLRECOV	$$$	$$$	$$$
ETNOLBAL =	0.00	-494.69	9.11	44,710.44	ETHRECOV	$$$	$$$	$$$
LIGNINBA =	0.00	35.31	48.27	50,922.99	LIGRECOV	$$$	$$$	$$$
PETROBAL =	0.00	-899.51	15.20	35,546.50	BDLRECOV	$	$	$
HEXPENBA =	0.00	-223.97	177.45	9,476.01	PWPURCH	$	$	$
SEATOTAL =	0.00	-198.31	177.45	14,029.42	ETHRECOV	$	$	$
CLASEBAL <	0.00	1.98	$	$	$	-9,961.95	29,510.40	STM15REQ
FURSALES =	0.00	-1,320.00	15.08	29,319.39	FURLIMIT	$$$	$$$	$$$
BTDLSALE =	0.00	-760.00	45.57	14,587.43	BDLLIMIT	$$$	$$$	$$$
ENDLSALE =	0.00	-540.00	9.11	44,297.51	ETHLIMIT	$$$	$$$	$$$
LIGNSALE =	0.00	-10.00	48.27	48,736.17	LIGFUEL	$$$	$$$	$$$
CHF2CAPC >	0.00	138.31	76.00	38,707.65	CHF1INHB	$	$	$

$$$ represents unbounded value.
'$' indicates meaningless value.

For illustrative purposes, the RHS of ASPENBAL constraint, the tenth row of Table 5.5, has increased by one unit from zero to one. According to the Marginal Analysis table, the profit will decrease by $267.40 and the basis variables remains unchanged, but their optimal values will change, since the change is within the allowable range. The test run, summarized in Table C1 and included in Appendix C, confirms our prediction. The profit has decreased to $48,951.41 per day and the optimal values of the basis variables have changed as shown in the top half of the table. The bottom half of the table displays the non-zero constraint activities. Note that the one unit increase in the ASPENBAL constraint has restricted the process to use one less unit of input wood chips. This is evidence as the sum of variable SEEJ4FGN and SEEG3FG2 activities is 194 tones.

5.4 CONCLUSIONS

This paper examined one particular renewable energy source forest biomass, as a chemical resource, by analyzing the economic feasibility of current bioconversion processes used in renewable energy R&D at Forintek Canada Corporation. The preliminary work done at Forintek formed a foundation upon which a more comprehensive and more finely detailed model can be elaborated. The information collected in the data scheme adopted in Section 4.1, which contains data on input costs, process technologies, outputs produced (intermediate and final), plant capacities etc., provides a basis for developing models, typically of the linear programming (LP) form. This serves for analysis of the technology at the economic level, in the context of market conditions and trends, addressing questions of sensitivity, adaptation and optimization. These analyses indicate the direction which future research and development into process technology and plant design should proceed.

Although this paper has been primarily concerned with forest biomass conversion, this technology may also be applied to other alternative sources of lignocellulosic material such as municipal solid wastes and agricultural residuals (rice and corn stalks).

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APPENDIX A

ACTIVITY ANALYSIS AND LP

Management science is characterized by a scientific approach to managerial decision making. It attempts to apply mathematical methods and the capabilities of computers to problems confronting managers. Mathematical modelling and optimization is an important branch.

Experience of LP, especially the vast experience in the somewhat similar petrochemical industry, suggests it will be important for management problems arising in the new industry based on bioconversion of wood residues.

To be considered now is how the scheme for LP model building, and optimization, may be applied to the kind of case that is in view. It will be with simplications, serving the purpose of illustration.

With a process or an activity, $\underline{a}$, we have some amount $\underline{a}_i$ produced of good i, or an amount $-\underline{a}_i$ consumed. The good is an output of the activity if $\underline{a}_i > 0$, and input if $\underline{a}_i < 0$; otherwise, if $\underline{a}_i = 0$, the activity is independent of the good. Thus, describing the activity, we have an activity vector

$$a = (a_1, \ldots, a_n).$$

Circumstances, in a particular context, such as the present, make available a collection of possible activities, forming a set $\underline{S}$, the activity set.

It may be that if an activity $\underline{a}$ is possible, then so is any activity where the inputs and outputs are scaled in the same proportion. That is, for any $\underline{t} \geqslant 0$, also the activity

$$at = (a_1 t, \ldots, a_n t)$$

is possible. This is the activity where $\underline{a}$ is performed with intensity $\underline{t}$.

Also, if two activities $\underline{a}$, $\underline{b}$ are possible, then so also is the activity

$$a + b = (a_1 + b_1, \ \ldots \ , a_n + b_n),$$

where their inputs and outputs are added.

In other words, with these two assumptions, we have a linear activity system $\underline{S}$, for which

$$a \in S, \ t \geqslant 0 \Longrightarrow at \in S.$$
$$a, \ b \in S \Longrightarrow a + b \in S.$$

With this model, the activity set $\underline{S}$ is infinite, but still it is generated from a finite basic set of activities, by taking combinations of these, with non-negative intensities.

The linear model requires caution as an overall assumption. For instance, though certain possible activities $\underline{a}$ and $\underline{b}$ may be performed in successive production runs, they may not be performable simultaneously in the same run, making a single possible activity $\underline{a} + \underline{b}$. We may need to distinguish certain activities $\underline{a}$, $\underline{a}'$, ... as exclusive possibilities, in effect providing different linear activity systems $\underline{S}$, $\underline{S}'$, ... containing these.

With such provisors, the model is useful, and opens the way to building models which employ the well established methodology of linear programming.

In order to perform a possible activity, or for its feasibility, the inputs it requires must be supplied. For instance, if $\underline{k} \geqslant 0$ represents a stock of goods available to supply

inputs, then feasibility of an activity $\underline{a}$ requires $\underline{k} + \underline{a} \geq 0$; in other words, the inputs it requires must not exceed availability. From here we get the LP constraints. A limit on resources that are available to supply inputs, for instance plant capacities, will reduce the basic set $\underline{S}$, of possible activities, to a subset $\underline{I} \subset \underline{S}$ of those which are feasible. The outputs provide incentives for activities, contributing to profit, or some more complex final objective, to be optimized under restrictions.

A simplified example will illustrate the concept.

A manufacturing firm produces two products, x_1, for acetone, x_2 for butanediol. Each product must be processed through two different machines. One machine, steam pretreatment, has 12 hour/day capacity and the second machine, fermentation, has 8 hour/day capacity. Each unit of acetone requires two hours of pretreatment and two hours of fermentation. Each unit of butanediol required three hours of pretreatment and one hour of fermentation. The profit from selling each unit of acetone is \$6 and \$7 for each unit of butanediol. The firm can sell as much as it can produce. The problem is to determine how much acetone and butanediol to produce using the available capacities of both machines.

Let x_1 = number of units of acetone to be produced.

x_2 = number of units of butanediol to be produced.

x_3 = the profit contributions by acetone.

x_4 = the profit contributions by butanediol.

The formulation of the activity analysis data scheme is as follow:

I/O variables	Activities: Basic activities x_1	Basic activities x_2	Selling activities x_3	Selling activities x_4	Resource activities K	Shadow prices
Pretreatment	-2	-3	0	0	12	2
Fermentation	-2	-1	0	0	8	1
Acetone	1	0	-1/6	0	0	0
Butanediol	0	1	0	-1/7	0	0
Profits	0	0	1	1	0	-
Intensities	3	2	18	14		

Then the inputs and outputs are added together as follow:

$$\begin{bmatrix} -2 & -3 & 0 & 0 \\ -2 & -1 & 0 & 0 \\ 1 & 0 & -1/6 & 0 \\ 0 & 1 & 0 & -1/7 \\ 0 & 0 & 1 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \end{bmatrix} = \begin{bmatrix} -2x_1 - 3x_2 + 0x_3 + 0x_4 \\ -2x_1 - 1x_2 + 0x_3 + 0x_4 \\ 1x_1 + 0x_2 - x_3/6 + 0x_4 \\ 0x_1 + 1x_2 + 0x_3 - x_4/7 \\ 0x_1 + 0x_2 + 1x_3 + 1x_4 \end{bmatrix}$$

If $\underline{K} \geqslant 0$ and represents the vector of available capacities, then for feasibility of the activities $\underline{A}$ require that $\underline{K} + \underline{A} \geqslant 0$

$$\begin{bmatrix} 12 \\ 8 \\ 0 \\ 0 \\ 0 \end{bmatrix} + \begin{bmatrix} -2x_1 - 3x_2 + 0x_3 + 0x_4 \\ -2x_1 - 1x_2 + 0x_3 + 0x_4 \\ 1x_1 + 0x_2 - x_3/6 + 0x_4 \\ 0x_1 + 1x_2 + 0x_3 - x_4/7 \\ 0x_1 + 0x_2 + 1x_3 + 1x_4 \end{bmatrix} \geqslant 0$$

$$\begin{aligned} &= 12 + (-2x_1 - 3x_2 + 0x_3 + 0x_4) \geqslant 0 \\ &\quad 8 + (-2x_1 - 1x_2 + 0x_3 + 0x_4) \geqslant 0 \\ &\quad 0 + (1x_1 + 0x_2 - x_3/6 + 0x_4) \geqslant 0 \\ &\quad 0 + (0x_1 + 1x_2 + 0x_3 - x_4/7) \geqslant 0 \\ &\quad 0 + (0x_1 + 0x_2 + 1x_3 + 1x_4) \geqslant 0 \end{aligned}$$

The above five equations imply that

$$\begin{aligned} 12 - 2x_1 - 3x_2 &\geqslant 0 \qquad & 12 &\geqslant 2x_1 + 3x_2 \\ 8 - 2x_1 - x_2 &\geqslant 0 \qquad & 8 &\geqslant 2x_1 + x_2 \\ x_1 - x_3/6 &\geqslant 0 \qquad & 6x_1 &\geqslant x_3 \\ x_2 - x_4/7 &\geqslant 0 \qquad & 7x_2 &\geqslant x_4 \\ x_3 + x_4 &\geqslant 0 \end{aligned}$$

Hence to find the optimal activity, we have to solve the LP problem of

$$\begin{aligned} \text{Max} \quad & 6x_1 + 7x_2 \\ \text{Subject to:} \quad & 2x_1 + 3x_2 \leqslant 12 \qquad \text{(1) pretreatment capacity} \\ & 2x_1 + x_2 \leqslant 8 \qquad \text{(2) fermentation capacity} \\ & x_1 , x_2 \geqslant 0 \end{aligned}$$

Its graphic solution is illustrates in Figure A1, which shows that a maximum profit of $32 can be attained by producing 3 units of acetone and 2 units of butanediol. At this production level, the capacities of both machines are fully utilized.

It can be seen from the figure that the linear constraints, in the form of inequalities, restrict the solution region to the cross-hatched area. This solution region is a polygon designated as 'convex' because all points on the line between any two points in the cross-hatched region are in the set of points that satisfy the constraints. The set of the objective function is a family of lines with slope of -6/7. The maximum value of the objective function occurs for the line passing through the polygon vertex D. At this vertex, all restrictions which imposed by the three constriants are satisfied.

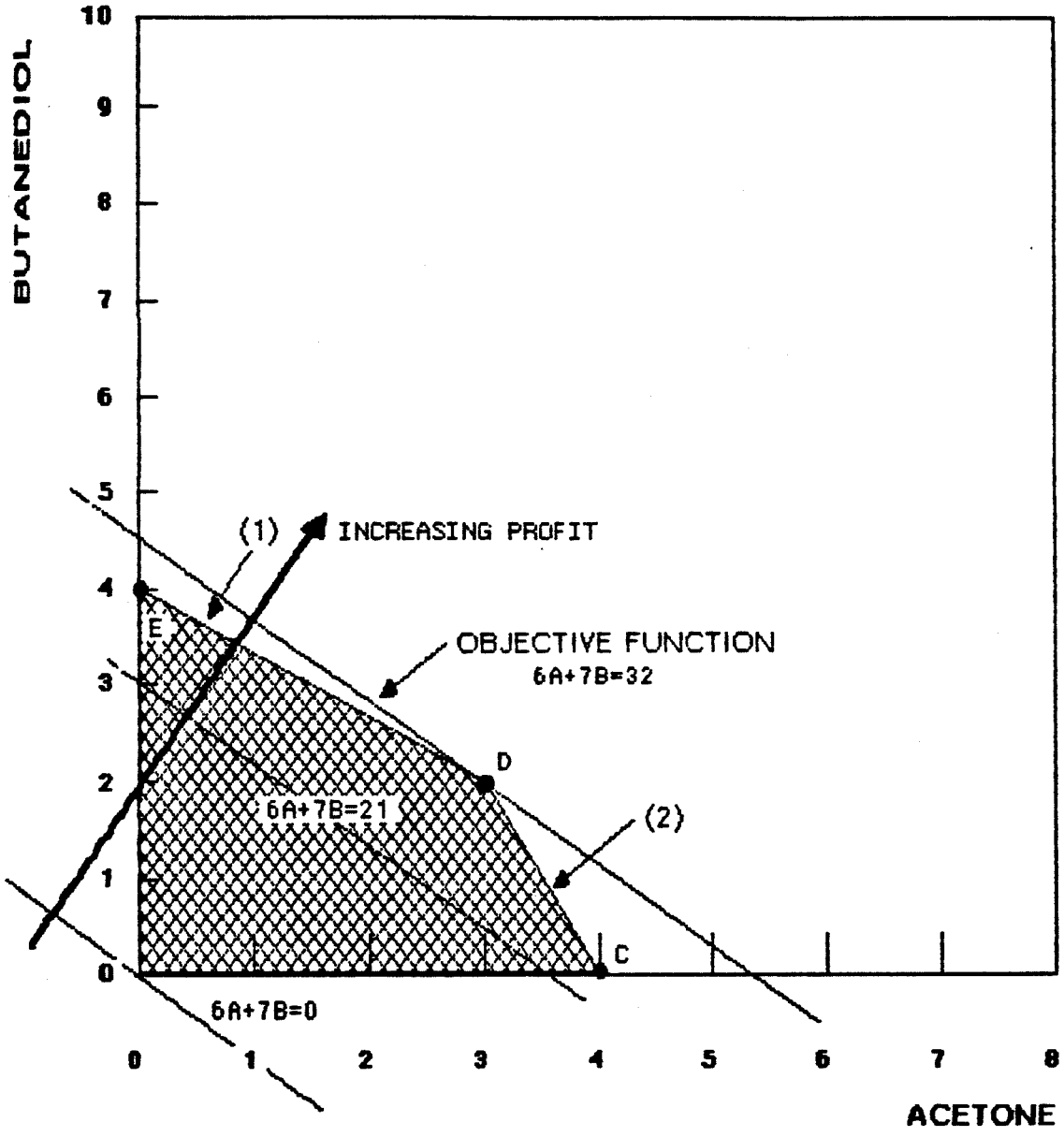

Figure A1: Graphical Illustration of Two-Dimensional Linear Programming Solution

APPENDIX B

LISTING OF SYMBOLS FOR FORINTEK LP PROGRAM

SE	STEAM EXPLOSION ACTIVITIES
S*T	STEAM EXPLODED ASPEN TO CHF
W	WATER-WASHING OF TOTAL SEA STREAM
EP	ENZYME PRODUCTION
H1	CHF OF TOTAL SEA STREAM
H2	CHF OF SEA-WS PENTOSAN STREAM
H3	CHF OF SEA-WI HEXOSAN STREAM
XXXRECOV	PRODUCT RECOVERY
XXXSALE	PRODUCT SALE

XXX	PRODUCT		
		ETH	ETHANOL
		BDL	BUTANEDIOL
		BUT	BUTANOL
		ACT	ACETONE
		FUR	FURFURAL
		LIG	LIGNIN
		LIGFUEL	LIGIN AS FUEL

PUR	RAW MATERIAL AND UTILITIES PURCHASE
MED	MEDIUM PURCHASE
H2SO4PUR	SULFURIC ACID PURCHASE (TONS)
POWERPUR	POWER PURCHASE (KWH)
CWPURCH	COOLING WATER PURCHASE (MMGAL)
PWPURCH	PROCESS WATER PURCHASE (MMGAL)
STM15PUR	15 LB STEAM PURCHASE (MMLB)
STM200PU	200 LB STEAM PURCHASE (MMLB)
STM600PU	600 LB STEAM PURCHASE (MMLB)
ENMEDIUM	ENZYME PRODUCTION MEDIUM PURCHASE (TONS)
FERMED	FERMENTATION MEDIUM PURCHASE (TONS)
ASPPURCH	ASPEN PURCHASE (TONS)

1. SE: STEAM-EXPLOSION ACTIVITIES

SE (A)(B)(C)(D)(E)(F)

A:	PROCESS	E	STEAM EXPLOSION
B:	DURATION	A	10 SECONDS
		B	15
		C	20
		D	30
		E	40
		F	60
		G	80
		H	90
		I	120
		J	180
		K	240
C:	TEMP	5	250 C
		4	240 C
		3	220 C
D:	CHIP SIZE	F	FORINTEK SIZE.
E:	MOISTURE	G	GREEN
		A	AIR DRIED
F:	CATALYST	N	NONE
		2	0.2% SULFURIC ACID

2. S*T: STEAM EXPLODED ASPEN TO CHF

S (A)(B)(C)(D)(E)(F) T

(A)-(F): IDENTICAL TO CORRESPONDING SYMBOLS UNDER SE

3. W: WATER-WASHING OF THE TOTAL SEA STREAM

W (X)(A)(B)(C)(D)(E)(F)

X:	WATER CONSUMPTION	5	5 L/KG
		1	10 L/KG

(A)-(F): IDENTICAL TO CORRESPONDING SYMBOLS UNDER SE

4. EP: ENZYME PRODUCTION

EP (A)(B)(C)(D)(E)(F)

A:	STEAM EXPLOSION CONDITIONS	A	240/ 20S/NA
		B	240/ 40S/NA
		C	240/ 80S/NA
		D	240/120S/NA
		E	240/180S/NA
		F	240/240S/NA
		G	220/10S/A
		H	220/20S/A
		I	220/40S/A
		J	220/80S/A
B:	RESIDENCE TIME	4	4 DAYS
C:	AERATION & AGITATION	S	STANDARD
D:	PROCESS TYPE	B	BATCH
E:	PROCESS TEMPERATURE	S	STANDARD
F:	PROCESS PH	S	STANDARD

5. H1: CHF OF THE TOTAL SEA STREAM

H1 (A)(B)(C)(D)(E)(F)

A:	END PRODUCT	D	BUTANEDIOL
		B	BUTANOL
B:	ENZYME LOADING	5	5 FPU/G
		1	10 FPU/G
C:	SUBSTRATE CONC.	2	2% (W/V)
		5	5%
D:	INHIBITOR REMOVAL	N	NONE
E:	RESIDENCE TIME	3	3 DAYS
		5	5 DAYS
F:	PROCESS TYPE	B	BATCH

6. H2: CHF OF SEA-WS PENTOSAN STREAM

H2 (A)(B)(C)(D)(E)(F)

A:	END PRODUCTS	D	BUTANEDIOL
		B	BUTANOL
B:	ENZYME LOADING	1	100 XIU/G
		2	200 XIU/G
C:	SUBSTRATE CONC	2	2%
		5	5%
D:	INHIBITOR REMOVAL	N	NONE
E:	RESIDENCE TIME	3	3 DAYS
		5	5 DAYS
F:	PROCESS TYPE	B	BATCH

7. H3: CHF OF SEA-WI HEXOSAN STREAM

H3 (A)(B)(C)(D)(E)(F)

A:	END PRODUCTS	D	BUTANEDIOL
		B	BUTANOL
		E	ETHANOL
B:	ENZYME LOADING	5	5 FPU/G
		1	10 FPU/G
		3	15 FPU/G
		2	20 FPU/G
C:	SUBSTRATE CONC	1	1%
		2	2%
		5	5%
		0	10%
D:	INHIBITOR REMOVAL	N	NONE
E:	RESIDENCE TIME	2	2 DAYS
		3	3 DAYS
		4	4 DAYS
		5	5 DAYS

```
..title
  BIOMASS CONVERSION LP
..objective maximize
  -15.00 ASPPURCH -3.68 SEEC4FGN -3.68 SEEE4FGN -3.68 SEEG4FGN
  -3.68 SEEI4FGN -3.68 SEEJ4FGN -3.68 SEEK4FGN -3.68 SEEB4FAN
  -3.68 SEED4FAN -3.68 SEEF4FAN -3.68 SEEH4FAN -3.68 SEEI4FAN
  -3.68 SEEA3FG2 -3.68 SEEC3FG2 -3.68 SEEE3FG2 -3.68 SEEG3FG2
  -52.34 H2SO4PUR -.046 POWERPUR -.073 CWPURCH -.65 PWPURCH
  -4.50 STM15PUR -4.80 STM200PU -5.00 STM600PU +0 SEC4FGNT
  +0 SEE4FGNT +0 SEG4FGNT +0 SEI4FGNT +0 SEJ4FGNT +0 SEK4FGNT
  +0 SEB4FANT +0 SED4FANT +0 SEF4FANT +0 SEH4FANT +0 SEI4FANT
  +0 SEA3FG2T +0 SEC3FG2T +0 SEE3FG2T +0 SEG3FG2T +0 FURRECOV
  +1320 FURSALE +0 H1D52N3B +0 H1D12N3B +0 H1D55N3B +0 H1D15N3B
  +0 H1D52N5B +0 H1D12N5B +0 H1D55N5B +0 H1D15N5B +0 H1B52N3B
  +0 H1B12N3B +0 H1B55N3B +0 H1B15N3B +0 H1B52N5B +0 H1B12N5B
  +0 H1B55N5B +0 H1B15N5B +0 W5EC4FGN +0 W5EE4FGN +0 W5EG4FGN
  +0 W5EI4FGN +0 W5EJ4FGN +0 W5EK4FGN +0 W5EB4FAN +0 W5ED4FAN
  +0 W5EF4FAN +0 W5EH4FAN +0 W5EI4FAN +0 W5EA3FG2 +0 W5EC3FG2
  +0 W5EE3FG2 +0 W5EG3FG2 +0 W1EC4FGN +0 W1EE4FGN +0 W1EG4FGN
  +0 W1EI4FGN +0 W1EJ4FGN +0 W1EK4FGN +0 W1EB4FAN +0 W1ED4FAN
  +0 W1EF4FAN +0 W1EH4FAN +0 W1EI4FAN +0 W1EA3FG2 +0 W1EC3FG2
  +0 W1EE3FG2 +0 W1EG3FG2 +0 EPA4SBSS +0 EPB4SBSS +0 EPC4SBSS
  +0 EPD4SBSS +0 EPE4SBSS +0 EPF4SBSS +0 EPG4SBSS +0 EPH4SBSS
  +0 EPI4SBSS +0 EPJ4SBSS +0 ETHRECOV +540 ETHSALE + 0 BDLRECOV
  +760 BDLSALE +0 BUTRECOV +720 BUTSALE +0 ACTRECOV +640 ACTSALE
  +0 LIGRECOV + 10 LIGFUEL +0 H2D12N3B +0 H2D22N3B +0 H2D15N3B
  +0 H2D25N3B +0 H2D12N5B +0 H2D22N5B +0 H2D15N5B +0 H2D25N5B
  +0 H2B12N3B +0 H2B22N3B +0 H2B15N3B +0 H2B25N3B +0 H2B12N5B
  +0 H2B22N5B +0 H2B15N5B +0 H2B25N5B - 16.38 ENMEDIUM
  -0 FERMED +0 H3D52N3B +0 H3D12N3B +0 H3D55N3B +0 H3D15N3B
  +0 H3D52N5B +0 H3D12N5B +0 H3D55N5B +0 H3D15N5B +0 H3B52N3B
  +0 H3B12N3B +0 H3B55N3B +0 H3B15N3B +0 H3B52N5B +0 H3B12N5B
  +0 H3B55N5B +0 H3B15N5B +0 H3E55N2B +0 H3E55N4B +0 H3E15N2B
  +0 H3E15N4B +0 H3E35N2B +0 H3E35N4B +0 H3E25N2B +0 H3E25N4B
  +0 H3E51N2B +0 H3E51N4B +0 H3E11N2B +0 H3E11N4B +0 H3E31N2B
  +0 H3E31N4B +0 H3E21N2B +0 H3E21N4B +0 H3E50N2B +0 H3E50N4B
  +0 H3E10N2B +0 H3E10N4B +0 H3E30N2B +0 H3E30N4B +0 H3E20N2B
  +0 H3E20N4B +0 SEATOTAL
..constraints
  ASPAVAIL: 1.0 ASPPURCH = 195
  ASPENBAL: 1.0 ASPPURCH -1.0 SEEC4FGN -1.0 SEEE4FGN -1.0 SEEG4FGN
            -1.0 SEEI4FGN -1.0 SEEJ4FGN -1.0 SEEK4FGN -1.0 SEEB4FAN
            -1.0 SEED4FAN -1.0 SEEF4FAN -1.0 SEEH4FAN -1.0 SEEI4FAN
            -1.0 SEEA3FG2 -1.0 SEEC3FG2 -1.0 SEEE3FG2 -1.0 SEEG3FG2 = 0
  SEACAPAC: 1.0 SEEC4FGN +1.0 SEEE4FGN +1.0 SEEG4FGN +1.0 SEEI4FGN
            +1.0 SEEJ4FGN +1.0 SEEK4FGN +1.0 SEEB4FAN +1.0 SEED4FAN
            +1.0 SEEF4FAN +1.0 SEEH4FAN +1.0 SEEI4FAN +1.0 SEEA3FG2
            +1.0 SEEC3FG2 +1.0 SEEE3FG2 +1.0 SEEG3FG2 >=0
  H2SO4CAP: 1.0 SEEA3FG2 +1.0 SEEC3FG2 +1.0 SEEE3FG2 +1.0 SEEG3FG2 >=0
  DRYCAPAC: 1.0 SEEB4FAN +1.0 SEED4FAN +1.0 SEEF4FAN +1.0 SEEH4FAN
            +1.0 SEEI4FAN >=0
```

```
H2SO4REQ: .012 SEEA3FG2 +.012 SEEC3FG2 +.012 SEEE3FG2 +.012 SEEG3FG2
          -1.0 H2SO4PUR =0
POWERREQ: 1.41 SEEC4FGN +1.41 SEEE4FGN +1.41 SEEG4FGN +1.41 SEEI4FGN
          +1.41 SEEJ4FGN +1.41 SEEK4FGN +1.41 SEEB4FAN +1.41 SEED4FAN
          +1.41 SEEF4FAN +1.41 SEEH4FAN +1.41 SEEI4FAN +1.41 SEEA3FG2
          +1.41 SEEC3FG2 +1.41 SEEE3FG2 +1.41 SEEG3FG2 +68.9 H1D52N3B
          +68.9 H1D12N3B +68.9 H1D55N3B +68.9 H1D15N3B +68.9 H1D52N5B
          +68.9 H1D12N5B +68.9 H1D55N5B +68.9 H1D15N5B +68.9 H1B52N3B
          +68.9 H1B12N3B +68.9 H1B55N3B +68.9 H1B15N3B +68.9 H1B52N5B
          +68.9 H1B12N5B +68.9 H1B55N5B +68.9 H1B15N5B +549. EPA4SBSS
          +549. EPB4SBSS +549. EPC4SBSS +549. EPD4SBSS +549. EPE4SBSS
          +549. EPF4SBSS +549. EPG4SBSS +549. EPH4SBSS +549. EPI4SBSS
          +549. EPJ4SBSS +68.9 H2D12N3B +68.9 H2D22N3B +68.9 H2D15N3B
          +68.9 H2D25N3B +68.9 H2D12N5B +68.9 H2D22N5B +68.9 H2D15N5B
          +68.9 H2D25N5B +68.9 H2B12N3B +68.9 H2B22N3B +68.9 H2B15N3B
          +68.9 H2B25N3B +68.9 H2B12N5B +68.9 H2B22N5B +68.9 H2B15N5B
          +68.9 H2B25N5B +68.9 H3D52N3B +68.9 H3D12N3B +68.9 H3D55N3B
          +68.9 H3D15N3B +68.9 H3D52N5B +68.9 H3D12N5B +68.9 H3D55N5B
          +68.9 H3D15N5B +68.9 H3B52N3B +68.9 H3B12N3B +68.9 H3B55N3B
          +68.9 H3B15N3B +68.9 H3B52N5B +68.9 H3B12N5B +68.9 H3B55N5B
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          +68.9 H3E15N4B +68.9 H3E35N2B +68.9 H3E35N4B +68.9 H3E25N2B
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          +68.9 H3E11N4B +68.9 H3E31N2B +68.9 H3E31N4B +68.9 H3E21N2B
          +68.9 H3E21N4B +68.9 H3E50N2B +68.9 H3E50N4B +68.9 H3E10N2B
          +68.9 H3E10N4B +68.9 H3E30N2B +68.9 H3E30N4B +68.9 H3E20N2B
          +68.9 H3E20N4B +4.24 FURRECOV +4.24 BDLRECOV +4.24 BUTRECOV
          +4.24 ACTRECOV +4.24 ETHRECOV +4.24 LIGRECOV -1 POWERPUR =0
COWATREQ: 2.53 H1D52N3B +2.53 H1D12N3B +2.52 H1D55N3B +2.52 H1D15N3B
          +2.53 H1D52N5B +2.53 H1D12N5B +2.52 H1D55N5B +2.53 H1D15N5B
          +2.53 H1B52N3B +2.53 H1B12N3B +2.53 H1B55N3B +2.53 H1B15N3B
          +2.53 H1B52N5B +2.53 H1B12N5B +2.53 H1B55N5B +2.53 H1B15N5B
          +4.05 EPA4SBSS +4.05 EPB4SBSS +4.05 EPC4SBSS +4.05 EPD4SBSS
          +4.05 EPE4SBSS +4.05 EPF4SBSS +4.05 EPG4SBSS +4.05 EPH4SBSS
          +4.05 EPI4SBSS +4.05 EPJ4SBSS +2.53 H2D12N3B +2.53 H2D22N3B
          +2.53 H2D15N3B +2.53 H2D25N3B +2.53 H2D12N5B +2.53 H2D22N5B
          +2.53 H2D15N5B +2.53 H2D25N5B +2.53 H2B12N3B +2.53 H2B22N3B
          +2.53 H2B15N3B +2.53 H2B25N3B +2.53 H2B12N5B +2.53 H2B22N5B
          +2.53 H2B15N5B +2.53 H2B25N5B +2.53 H3D52N3B +2.53 H3D12N3B
          +2.53 H3D55N3B +2.53 H3D15N3B +2.53 H3D52N5B +2.53 H3D12N5B
          +2.53 H3D55N5B +2.53 H3D15N5B +2.53 H3B52N3B +2.53 H3B12N3B
          +2.53 H3B55N3B +2.53 H3B15N3B +2.53 H3B52N5B +2.53 H3B12N5B
          +2.53 H3B55N5B +2.53 H3B15N5B +2.53 H3E55N2B +2.53 H3E55N4B
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          +2.53 H3E25N2B +2.53 H3E25N4B +2.53 H3E51N2B +2.53 H3E51N4B
          +2.53 H3E11N2B +2.53 H3E11N4B +2.53 H3E31N2B +2.53 H3E31N4B
          +2.53 H3E21N2B +2.53 H3E21N4B +2.53 H3E50N2B +2.53 H3E50N4B
          +2.53 H3E10N2B +2.53 H3E10N4B +2.53 H3E30N2B +2.53 H3E30N4B
          +2.53 H3E20N2B +2.53 H3E20N4B +20.3 FURRECOV +20.3 BDLRECOV
          +20.3 BUTRECOV +20.3 ETHRECOV +20.3 ACTRECOV +20.3 LIGRECOV
          -1.0 CWPURCH =0
PRWATREQ: .33 H1D52N3B +.33 H1D12N3B +.33 H1D55N3B +.33 H1D15N3B
```

```
          +.33 H1D52N5B +.33 H1D12N5B +.33 H1D55N5B +.33 H1D15N5B
          +.33 H1B52N3B +.33 H1B12N3B +.33 H1B55N3B +.33 H1B15N3B
          +.33 H1B52N5B +.33 H1B12N5B +.33 H1B55N5B +.33 H1B15N5B
          +.001 W5EC4FGN +.001 W5EE4FGN +.001 W5EG4FGN +.001 W5EI4FGN
          +.001 W5EJ4FGN +.001 W5EK4FGN +.001 W5EB4FAN +.001 W5ED4FAN
          +.001 W5EF4FAN +.001 W5EH4FAN +.001 W5EI4FAN +.001 W5EA3FG2
          +.001 W5EC3FG2 +.001 W5EE3FG2 +.001 W5EG3FG2 +.002 W1EC4FGN
          +.002 W1EE4FGN +.002 W1EG4FGN +.002 W1EI4FGN +.002 W1EJ4FGN
          +.002 W1EK4FGN +.002 W1EB4FAN +.002 W1ED4FAN +.002 W1EF4FAN
          +.002 W1EH4FAN +.002 W1EI4FAN +.002 W1EA3FG2 +.002 W1EC3FG2
          +.002 W1EE3FG2 +.002 W1EG3FG2 +53.0 EPA4SBSS +53.0 EPB4SBSS
          +53.0 EPC4SBSS +53.0 EPD4SBSS +53.0 EPE4SBSS +53.0 EPF4SBSS
          +53.0 EPG4SBSS +53.0 EPH4SBSS +53.0 EPI4SBSS +53.0 EPJ4SBSS
          +.33 H2D12N3B +.33 H2D22N3B +.33 H2D15N3B +.33 H2D25N3B
          +.33 H2D12N5B +.33 H2D22N5B +.33 H2D15N5B +.33 H2D25N5B
          +.33 H2B12N3B +.33 H2B22N3B +.33 H2B15N3B +.33 H2B25N3B
          +.33 H2B12N5B +.33 H2B22N5B +.33 H2B15N5B +.33 H2B25N5B
          +.33 H3D52N3B +.33 H3D12N3B +.33 H3D55N3B +.33 H3D15N3B
          +.33 H3D52N5B +.33 H3D12N5B +.33 H3D55N5B +.33 H3D15N5B
          +.33 H3B52N3B +.33 H3B12N3B +.33 H3B55N3B +.33 H3B15N3B
          +.33 H3B52N5B +.33 H3B12N5B +.33 H3B55N5B +.33 H3B15N5B
          +.33 H3E55N2B +.33 H3E55N4B +.33 H3E15N2B +.33 H3E15N4B
          +.33 H3E35N2B +.33 H3E35N4B +.33 H3E25N2B +.33 H3E25N4B
          +.33 H3E51N2B +.33 H3E51N4B +.33 H3E11N2B +.33 H3E11N4B
          +.33 H3E31N2B +.33 H3E31N4B +.33 H3E21N2B +.33 H3E21N4B
          +.33 H3E50N2B +.33 H3E50N4B +.33 H3E10N2B +.33 H3E10N4B
          +.33 H3E30N2B +.33 H3E30N4B +.33 H3E20N2B +.33 H3E20N4B
          -1.0 PWPURCH =0
STM15REQ: -.38 SEEC4FGN -.38 SEEE4FGN -.38 SEEG4FGN -.38 SEEI4FGN
          -.38 SEEJ4FGN -.38 SEEK4FGN -.38 SEEB4FAN -.38 SEED4FAN
          -.38 SEEF4FAN -.38 SEEH4FAN -.38 SEEI4FAN -.38 SEEA3FG2
          -.38 SEEC3FG2 -.38 SEEE3FG2 -.38 SEEG3FG2 +.19 H1D52N3B
          +.19 H1D12N3B +.19 H1D55N3B +.19 H1D15N3B +.19 H1D52N5B
          +.19 H1D12N5B +.19 H1D55N5B +.19 H1D15N5B +.19 H1B52N3B
          +.19 H1B12N3B +.19 H1B55N3B +.19 H1B15N3B +.19 H1B52N5B
          +.19 H1B12N5B +.19 H1B55N5B +.19 H1B15N5B +.90 EPA4SBSS
          +.90 EPB4SBSS +.90 EPC4SBSS +.90 EPD4SBSS +.90 EPE4SBSS
          +.90 EPF4SBSS +.90 EPG4SBSS +.90 EPH4SBSS +.90 EPI4SBSS
          +.90 EPJ4SBSS +.19 H2D12N3B +.19 H2D22N3B +.19 H2D15N3B
          +.19 H2D25N3B +.19 H2D12N5B +.19 H2D22N5B +.19 H2D15N5B
          +.19 H2D25N5B +.19 H2B12N3B +.19 H2B22N3B +.19 H2B15N3B
          +.19 H2B25N3B +.19 H2B12N5B +.19 H2B22N5B +.19 H2B15N5B
          +.19 H2B25N5B +.19 H3D52N3B +.19 H3D12N3B +.19 H3D55N3B
          +.19 H3D15N3B +.19 H3D52N5B +.19 H3D12N5B +.19 H3D55N5B
          +.19 H3D15N5B +.19 H3B52N3B +.19 H3B12N3B +.19 H3B55N3B
          +.19 H3B15N3B +.19 H3B52N5B +.19 H3B12N5B +.19 H3B55N5B
          +.19 H3B15N5B +.19 H3E55N2B +.19 H3E55N4B +.19 H3E15N2B
          +.19 H3E15N4B +.19 H3E35N2B +.19 H3E35N4B +.19 H3E25N2B
          +.19 H3E25N4B +.19 H3E51N2B +.19 H3E51N4B +.19 H3E11N2B
          +.19 H3E11N4B +.19 H3E31N2B +.19 H3E31N4B +.19 H3E21N2B
          +.19 H3E21N4B +.19 H3E50N2B +.19 H3E50N4B +.19 H3E10N2B
          +.19 H3E10N4B +.19 H3E30N2B +.19 H3E30N4B +.19 H3E20N2B
```

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          +.19 H3E20N4B -1.0 STM15PUR <=0
ST200REQ: 9.09 FURRECOV +9.09 BDLRECOV +9.09 BUTRECOV +9.09 ETHRECOV
          +9.09 ACTRECOV +9.09 LIGRECOV -1.0 STM200PU =0
ST600REQ: .38 SEEC4FGN +.38 SEEE4FGN +.38 SEEG4FGN +.38 SEEI4FGN
          +.38 SEEJ4FGN +.38 SEEK4FGN +.38 SEEB4FAN +.38 SEED4FAN
          +.38 SEEF4FAN +.38 SEEH4FAN +.38 SEEI4FAN +.38 SEEA3FG2
          +.38 SEEC3FG2 +.38 SEEE3FG2 +.38 SEEG3FG2
          -1.0 STM600PU =0
FURBALAN: .002 SEEC4FGN +.004 SEEE4FGN +.008 SEEG4FGN +.017 SEEI4FGN
          +.025 SEEJ4FGN +.040 SEEK4FGN +.004 SEEB4FAN +.008 SEED4FAN
          +.017 SEEF4FAN +.025 SEEH4FAN +.040 SEEI4FAN +.008 SEEA3FG2
          +.034 SEEC3FG2 +.050 SEEE3FG2 +.080 SEEG3FG2
          -1.0 FURRECOV =0
FURSALES: +1.0 FURRECOV -1.0 FURSALE =0
FURLIMIT: +1.0 FURSALE >=0
SEA1BALN: .955 SEEC4FGN -1.0 SEC4FGNT -1.0 W5EC4FGN -1.0 W1EC4FGN
          -1.0 EPA4SBSS =0
SEA2BALN: .948 SEEE4FGN -1.0 SEE4FGNT -1.0 W5EE4FGN -1.0 W1EE4FGN
          -1.0 EPB4SBSS =0
SEA3BALN: .933 SEEG4FGN -1.0 SEG4FGNT -1.0 W5EG4FGN -1.0 W1EG4FGN
          -1.0 EPC4SBSS =0
SEA4BALN: .899 SEEI4FGN -1.0 SEI4FGNT -1.0 W5EI4FGN -1.0 W1EI4FGN
          -1.0 EPD4SBSS =0
SEA5BALN: .842 SEEJ4FGN -1.0 SEJ4FGNT -1.0 W5EJ4FGN -1.0 W1EJ4FGN
          -1.0 EPE4SBSS =0
SEA6BALN: .785 SEEK4FGN -1.0 SEK4FGNT -1.0 W5EK4FGN -1.0 W1EK4FGN
          -1.0 EPF4SBSS =0
SEA7BALN: .960 SEEB4FAN -1.0 SEB4FANT -1.0 W5EB4FAN -1.0 W1EB4FAN
          =0
SEA8BALN: .942 SEED4FAN -1.0 SED4FANT -1.0 W5ED4FAN -1.0 W1ED4FAN
          =0
SEA9BALN: .890 SEEF4FAN -1.0 SEF4FANT -1.0 W5EF4FAN -1.0 W1EF4FAN
          =0
SEA10BAL: .878 SEEH4FAN -1.0 SEH4FANT -1.0 W5EH4FAN -1.0 W1EH4FAN
          =0
SEA11BAL: .858 SEEI4FAN -1.0 SEI4FANT -1.0 W5EI4FAN -1.0 W1EI4FAN
          =0
SEA12BAL: .886 SEEA3FG2 -1.0 SEA3FG2T -1.0 W5EA3FG2 -1.0 W1EA3FG2
          -1.0 EPG4SBSS =0
SEA13BAL: .881 SEEC3FG2 -1.0 SEC3FG2T -1.0 W5EC3FG2 -1.0 W1EC3FG2
          -1.0 EPH4SBSS =0
SEA14BAL: .855 SEEE3FG2 -1.0 SEE3FG2T -1.0 W5EE3FG2 -1.0 W1EE3FG2
          -1.0 EPI4SBSS =0
SEA15BAL: .910 SEEG3FG2 -1.0 SEG3FG2T -1.0 W5EG3FG2 -1.0 W1EG3FG2
          -1.0 EPJ4SBSS =0
SEATOTAL: 1.0 SEC4FGNT +1.0 SEE4FGNT +1.0 SEG4FGNT +1.0 SEI4FGNT
          +1.0 SEJ4FGNT +1.0 SEK4FGNT +1.0 SEB4FANT +1.0 SED4FANT
          +1.0 SEF4FANT +1.0 SEH4FANT +1.0 SEI4FANT +1.0 SEA3FG2T
          +1.0 SEC3FG2T +1.0 SEE3FG2T +1.0 SEG3FG2T -1.0 SEATOTAL
          =0
BDIOLBAL: .17 H1D52N3B +.27 H1D12N3B +.10 H1D55N3B +.16 H1D15N3B
          +.20 H1D52N5B +.22 H1D12N5B +.12 H1D55N5B +.13 H1D15N5B
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            +.17 H2D12N3B +.23 H2D22N3B +.10 H2D15N3B +.13 H2D25N3B
            +.20 H2D12N5B +.26 H2D22N5B +.12 H2D15N5B +.15 H2D25N5B
            +.15 H3D52N3B +.20 H3D12N3B +.09 H3D55N3B +.09 H3D15N3B
            +.18 H3D52N5B +.23 H3D12N5B +.11 H3D55N5B +.14 H3D15N5B
            -1.0 BDLRECOV =0
 BUTANBAL: .12 H1B52N3B +.16 H1B12N3B +.07 H1B55N3B +.09 H1B15N3B
            +.15 H1B52N5B +.19 H1B12N5B +.09 H1B55N5B +.12 H1B15N5B
            +.09 H2B12N3B +.12 H2B22N3B +.06 H2B15N3B +.08 H2B25N3B
            +.11 H2B12N5B +.14 H2B22N5B +.07 H2B15N5B +.09 H2B25N5B
            +.15 H3B52N3B +.20 H3B12N3B +.09 H3B55N3B +.09 H3B15N3B
            +.18 H3B52N5B +.23 H3B12N5B +.11 H3B55N5B +.14 H3B15N5B
            -1.0 BUTRECOV =0
 ACTONBAL: .06 H1B52N3B +.08 H1B12N3B +.04 H1B55N3B +.05 H1B15N3B
            +.08 H1B52N5B +.10 H1B12N5B +.05 H1B55N5B +.06 H1B15N5B
            +.05 H2B12N3B +.06 H2B22N3B +.03 H2B15N3B +.04 H2B25N3B
            +.06 H2B12N5B +.07 H2B22N5B +.04 H2B15N5B +.05 H2B25N5B
            +.08 H3B52N3B +.10 H3B12N3B +.05 H3B55N3B +.05 H3B15N3B
            +.09 H3B52N5B +.12 H3B12N5B +.06 H3B55N5B +.07 H3B15N5B
            -1.0 ACTRECOV =0
 ETNOLBAL: .030 H1D52N3B +.054 H1D12N3B +.020 H1D55N3B +.032 H1D15N3B
            +.040 H1D52N5B +.044 H1D12N5B +.024 H1D55N5B +.026 H1D15N5B
            +.02 H1B52N3B +.03 H1B12N3B +.01 H1B55N3B +.02 H1B15N3B
            +.03 H1B52N5B +.03 H1B12N5B +.02 H1B55N5B +.02 H1B15N5B
            +.034 H2D12N3B +.046 H2D22N3B +.020 H2D15N3B +.026 H2D25N3B
            +.040 H2D12N5B +.052 H2D22N5B +.024 H2D15N5B +.030 H2D25N5B
            +.015 H2B12N3B +.010 H2B22N3B +.010 H2B15N3B +.013 H2B25N3B
            +.055 H2B12N5B +.070 H2B22N5B +.035 H2B15N5B +.045 H2B25N5B
            +.030 H3D52N3B +.040 H3D12N3B +.018 H3D55N3B +.018 H3D15N3B
            +.036 H3D52N5B +.046 H3D12N5B +.022 H3D55N5B +.028 H3D15N5B
            +.025 H3B52N3B +.033 H3B12N3B +.015 H3B55N3B +.015 H3B15N3B
            +.030 H3B52N5B +.038 H3B12N5B +.018 H3B55N5B +.023 H3B15N5B
            +.15 H3E55N2B +.21 H3E55N4B +.20 H3E15N2B +.27 H3E15N4B
            +.25 H3E35N2B +.28 H3E35N4B +.26 H3E25N2B +.30 H3E25N4B
            +.18 H3E51N2B +.24 H3E51N4B +.24 H3E11N2B +.31 H3E11N4B
            +.29 H3E31N2B +.32 H3E31N4B +.31 H3E21N2B +.34 H3E21N4B
            +.11 H3E50N2B +.14 H3E50N4B +.15 H3E10N2B +.19 H3E10N4B
            +.18 H3E30N2B +.19 H3E30N4B +.19 H3E20N2B +.21 H3E20N4B
            -1.0 ETHRECOV =0
 BTDLSALE: +1.0 BDLRECOV -1.0 BDLSALE =0
 BDLLIMIT: +1.0 BDLSALE >=0
 BTOLSALE: +1.0 BUTRECOV -1.0 BUTSALE =0
 BUTLIMIT: +1.0 BUTSALE >=0
 ACTNSALE: +1.0 ACTRECOV -1.0 ACTSALE =0
 ACTLIMIT: +1.0 ACTSALE >=0
 ENOLSALE: +1.0 ETHRECOV -1.0 ETHSALE =0
 ETHLIMIT: +1.0 ETHSALE >=0
LIGNINBA: .236 SEEC4FGN +.231 SEEE4FGN +.247 SEEG4FGN +.215 SEEI4FGN
           +.238 SEEJ4FGN +.224 SEEK4FGN +.247 SEEB4FAN +.233 SEED4FAN
           +.228 SEEF4FAN +.231 SEEH4FAN +.230 SEEI4FAN +.200 SEEA3FG2
           +.194 SEEC3FG2 +.212 SEEE3FG2 +.248 SEEG3FG2 -1.0 LIGRECOV
           =0
 LIGNSALE: +1.0 LIGRECOV -1.0 LIGFUEL =0
```

```
CHF1INHB: 1.0 SEATOTAL >=0
CHF1BALN: 1.0 H1D52N3B +1.0 H1D12N3B +1.0 H1D55N3B +1.0 H1D15N3B
          +1.0 H1D52N5B +1.0 H1D12N5B +1.0 H1D55N5B +1.0 H1D15N5B
          +1.0 H1B52N3B +1.0 H1B12N3B +1.0 H1B55N3B +1.0 H1B15N3B
          +1.0 H1B52N5B +1.0 H1B12N5B +1.0 H1B55N5B +1.0 H1B15N5B
          -1.0 SEATOTAL =0
CHF1CAPC: 3.0 H1D52N3B +3.0 H1D12N3B +3.0 H1D55N3B +3.0 H1D15N3B
          +5.0 H1D52N5B +5.0 H1D12N5B +5.0 H1D55N5B +5.0 H1D15N5B
          +3.0 H1B52N3B +3.0 H1B12N3B +3.0 H1B55N3B +3.0 H1B15N3B
          +5.0 H1B52N5B +5.0 H1B12N5B +5.0 H1B55N5B +5.0 H1B15N5B >=0
CLASEBAL: 4.5 H1D52N3B + 9.0 H1D12N3B +4.5 H1D55N3B +9.0 H1D15N3B
          +4.5 H1D52N5B +9.0 H1D12N5B +4.5 H1D55N5B +9.0 H1D15N5B
          +4.5 H1B52N3B +9.0 H1B12N3B +4.5 H1B55N3B +9.0 H1B15N3B
          +4.5 H1B52N5B +9.0 H1B12N5B +4.5 H1B55N5B +9.0 H1B15N5B
          +4.5 H3D52N3B +9.0 H3D12N3B +4.5 H3D55N3B +9.0 H3D15N3B
          +4.5 H3D52N5B +9.0 H3D12N5B +4.5 H3D55N5B +9.0 H3D15N5B
          +4.5 H3B52N3B +9.0 H3B12N3B +4.5 H3B55N3B +9.0 H3B15N3B
          +4.5 H3B52N5B +9.0 H3B12N5B +4.5 H3B55N5B +9.0 H3B15N5B
          +4.5 H3E55N2B +4.5 H3E55N4B +9.0 H3E15N2B +9.0 H3E15N4B
          +13.5 H3E35N2B +13.5 H3E35N4B +18.0 H3E25N2B + 18.0 H3E25N4B
          +4.5 H3E51N2B + 4.5 H3E51N4B +9.0 H3E11N2B +9.0 H3E11N4B
          +13.5 H3E31N2B +13.5 H3E31N4B +18.0 H3E21N2B +18.0 H3E21N4B
          +4.5 H3E50N2B +4.5 H3E50N4B +9.0 H3E10N2B +9.0 H3E10N4B
          +13.5 H3E30N2B +13.5 H3E30N4B +18.0 H3E20N2B +18.0 H3E20N4B
          -55.4 EPA4SBSS -86.3 EPB4SBSS -154.5 EPC4SBSS
          -149.1 EPD4SBSS -189.1 EPE4SBSS - 132.7 EPF4SBSS
          -67.3 EPG4SBSS -45.5 EPH4SBSS - 65.4 EPI4SBSS
          -50.0 EPJ4SBSS <=0
FERMEDRQ: .1 H1D52N3B +.1 H1D12N3B +.1 H1D55N3B +.1 H1D15N3B
          +.1 H1D52N5B +.1 H1D12N5B +.1 H1D55N5B +.1 H1D15N5B
          +.1 H1B52N3B +.1 H1B12N3B +.1 H1B55N3B +.1 H1B15N3B
          +.1 H1B52N5B +.1 H1B12N5B +.1 H1B55N5B +.1 H1B15N5B
          +.1 H2D12N3B +.1 H2D22N3B +.1 H2D15N3B +.1 H2D25N3B
          +.1 H2D12N5B +.1 H2D22N5B +.1 H2D15N5B +.1 H2D25N5B
          +.1 H2B12N3B +.1 H2B22N3B +.1 H2B15N3B +.1 H2B25N3B
          +.1 H2B12N5B +.1 H2B22N5B +.1 H2B15N5B +.1 H2B25N5B
          +.1 H3D52N3B +.1 H3D12N3B +.1 H3D55N3B +.1 H3D15N3B
          +.1 H3D52N5B +.1 H3D12N5B +.1 H3D55N5B +.1 H3D15N5B
          +.1 H3B52N3B +.1 H3B12N3B +.1 H3B55N3B +.1 H3B15N3B
          +.1 H3B52N5B +.1 H3B12N5B +.1 H3B55N5B +.1 H3B15N5B
          -1.0 FERMED =0
WWCAPACT: 1.0 W5EC4FGN +1.0 W5EE4FGN +1.0 W5EG4FGN +1.0 W5EI4FGN
          +1.0 W5EJ4FGN +1.0 W5EK4FGN +1.0 W5EB4FAN +1.0 W5ED4FAN
          +1.0 W5EF4FAN +1.0 W5EH4FAN +1.0 W5EI4FAN +1.0 W5EA3FG2
          +1.0 W5EC3FG2 +1.0 W5EE3FG2 +1.0 W5EG3FG2 +1.0 W1EC4FGN
          +1.0 W1EE4FGN +1.0 W1EG4FGN +1.0 W1EI4FGN +1.0 W1EJ4FGN
          +1.0 W1EK4FGN +1.0 W1EB4FAN +1.0 W1ED4FAN +1.0 W1EF4FAN
          +1.0 W1EH4FAN +1.0 W1EI4FAN +1.0 W1EA3FG2 +1.0 W1EC3FG2
          +1.0 W1EE3FG2 +1.0 W1EG3FG2 >=0
PETROBAL: .081 W5EC4FGN +.090 W5EE4FGN +.088 W5EG4FGN +.075 W5EI4FGN
          +.046 W5EJ4FGN +.034 W5EK4FGN +.079 W5EB4FAN +.094 W5ED4FAN
          +.108 W5EF4FAN +.097 W5EH4FAN +.080 W5EI4FAN +.117 W5EA3FG2
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          +.124 W5EC3FG2 +.120 W5EE3FG2 +.098 W5EG3FG2 +.088 W1EC4FGN
          +.098 W1EE4FGN +.096 W1EG4FGN +.082 W1EI4FGN +.051 W1EJ4FGN
          +.037 W1EK4FGN +.086 W1EB4FAN +.103 W1ED4FAN +.117 W1EF4FAN
          +.105 W1EH4FAN +.088 W1EI4FAN +.128 W1EA3FG2 +.135 W1EC3FG2
          +.131 W1EE3FG2 +.107 W1EG3FG2 -1.0 H2D12N3B -1.0 H2D22N3B
          -1.0 H2D15N3B -1.0 H2D25N3B -1.0 H2D12N5B -1.0 H2D22N5B
          -1.0 H2D15N5B -1.0 H2D25N5B -1.0 H2B12N3B -1.0 H2B22N3B
          -1.0 H2B15N3B -1.0 H2B25N3B -1.0 H2B12N5B -1.0 H2B22N5B
          -1.0 H2B15N5B -1.0 H2B25N5B =0
WSREMBAL: +.106 W5EC4FGN +.103 W5EE4FGN +.098 W5EG4FGN +.119 W5EI4FGN
          +.122 W5EJ4FGN +.124 W5EK4FGN +.078 W5EB4FAN +.088 W5ED4FAN
          +.101 W5EF4FAN +.098 W5EH4FAN +.126 W5EI4FAN +.134 W5EA3FG2
          +.148 W5EC3FG2 +.175 W5EE3FG2 +.167 W5EG3FG2 +.106 W1EC4FGN
          +.103 W1EE4FGN +.098 W1EG4FGN +.119 W1EI4FGN +.122 W1EJ4FGN
          +.124 W1EK4FGN +.076 W1EB4FAN +.088 W1ED4FAN +.101 W1EF4FAN
          +.098 W1EH4FAN +.126 W1EI4FAN +.134 W1EA3FG2 +.148 W1EC3FG2
          +.175 W1EE3FG2 +.167 W1EG3FG2 >=0
WIPENTBA: .058 W5EC4FGN +.036 W5EE4FGN +.019 W5EG4FGN +.014 W5EI4FGN
          +.008 W5EJ4FGN +.007 W5EK4FGN +.061 W5EB4FAN +.037 W5ED4FAN
          +.017 W5EF4FAN +.014 W5EH4FAN +.007 W5EI4FAN +.010 W5EA3FG2
          +.006 W5EC3FG2 +.004 W5EE3FG2 +.003 W5EG3FG2 +.058 W1EC4FGN
          +.036 W1EE4FGN +.019 W1EG4FGN +.014 W1EI4FGN +.008 W1EJ4FGN
          +.007 W1EK4FGN +.061 W1EB4FAN +.037 W1ED4FAN +.017 W1EF4FAN
          +.014 W1EH4FAN +.007 W1EI4FAN +.010 W1EA3FG2 +.006 W1EC3FG2
          +.004 W1EE3FG2 +.003 W1EG3FG2 >=0
WIHEXOBA: .474 W5EC4FGN +.489 W5EE4FGN +.487 W5EG4FGN +.488 W5EI4FGN
          +.464 W5EJ4FGN +.428 W5EK4FGN +.496 W5EB4FAN +.493 W5ED4FAN
          +.474 W5EF4FAN +.437 W5EH4FAN +.438 W5EI4FAN +.442 W5EA3FG2
          +.420 W5EC3FG2 +.337 W5EE3FG2 +.409 W5EG3FG2 +.474 W1EC4FGN
          +.489 W1EE4FGN +.487 W1EG4FGN +.488 W1EI4FGN +.464 W1EJ4FGN
          +.428 W1EK4FGN +.496 W1EB4FAN +.493 W1ED4FAN +.474 W1EF4FAN
          +.437 W1EH4FAN +.438 W1EI4FAN +.442 W1EA3FG2 +.420 W1EC3FG2
          +.337 W1EE3FG2 +.409 W1EG3FG2 >=0
HEXPENBA: +.532 W5EC4FGN +.525 W5EE4FGN +.506 W5EG4FGN +.502 W5EI4FGN
          +.472 W5EJ4FGN +.435 W5EK4FGN +.557 W5EB4FAN +.530 W5ED4FAN
          +.491 W5EF4FAN +.451 W5EH4FAN +.445 W5EI4FAN +.452 W5EA3FG2
          +.426 W5EC3FG2 +.381 W5EE3FG2 +.412 W5EG3FG2 +.532 W1EC4FGN
          +.525 W1EE4FGN +.506 W1EG4FGN +.502 W1EI4FGN +.472 W1EJ4FGN
          +.435 W1EK4FGN +.557 W1EB4FAN +.530 W1ED4FAN +.491 W1EF4FAN
          +.451 W1EH4FAN +.445 W1EI4FAN +.452 W1EA3FG2 +.426 W1EC3FG2
          +.381 W1EE3FG2 +.412 W1EG3FG2 -1.0 H3D52N3B -1.0 H3D12N3B
          -1.0 H3D55N3B -1.0 H3D15N3B -1.0 H3D52N5B -1.0 H3D12N5B
          -1.0 H3D55N5B -1.0 H3D15N5B -1.0 H3B52N3B -1.0 H3B12N3B
          -1.0 H3B55N3B -1.0 H3B15N3B -1.0 H3B52N5B -1.0 H3B12N5B
          -1.0 H3B55N5B -1.0 H3B15N5B -1.0 H3E55N2B -1.0 H3E55N4B
          -1.0 H3E15N2B -1.0 H3E15N4B -1.0 H3E35N2B -1.0 H3E35N4B
          -1.0 H3E25N2B -1.0 H3E25N4B -1.0 H3E51N2B -1.0 H3E51N4B
          -1.0 H3E11N2B -1.0 H3E11N4B -1.0 H3E31N2B -1.0 H3E31N4B
          -1.0 H3E21N2B -1.0 H3E21N4B -1.0 H3E50N2B -1.0 H3E50N4B
          -1.0 H3E10N2B -1.0 H3E10N4B -1.0 H3E30N2B -1.0 H3E30N4B
          -1.0 H3E20N2B -1.0 H3E20N4B =0
XYASEBAL: +16.6 EPA4SBSS +25.9 EPB4SBSS +46.4 EPC4SBSS +44.7 EPD4SBSS
```

```
          +56.7 EPE4SBSS +39.8 EPF4SBSS +20.2 EPG4SBSS +13.6 EPH4SBSS
          +19.6 EPI4SBSS +15.0 EPJ4SBSS -.09 H2D12N3B -.18 H2D22N3B
          -.09 H2D15N3B -.18 H2D25N3B -.09 H2D12N5B -.18 H2D22N5B
          -.09 H2D15N5B -.18 H2D25N5B -.09 H2B12N3B -.18 H2B22N3B
          -.09 H2B15N3B -.18 H2B25N3B -.09 H2B12N5B -.18 H2B22N5B
          -.09 H2B15N5B -.18 H2B25N5B >=0
ENPRDCAP: 4.0 EPA4SBSS +4.0 EPB4SBSS +4.0 EPC4SBSS +4.0 EPD4SBSS
          +4.0 EPE4SBSS +4.0 EPF4SBSS +4.0 EPG4SBSS +4.0 EPH4SBSS
          +4.0 EPI4SBSS +4.0 EPJ4SBSS >=0
ENMEDREQ: 1.08 EPA4SBSS +1.08 EPB4SBSS +1.08 EPC4SBSS +1.08 EPD4SBSS
          +1.08 EPE4SBSS +1.08 EPF4SBSS +1.08 EPG4SBSS +1.08 EPH4SBSS
          +1.08 EPI4SBSS +1.08 EPJ4SBSS -1.0 ENMEDIUM =0
CHF2INHB: 1.0 H2D12N3B +1.0 H2D22N3B +1.0 H2D15N3B +1.0 H2D25N3B
          +1.0 H2D12N5B +1.0 H2D22N5B +1.0 H2D15N5B +1.0 H2D25N5B
          +1.0 H2B12N3B +1.0 H2B22N3B +1.0 H2B15N3B +1.0 H2B25N3B
          +1.0 H2B12N5B +1.0 H2B22N5B +1.0 H2B15N5B
          +1.0 H2B25N5B >=0
CHF2CAPC: 3.0 H2D12N3B +3.0 H2D22N3B +3.0 H2D15N3B +3.0 H2D25N3B
          +5.0 H2D12N5B +5.0 H2D22N5B +5.0 H2D15N5B +5.0 H2D25N5B
          +3.0 H2B12N3B +3.0 H2B22N3B +3.0 H2B15N3B +3.0 H2B25N3B
          +5.0 H2B12N5B +5.0 H2B22N5B +5.0 H2B15N5B
          +5.0 H2B25N5B >=0
CHF3CAPC: 3.0 H3D52N3B +3.0 H3D12N3B +3.0 H3D55N3B +3.0 H3D15N3B
          +5.0 H3D52N5B +5.0 H3D12N5B +5.0 H3D55N5B +5.0 H3D15N5B
          +3.0 H3B52N3B +3.0 H3B12N3B +3.0 H3B55N3B +3.0 H3B15N3B
          +5.0 H3B52N5B +5.0 H3B12N5B +5.0 H3B55N5B +5.0 H3B15N5B
          +2.0 H3E55N2B +4.0 H3E55N4B +2.0 H3E15N2B +4.0 H3E15N4B
          +2.0 H3E35N2B +4.0 H3E35N4B +2.0 H3E25N2B +4.0 H3E25N4B
          +2.0 H3E51N2B +4.0 H3E51N4B +2.0 H3E11N2B +4.0 H3E11N4B
          +2.0 H3E31N2B +4.0 H3E31N4B +2.0 H3E21N2B +4.0 H3E21N4B
          +2.0 H3E50N2B +4.0 H3E50N4B +2.0 H3E10N2B +4.0 H3E10N4B
          +2.0 H3E30N2B +4.0 H3E30N4B +2.0 H3E20N2B +4.0 H3E20N4B
          >=0
```

Forintek LP - variables

File: Forint 27 May 1986
SOLUTION (Maximized): 49,218.8148 BIOMASS CONVERSION LP

Variable	Activity	Cost	Variable	Activity	Cost
ASPPURCH	195.0000	-15.0000	SEEC4FGN	0.0000	-3.6800
SEEE4FGN	0.0000	-3.6800	SEEG4FGN	0.0000	-3.6800
SEEI4FGN	0.0000	-3.6800	SEEJ4FGN	9.5396	-3.6800
SEEK4FGN	0.0000	-3.6800	SEEB4FAN	0.0000	-3.6800
SEED4FAN	0.0000	-3.6800	SEEF4FAN	0.0000	-3.6800
SEEH4FAN	0.0000	-3.6800	SEEI4FAN	0.0000	-3.6800
SEEA3FG2	0.0000	-3.6800	SEEC3FG2	0.0000	-3.6800
SEEE3FG2	0.0000	-3.6800	SEEG3FG2	185.4604	-3.6800
H2SO4PUR	2.2255	-52.3400	POWERPUR	16,813.3083	-0.0460
CWPURCH	2,855.3440	-0.0730	PWPURCH	481.4092	-0.6500
STM15PUR	0.0000	-4.5000	STM200PU	1,072.8114	-4.8000
STM600PU	74.1000	-5.0000	SEC4FGNT	0.0000	0.0000
SEE4FGNT	0.0000	0.0000	SEG4FGNT	0.0000	0.0000
SEI4FGNT	0.0000	0.0000	SEJ4FGNT	0.0000	0.0000
SEK4FGNT	0.0000	0.0000	SEB4FANT	0.0000	0.0000
SED4FANT	0.0000	0.0000	SEF4FANT	0.0000	0.0000
SEH4FANT	0.0000	0.0000	SEI4FANT	0.0000	0.0000
SEA3FG2T	0.0000	0.0000	SEC3FG2T	0.0000	0.0000
SEE3FG2T	0.0000	0.0000	SEG3FG2T	168.7689	0.0000
FURRECOV	15.0753	0.0000	FURSALE	15.0753	1,320.0000
H1D52N3B	0.0000	0.0000	H1D12N3B	168.7689	0.0000
H1D55N3B	0.0000	0.0000	H1D15N3B	0.0000	0.0000
H1D52N5B	0.0000	0.0000	H1D12N5B	0.0000	0.0000
H1D55N5B	0.0000	0.0000	H1D15N5B	0.0000	0.0000
H1B52N3B	0.0000	0.0000	H1B12N3B	0.0000	0.0000
H1B55N3B	0.0000	0.0000	H1B15N3B	0.0000	0.0000
H1B52N5B	0.0000	0.0000	H1B12N5B	0.0000	0.0000
H1B55N5B	0.0000	0.0000	H1B15N5B	0.0000	0.0000
W5EC4FGN	0.0000	0.0000	W5EE4FGN	0.0000	0.0000
W5EG4FGN	0.0000	0.0000	W5EI4FGN	0.0000	0.0000
W5EJ4FGN	0.0000	0.0000	W5EK4FGN	0.0000	0.0000
W5EB4FAN	0.0000	0.0000	W5ED4FAN	0.0000	0.0000
W5EF4FAN	0.0000	0.0000	W5EH4FAN	0.0000	0.0000
W5EI4FAN	0.0000	0.0000	W5EA3FG2	0.0000	0.0000
W5EC3FG2	0.0000	0.0000	W5EE3FG2	0.0000	0.0000
W5EG3FG2	0.0000	0.0000	W1EC4FGN	0.0000	0.0000
W1EE4FGN	0.0000	0.0000	W1EG4FGN	0.0000	0.0000
W1EI4FGN	0.0000	0.0000	W1EJ4FGN	0.0000	0.0000
W1EK4FGN	0.0000	0.0000	W1EB4FAN	0.0000	0.0000
W1ED4FAN	0.0000	0.0000	W1EF4FAN	0.0000	0.0000
W1EH4FAN	0.0000	0.0000	W1EI4FAN	0.0000	0.0000
W1EA3FG2	0.0000	0.0000	W1EC3FG2	0.0000	0.0000
W1EE3FG2	0.0000	0.0000	W1EG3FG2	0.0000	0.0000
EPA4SBSS	0.0000	0.0000	EPB4SBSS	0.0000	0.0000
EPC4SBSS	0.0000	0.0000	EPD4SBSS	0.0000	0.0000
EPE4SBSS	8.0324	0.0000	EPF4SBSS	0.0000	0.0000
EPG4SBSS	0.0000	0.0000	EPH4SBSS	0.0000	0.0000
EPI4SBSS	0.0000	0.0000	EPJ4SBSS	0.0000	0.0000
ETHRECOV	9.1135	0.0000	ETHSALE	9.1135	540.0000
BDLRECOV	45.5676	0.0000	BDLSALE	45.5676	760.0000
BUTRECOV	0.0000	0.0000	BUTSALE	0.0000	720.0000
ACTRECOV	0.0000	0.0000	ACTSALE	0.0000	640.0000
LIGRECOV	48.2646	0.0000	LIGFUEL	48.2646	10.0000
H2D12N3B	0.0000	0.0000	H2D22N3B	0.0000	0.0000
H2D15N3B	0.0000	0.0000	H2D25N3B	0.0000	0.0000
H2D12N5B	0.0000	0.0000	H2D22N5B	0.0000	0.0000
H2D15N5B	0.0000	0.0000	H2D25N5B	0.0000	0.0000
H2B12N3B	0.0000	0.0000	H2B22N3B	0.0000	0.0000
H2B15N3B	0.0000	0.0000	H2B25N3B	0.0000	0.0000
H2B12N5B	0.0000	0.0000	H2B22N5B	0.0000	0.0000
H2B15N5B	0.0000	0.0000	H2B25N5B	0.0000	0.0000
ENMEDIUM	8.6750	-16.3800	FERMED	16.8769	0.0000
H3D52N3B	0.0000	0.0000	H3D12N3B	0.0000	0.0000
H3D55N3B	0.0000	0.0000	H3D15N3B	0.0000	0.0000
H3D52N5B	0.0000	0.0000	H3D12N5B	0.0000	0.0000

H3D55N5B	0.0000	0.0000	H3D15N5B	0.0000	0.0000
H3B52N3B	0.0000	0.0000	H3B12N3B	0.0000	0.0000
H3B55N3B	0.0000	0.0000	H3B15N3B	0.0000	0.0000
H3B52N5B	0.0000	0.0000	H3B12N5B	0.0000	0.0000
H3B55N5B	0.0000	0.0000	H3B15N5B	0.0000	0.0000
H3E55N2B	0.0000	0.0000	H3E55N4B	0.0000	0.0000
H3E15N2B	0.0000	0.0000	H3E15N4B	0.0000	0.0000
H3E35N2B	0.0000	0.0000	H3E35N4B	0.0000	0.0000
H3E25N2B	0.0000	0.0000	H3E25N4B	0.0000	0.0000
H3E51N2B	0.0000	0.0000	H3E51N4B	0.0000	0.0000
H3E11N2B	0.0000	0.0000	H3E11N4B	0.0000	0.0000
H3E31N2B	0.0000	0.0000	H3E31N4B	0.0000	0.0000
H3E21N2B	0.0000	0.0000	H3E21N4B	0.0000	0.0000
H3E50N2B	0.0000	0.0000	H3E50N4B	0.0000	0.0000
H3E10N2B	0.0000	0.0000	H3E10N4B	0.0000	0.0000
H3E30N2B	0.0000	0.0000	H3E30N4B	0.0000	0.0000
H3E20N2B	0.0000	0.0000	H3E20N4B	0.0000	0.0000
SEATOTAL	168.7689	0.0000			

Constraint	Activity		RHS	Constraint	Activity		RHS
ASPAVAIL	195.0000	=	195.0000	ASPENBAL	0.0000	=	0.0000
SEACAPAC	195.0000	>	0.0000	H2SO4CAP	185.4604	>	0.0000
DRYCAPAC	0.0000	>	0.0000	H2SO4REQ	0.0000	=	0.0000
POWERREQ	0.0000	=	0.0000	COWATREQ	0.0000	=	0.0000
PRWATREQ	0.0000	=	0.0000	STM15REQ	-34.8048	<	0.0000
ST200REQ	0.0000	=	0.0000	ST600REQ	0.0000	=	0.0000
FURBALAN	0.0000	=	0.0000	FURSALES	0.0000	=	0.0000
FURLIMIT	15.0753	>	0.0000	SEA1BALN	0.0000	=	0.0000
SEA2BALN	0.0000	=	0.0000	SEA3BALN	0.0000	=	0.0000
SEA4BALN	0.0000	=	0.0000	SEA5BALN	0.0000	=	0.0000
SEA6BALN	0.0000	=	0.0000	SEA7BALN	0.0000	=	0.0000
SEA8BALN	0.0000	=	0.0000	SEA9BALN	0.0000	=	0.0000
SEA10BAL	0.0000	=	0.0000	SEA11BAL	0.0000	=	0.0000
SEA12BAL	0.0000	=	0.0000	SEA13BAL	0.0000	=	0.0000
SEA14BAL	0.0000	=	0.0000	SEA15BAL	0.0000	=	0.0000
SEATOTAL	0.0000	=	0.0000	BDIOLBAL	0.0000	=	0.0000
BUTANBAL	0.0000	=	0.0000	ACTONBAL	0.0000	=	0.0000
ETNOLBAL	0.0000	=	0.0000	BTDLSALE	0.0000	=	0.0000
BDLLIMIT	45.5676	>	0.0000	BTOLSALE	0.0000	=	0.0000
BUTLIMIT	0.0000	>	0.0000	ACTNSALE	0.0000	=	0.0000
ACTLIMIT	0.0000	>	0.0000	ENDLSALE	0.0000	=	0.0000
ETHLIMIT	9.1135	>	0.0000	LIGNINBA	0.0000	=	0.0000
LIGNSALE	0.0000	=	0.0000	CHF1INHB	168.7689	>	0.0000
CHF1BALN	0.0000	=	0.0000	CHF1CAPC	506.3068	>	0.0000
CLASEBAL	0.0000	<	0.0000	FERMEDRQ	0.0000	=	0.0000
WWCAPACT	0.0000	>	0.0000	PETROBAL	0.0000	=	0.0000
WSREMBAL	0.0000	>	0.0000	WIPENTBA	0.0000	>	0.0000
WIHEXOBA	0.0000	>	0.0000	HEXPENBA	0.0000	=	0.0000
XYASEBAL	455.4352	>	0.0000	ENPRDCAP	32.1295	>	0.0000
ENMEDREQ	0.0000	=	0.0000	CHF2INHB	0.0000	>	0.0000
CHF2CAPC	0.0000	>	0.0000	CHF3CAPC	0.0000	>	0.0000

Total Error: 0.000000

APPENDIX C

Table C1: Summary Solution with ASPENBAL Modified

Current ASPENBAL : 1.0 ASPPURCH - 1.0 SEEC4FGN - 1.0 SEE4FGN - 1.0 SEE64FGN
- 1.0 SEE14FGN - 1.0 SEEJ4FGN - 1.0 SEEK4FGN - 1.0 SEEB4FAN
- 1.0 SEED4FAN - 1.0 SEEF4FAN - 1.0 SEEH4FAN - 1.0 SEEI4FAN
- 1.0 SEEA3FG2 - 1.0 SEEC3FG2 - 1.0 SEEE3FG2 - 1.0 SEE63FG2 = 0

Modified ASPENBAL : 1.0 ASPPURCH - 1.0 SEEC4FGN - 1.0 SEEE4FGN - 1.0 SEE64FGN
- 1.0 SEE14FGN - 1.0 SEEJ4FGN - 1.0 SEEK4FGN - 1.0 SEEB4FAN
- 1.0 SEED4FAN - 1.0 SEEF4FAN - 1.0 SEEH4FAN - 1.0 SEEI4FAN
- 1.0 SEEA3FG2 - 1.0 SEEC3FG2 - 1.0 SEEE3FG2 - 1.0 SEE63FG2 = 1

Objective Function Value = $48,951.41 per day

Variable	Activity	Cost per unit	Costs	Sales value per unit	Revenue
ASPPURCH	195.00 tons	$15.00	$2,925.00		
SEEJ4FGN	9.49 tons	$3.68	$34.92		
SEE63FG2	184.51 tons	$3.68	$678.99		
SE63FG2T	167.90 tons	$0.00			
H1D12N3B	167.90 tons	$0.00			
SEATOTAL	167.90 tons	$0.00			
EPE4SBSS	7.99 tons	$0.00			
BDLRECOV	45.33 tons	$0.00			
BDLSALE	45.33 tons			$760.00	$34,450.00
ETHRECOV	9.07 tons	$0.00			
ETHSALE	9.07 tons	.		$540.00	$4,897.80
LIGRECOV	48.02 tons	$0.00			
LIGFUEL	48.02 tons			$10.00	$480.20
FURRECOV	14.99 tons	$0.00			
FURSALE	14.99 tons			$1,320.00	$19,786.80
H2SO4PUR	2.21 tons	$52.34	$115.67		
POWERPUR	16,727.09 kwh	4.6 cents	$769.45		
CWPURCH	2,840.70 mmgal	7.3 cents	$207.37		
PWPURCH	478.94 mmgal	$0.65	$311.31		
STM200PU	1,067.31 mmlb	$4.80	$5,123.09		
STM600PU	73.72 mmlb	$5.00	$368.60		
ENMED1UM	8.63 tons	$16.38	$141.36		
FERMED	16.79 tons	$0.00			

Constraint	Activity	Types of Constraint	RHS	
ASPAVAIL	195.00	=	195.00	
ASPENBAL	1.0	=	1.0	A unit increases in the RHS implies that there will be a 1 ton of chips/day not used in the conversion. Thus the profit will be decreased.
SEACAPAC	194.00	>	0	
H2SO4CAP	184.51	>	0	
STM15REQ	-34.63	<	0	
FURLIMIT	14.99	>	0	
BDLLIMIT	45.33	>	0	
ETHLIMIT	9.07	>	0	
CHF1INHB	167.90	>	0	
CHF1CAPC	503.71	>	0	
IYASEBAL	453.09	>	0	
ENPRDCAP	31.96	>	0	

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Buy ...

I/O:	variables	ASPPURCH	H2SO4PUR	POWERPUR	CWPURCH$	PWPURCH$	STM15PUR	STM200PU	STM600PU	ENMEDIUM	FERMED$$
objective (max profit)		-15	-52.34	-0.046	-0.073	-0.65	-4.5	-4.8	-5	-16.38	
capacity	SEACAPAC										
	H2SO4CAP										
	DRYCAPAC										
	WWCAPACT										
	ENPRDCAP										
	CHF1CAPC										
	CHF2CAPC										
	CHF3CAPC										
inputs	ASPAVAIL	1									
	H2SO4REQ		-1								
	POWERREQ			-1							
	COWATREQ				-1						
	PRWATREQ					-1					
	STM15REQ						-1				
	ST200REQ							-1			
	ST600REQ								-1		
	ENMEDREQ									-1	
	FERMEDRQ										-1
balance	ASPENBAL	1									
	SEA1BALN										
	SEA2BALN										
	SEA3BALN										
	SEA4BALN										
	SEA5BALN										
	SEA6BALN										
	SEA7BALN										
	SEA8BALN										
	SEA9BALN										
	SEA10BAL										
	SEA11BAL										
	SEA12BAL										
	SEA13BAL										
	SEA14BAL										
	SEA15BAL										
	SEATOTAL										
	PETROBAL										
	WSREMBAL										
	WIPENTBA										
	WIHEXOBA										
	HEXPENBA										
	XYASEBAL										
	CLASEBAL										
	FURBALAN										
	BDIOLBAL										
	BUTANBAL										
	ACTONBAL										
	ETNOLBAL										
	LIGNINBA										
	CHF1INHB										
	CHF1BALN										
	CHF2INHB										
limits	FURLIMIT										
	BDLLIMIT										
	BUTLIMIT										
	ACTLIMIT										
	ETHLIMIT										
sales	FURSALES										
	ENOLSALE										
	BTDLSALE										
	BTOLSALE										
	ACTNSALE										
	LIGNSALE										
Optimum		195	2.225524	16813.30	2855.344	481.4091		1072.811	74.1	8.674955	16.87689
Reduced cost							4.5				

ation to the coefficient of SEE63F62 variable.

steam explosion ...

	with green chips						with air dried chips					with acid
	SEEC4FGN	SEEE4FGN	SEE64FGN	SEEI4FGN	SEEJ4FGN	SEEK4FGN	SEEB4FAN	SEED4FAN	SEEF4FAN	SEEH4FAN	SEEI4FAN	SEEA3F62
(max profit)	-3.68	-3.68	-3.68	-3.68	-3.68	-3.68	-3.68	-3.68	-3.68	-3.68	-3.68	-3.68
SEACAPAC	1	1	1	1	1	1	1	1	1	1	1	1
H2SO4CAP												1
DRYCAPAC							1	1	1	1	1	
WWCAPACT												
ENPRDCAP												
CHF1CAPC												
CHF2CAPC												
CHF3CAPC												
ASPAVAIL												0.012
H2SO4REQ												1.41
POWERREQ	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	
COWATREQ												
PRWATREQ												
STM15REQ	-0.38	-0.38	-0.38	-0.38	-0.38	-0.38	-0.38	-0.38	-0.38	-0.38	-0.38	-0.38
ST200REQ												
ST600REQ	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38
ENMEDREQ												
FERMEDRQ												
ASPENBAL	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
SEA1BALN	0.955											
SEA2BALN		0.948										
SEA3BALN			0.933									
SEA4BALN				0.899								
SEA5BALN					0.842							
SEA6BALN						0.785						
SEA7BALN							0.96					
SEA8BALN								0.942				
SEA9BALN									0.89			
SEA10BAL										0.878		
SEA11BAL											0.858	
SEA12BAL												0.886
SEA13BAL												
SEA14BAL												
SEA15BAL												
SEATOTAL												
PETROBAL												
WSREMBAL												
WIPENTBA												
WIHEXOBA												
HEXPENBA												
XYASEBAL												
CLASEBAL												
FURBALAN	0.002	0.004	0.008	0.017	0.025	0.04	0.004	0.008	0.017	0.025	0.04	0.008
BDIOLBAL												
BUTANBAL												
ACTONBAL												
ETNOLBAL												
LIGNINBA	0.236	0.231	0.247	0.215	0.238	0.224	0.247	0.233	0.228	0.231	0.23	0.2
CHF1INHB												
CHF1BALN												
CHF2INHB												
FURLIMIT												
BDLLIMIT												
BUTLIMIT												
ACTLIMIT												
ETHLIMIT												
FURSALES												
ENOLSALE												
BTOLSALE												
BTOLSALE												
ACTNSALE												
LIGNSALE												
Optimum					9.539627							
Reduced cost	32.03787	31.36877				34.56919						

				to combined hydrolysis ...								
	impregnated chips			green chips						air dried chips		
	SEEC3F62	SEEE3F62	SEE63F62	SEC4F6NT	SEE4F6NT	SE64F6NT	SE14F6NT	SEJ4F6NT	SEK4F6NT	SEB4FANT	SED4FANT	SEF4FANT
(max profit)	-3.68	-3.68	-43.68									
SEACAPAC	1	1	1									
H2SO4CAP	1	1	1									
DRYCAPAC												
WWCAPACT												
ENPRDCAP												
CHF1CAPC												
CHF2CAPC												
CHF3CAPC												
ASPAVAIL												
H2SO4REQ	0.012	0.012	0.012									
POWERREQ	1.41	1.41	1.41									
COWATREQ												
PRWATREQ												
STM15REQ	-0.38	-0.38	-0.38									
ST200REQ												
ST600REQ	0.38	0.38	0.38									
ENMEDREQ												
FERMEDRQ												
ASPENBAL	-1	-1	-1									
SEA1BALN				-1								
SEA2BALN					-1							
SEA3BALN						-1						
SEA4BALN							-1					
SEA5BALN								-1				
SEA6BALN									-1			
SEA7BALN										-1		
SEA8BALN											-1	
SEA9BALN												-1
SEA10BAL												
SEA11BAL												
SEA12BAL												
SEA13BAL	0.881											
SEA14BAL		0.855										
SEA15BAL			0.91									
SEATOTAL				1	1	1	1	1	1	1	1	1
PETROBAL												
WSREMBAL												
WIPENTBA												
WIHEXOBA												
HEXPENBA												
XYASEBAL												
CLASEBAL												
FURBALAN	0.034	0.05	0.08									
BDIOLBAL												
BUTANBAL												
ACTONBAL												
ETNOLBAL												
LIGNINBA	0.194	0.212	0.248									
CHF1INHB												
CHF1BALN												
CHF2INHB												
FURLIMIT												
BDLLIMIT												
BUTLIMIT												
ACTLIMIT												
ETHLIMIT												
FURSALES												
ENOLSALE												
BTOLSALE												
BTOLSALE												
ACTNSALE												
LIGNSALE												
Optimum			185.4603									
Reduced cost		7.994710		18.13163	17.57601	49.84337	45.29174	50.78132		27.12768	25.53896	25.65468

CHF1 ...
production of butanediol and its co-product

acid impreganted chips

	SEH4FANT	SEI4FANT	SEA3F62T	SEC3F62T	SEE3F62T	SE63F62T	H1D52N3B	H1D12N3B	H1D55N3B	H1D15N3B	H1D52N5B	H1D12N5B
(max profit)												
SEACAPAC												
H2SO4CAP												
BRYCAPAC												
WWCAPACT												
ENPRDCAP							3	3	3	3	5	5
CHF1CAPC												
CHF2CAPC												
CHF3CAPC												
ASPAVAIL												
H2SO4REQ							68.9	68.9	68.9	68.9	68.9	68.9
POWERREQ							2.53	2.53	2.53	2.53	2.53	2.53
COWATREQ							0.33	0.33	0.33	0.33	0.33	0.33
PRWATREQ							0.19	0.19	0.19	0.19	0.19	0.19
STM15REQ												
ST200REQ												
ST600REQ												
ENMEDREQ							0.1	0.1	0.1	0.1	0.1	0.1
FERMEDRQ												
ASPENBAL												
SEA1BALN												
SEA2BALN												
SEA3BALN												
SEA4BALN												
SEA5BALN												
SEA6BALN												
SEA7BALN												
SEA8BALN												
SEA9BALN												
SEA10BAL	-1											
SEA11BAL		-1										
SEA12BAL			-1									
SEA13BAL				-1								
SEA14BAL					-1							
SEA15BAL						-1						
SEATOTAL	1	1	1	1	1	1						
PETROBAL												
WSREMBAL												
WIPENTBA												
WIHEXOBA												
HEXPENBA												
XYASEBAL							4.5	9	4.5	9	4.5	9
CLASEBAL							4.5	9	4.5	9	4.5	9
FURBALAN							0.17	0.27	0.1	0.16	0.2	0.22
BDIOLBAL												
BUTANBAL												
ACTONBAL							0.03	0.054	0.02	0.032	0.04	0.044
ETNOLBAL												
LIGNINBA												
CHF1INHB							1	1	1	1	1	1
CHF1BALN												
CHF2INHB												
FURLIMIT												
BDLLIMIT												
BUTLIMIT												
ACTLIMIT												
ETHLIMIT												
FURSALES												
ENDLSALE												
BTDLSALE												
BTOLSALE												
ACTNSALE												
LIGNSALE												
Optimum						168.7689		168.7689				
Reduced cost	17.25119		61.95697	25.58721			75.51422		130.4895	89.49921	49.12657	40.68146

butanol and its co-products

water washing ...
5 litres/kg of wat
with green chips

	H1D55N5B	H1D15N5B	H1B52N3B	H1B12N3B	H1B55N3B	H1B15N3B	H1B52N5B	H1B12N5B	H1B55N5B	H1B15N5B	W5EC4F6N	W5EE4F6N
(max profit)												
SEACAPAC												
H2SO4CAP												
DRYCAPAC											1	1
WWCAPACT												
EWPRDCAP												
CHF1CAPC	5	5	3	3	3	3	5	5	5	5		
CHF2CAPC												
CHF3CAPC												
ASPAVAIL												
H2SO4REQ												
POWERREQ	68.9	68.9	68.9	68.9	68.9	68.9	68.9	68.9	68.9	68.9		
COWATREQ	2.53	2.53	2.53	2.53	2.53	2.53	2.53	2.53	2.53	2.53		
PRWATREQ	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.001	0.001
STM15REQ	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19		
ST200REQ												
ST600REQ												
ENMEDREQ												
FERMEDRQ	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1		
ASPENBAL											-1	
SEA1BALN												-1
SEA2BALN												
SEA3BALN												
SEA4BALN												
SEA5BALN												
SEA6BALN												
SEA7BALN												
SEA8BALN												
SEA9BALN												
SEA10BAL												
SEA11BAL												
SEA12BAL												
SEA13BAL												
SEA14BAL												
SEA15BAL												
SEATOTAL											0.081	0.09
PETROBAL											0.106	0.103
WSREMBAL											0.058	0.036
WIPENTBA											0.474	0.489
WIHEXOBA											0.532	0.525
HEXPENBA												
XYASEBAL												
CLASEBAL	4.5	9	4.5	9	4.5	9	4.5	9	4.5	9		
FURBALAN	4.5	9	4.5	9	4.5	9	4.5	9	4.5	9		
BDIOLBAL	0.12	0.13										
BUTANBAL			0.12	0.16	0.07	0.09	0.15	0.19	0.09	0.12		
ACTONBAL			0.06	0.08	0.04	0.05	0.08	0.1	0.05	0.06		
ETNOLBAL	0.024	0.026	0.02	0.03	0.01	0.02	0.03	0.03	0.02	0.02		
LIGNINBA												
CHF1INHB												
CHF1BALN	1	1	1	1	1	1	1	1	1	1		
CHF2INHB												
FURLIMIT												
BDLLIMIT												
BUTLIMIT												
ACTLIMIT												
ETHLIMIT												
FURSALES												
ENOLSALE												
BTOLSALE												
BTOLSALE												
ACTNSALE												
LIGNSALE												
Optimum												
Reduced cost	114.2169	113.9080	74.46447	34.84698	129.5604	111.1920	34.67057		103.3645	82.29194	1.455175	1.663150

	er consuaption				with air dried chips					with acid impregnated chips		
	W5EG4FGN	W5EI4FGN	W5EJ4FGN	W5EK4FGN	W5EB4FAN	W5ED4FAN	W5EF4FAN	W5EH4FAN	W5EI4FAN	W5EA3FG2	W5EC3FG2	W5EE3FG2
(max profit)												
SEACAPAC												
H2SO4CAP												
DRYCAPAC												
WWCAPACT	1	1	1	1	1	1	1	1	1	1	1	1
ENPRDCAP												
CHF1CAPC												
CHF2CAPC	..											
CHF3CAPC												
ASPAVAIL												
H2SO4REQ												
POWERREQ												
CDWATREQ												
PRWATREQ	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
STM15REQ												
ST200REQ												
ST600REQ												
ENMEDREQ	..											
FERMEDRQ												
ASPENBAL												
SEA1BALN												
SEA2BALN												
SEA3BALN	-1											
SEA4BALN		-1										
SEA5BALN			-1									
SEA6BALN				-1								
SEA7BALN					-1							
SEA8BALN						-1						
SEA9BALN							-1					
SEA10BAL								-1				
SEA11BAL									-1			
SEA12BAL										-1		
SEA13BAL											-1	
SEA14BAL												
SEA15BAL												
SEATOTAL												
PETROBAL	0.088	0.075	0.046	0.034	0.079	0.094	0.108	0.097	0.08	0.117	0.124	0.12
WSREMBAL	0.098	0.119	0.122	0.124	0.078	0.088	0.101	0.098	0.126	0.134	0.148	0.175
WIPENTBA	0.019	0.014	0.008	0.007	0.061	0.037	0.017	0.014	0.007	0.01	0.006	0.004
WIHEXOBA	0.487	0.488	0.464	0.428	0.496	0.493	0.474	0.437	0.438	0.442	0.42	0.337
HEXPENBA	0.506	0.502	0.472	0.435	0.557	0.53	0.491	0.451	0.445	0.452	0.426	0.381
XYASEBAL												
CLASEBAL												
FURBALAN												
BDIOLBAL												
BUTANBAL												
ACTONBAL												
ETNOLBAL												
LIGNINBA												
CHF1INHB												
CHF1BALN												
CHF2INHB												
FURLIMIT												
BDLLIMIT												
BUTLIMIT												
ACTLIMIT												
ETHLIMIT												
FURSALES												
ENOLSALE												
BTOLSALE												
BTOLSALE												
ACTNSALE												
LIGNSALE												
ptimum												
Reduced cost	41.49958	41.15755	63.97280	29.61695	1.455175	6.911794	18.79859	27.74203	16.28530	67.91183	39.87474	32.06103

10 litres/kg of water consumption

	with green chips						with air dried chips					
	W5E63F62	W1EC4FGN	W1EE4FGN	W1EG4FGN	W1EI4FGN	W1EJ4FGN	W1EK4FGN	W1EB4FAN	W1ED4FAN	W1EF4FAN	W1EH4FAN	W1EI4FAN
(max profit)												
SEACAPAC												
H2SO4CAP												
DRYCAPAC												
WWCAPACT	1	1	1	1	1	1	1	1	1	1	1	1
ENPRDCAP												
CHF1CAPC												
CHF2CAPC												
CHF3CAPC												
ASPAVAIL												
H2SO4REQ												
POWERREQ												
COWATREQ												
PRWATREQ	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
STM15REQ												
ST200REQ												
ST600REQ												
ENMEDREQ												
FERMEDRQ												
ASPENBAL												
SEA1BALN		-1										
SEA2BALN			-1									
SEA3BALN				-1								
SEA4BALN					-1							
SEA5BALN						-1						
SEA6BALN							-1					
SEA7BALN								-1				
SEA8BALN									-1			
SEA9BALN										-1		
SEA10BAL											-1	
SEA11BAL												
SEA12BAL												
SEA13BAL												
SEA14BAL												
SEA15BAL	-1											
SEATOTAL												
PETROBAL	0.098	0.088	0.098	0.096	0.082	0.051	0.037	0.086	0.103	0.117	0.105	0.088
WSREMBAL	0.167	0.106	0.103	0.098	0.119	0.122	0.124	0.076	0.088	0.101	0.098	0.126
WIPENTBA	0.003	0.058	0.036	0.019	0.014	0.008	0.007	0.061	0.037	0.017	0.014	0.007
WIHEXOBA	0.409	0.474	0.489	0.487	0.488	0.464	0.428	0.496	0.493	0.474	0.437	0.438
HEXPENBA	0.412	0.532	0.525	0.506	0.502	0.472	0.435	0.557	0.53	0.491	0.451	0.445
XYASEBAL												
CLASEBAL												
FURBALAN												
BDIOLBAL												
BUTANBAL												
ACTONBAL												
ETNOLBAL												
LIGNINBA												
CHF1INHB												
CHF1BALN												
CHF2INHB												
FURLIMIT												
BDLLIMIT												
BUTLIMIT												
ACTLIMIT												
ETHLIMIT												
FURSALES												
ENOLSALE												
BTOLSALE												
BTOLSALE												
ACTNSALE												
LIGNSALE												

ptimum

Reduced cost 24.96560 39.83643 39.70237 62.93358 28.99368 5.040669 16.92747 26.07888 14.62215

Enzyme production ...

with acid impreganted chips

	W1EA3FG2	W1EC3FG2	W1EE3FG2	W1EG3FG2	EPA4SBSS	EPB4SBSS	EPC4SBSS	EPD4SBSS	EPE4SBSS	EPF4SBSS	EPG4SBSS	EPH4SBSS
(max profit)												
SEACAPAC												
H2SO4CAP												
DRYCAPAC												
WWCAPACT	1	1	1	1	4	4	4	4	4	4	4	4
ENPRDCAP												
CHF1CAPC												
CHF2CAPC												
CHF3CAPC	..											
ASPAVAIL												
H2SO4REQ					549	549	549	549	549	549	549	549
POWERREQ					4.05	4.05	4.05	4.05	4.05	4.05	4.05	4.05
CONATREQ					53	53	53	53	53	53	53	53
PRNATREQ	0.002	0.002	0.002	0.002	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
STM15REQ												
ST200REQ												
ST600REQ					1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08
ENMEDREQ	-											
FERMEDRQ												
ASPENBAL					-1							
SEA1BALN						-1						
SEA2BALN							-1					
SEA3BALN								-1				
SEA4BALN									-1			
SEA5BALN										-1		
SEA6BALN												
SEA7BALN												
SEA8BALN												
SEA9BALN												
SEA10BAL												
SEA11BAL											-1	
SEA12BAL	-1											-1
SEA13BAL		-1										
SEA14BAL			-1									
SEA15BAL				-1								
SEATOTAL												
PETROBAL	0.128	0.135	0.131	0.107								
WSREMBAL	0.134	0.148	0.175	0.167								
WIPENTBA	0.01	0.006	0.004	0.003								
WIHEXOBA	0.442	0.42	0.337	0.409								
HEXPENBA	0.452	0.426	0.381	0.412								
XYASEBAL					16.6	25.9	46.4	44.7	56.7	39.8	20.2	13.6
CLASEBAL					-55.4	-86.3	-154.5	-149.1	-189.1	-132.7	-67.3	-45.5
FURBALAN												
BDIOLBAL												
BUTANBAL												
ACTONBAL												
ETNOLBAL												
LIGNINBA												
CHF1INHB												
CHF1BALN												
CHF2INHB												
FURLIMIT												
BDLLIMIT												
BUTLIMIT												
ACTLIMIT												
ETHLIMIT												
FURSALES												
ENOLSALE												
BTDLSALE												
BTOLSALE												
ACTNSALE												
LIGNSALE												
Optimum	..								8.032366			
Reduced cost	65.62476	37.58767	29.77396	23.09447	199.9131	145.6089	59.24661	64.08795		47.32298	223.0392	224.5892

CHF2 ...
production of butanediol and its co-product

butanol and its co

	EP14SBSS	EPJ4SBSS	H2D12N3B	H2D22N3B	H2D15N3B	H2D25N3B	H2D12N5B	H2D22N5B	H2D15N5B	H2D25N5B	H2B12N3B	H2B22N3B
(max profit)												
SEACAPAC												
H2SO4CAP												
DRYCAPAC												
WWCAPACT												
ENPRDCAP	4	4										
CHF1CAPC												
CHF2CAPC			3	3	3	3	5	5	5	5	3	3
CHF3CAPC												
ASPAVAIL												
H2SO4REQ												
POWERREQ	549	549	68.9	68.9	68.9	68.9	68.9	68.9	68.9	68.9	68.9	68.9
COWATREQ	4.05	4.05	2.53	2.53	2.53	2.53	2.53	2.53	2.53	2.53	2.53	2.53
PRWATREQ	53	53	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
STM15REQ	0.9	0.9	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
ST200REQ												
ST600REQ												
ENMEDREQ	1.08	1.08										
FERMEDRQ			0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
ASPENBAL												
SEA1BALN												
SEA2BALN												
SEA3BALN												
SEA4BALN												
SEA5BALN												
SEA6BALN												
SEA7BALN												
SEA8BALN												
SEA9BALN												
SEA10BAL												
SEA11BAL												
SEA12BAL												
SEA13BAL												
SEA14BAL	-1											
SEA15BAL		-1										
SEATOTAL												
PETROBAL			-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
WSREMBAL												
WIPENTBA												
WIHEXOBA												
HEXPENBA												
XYASEBAL	19.6	15	-0.09	-0.18	-0.09	-0.18	-0.09	-0.18	-0.09	-0.18	-0.09	-0.18
CLASEBAL	-65.4	-50										
FURBALAN												
BDIOLBAL			0.17	0.23	0.1	0.13	0.2	0.26	0.12	0.15		
BUTANBAL											0.09	0.12
ACTONBAL											0.05	0.06
ETNOLBAL			0.034	0.046	0.02	0.026	0.04	0.052	0.024	0.03	0.015	0.01
LIGNINBA												
CHF1INHB												
CHF1BALN												
CHF2INHB			1	1	1	1	1	1	1	1	1	1
FURLIMIT												
BDLLIMIT												
BUTLIMIT												
ACTLIMIT												
ETHLIMIT												
FURSALES												
ENOLSALE												
BTDLSALE												
BTOLSALE												
ACTNSALE												
LIGNSALE												
Optimum												
Reduced cost	164.3871	191.1745	73.22663	24.40887	130.1806	105.7718	48.81775		113.9080	89.49921	105.5291	79.10256

CHF3 ...
production of butanediol and its co-product

-products

	M2B15N3B	M2B25N3B	M2B12N5B	M2B22N5B	M2B15N5B	M2B25N5B	M3D52N3B	M3D12N3B	M3D55N3B	M3D15N3B	M3D52N5B	M3D12N5B
(max profit)												
SEACAPAC												
M2SO4CAP												
DRYCAPAC												
WWCAPACT												
ENPRDCAP												
CHF1CAPC												
CHF2CAPC	3	3	5	5	5	5	3	3	3	3	5	5
CHF3CAPC												
ASPAVAIL												
M2SO4REQ												
POWERREQ	68.9	68.9	68.9	68.9	68.9	68.9	68.9	68.9	68.9	68.9	68.9	68.9
COWATREQ	2.53	2.53	2.53	2.53	2.53	2.53	2.53	2.53	2.53	2.53	2.53	2.53
PRWATREQ	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
STM15REQ	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
ST200REQ												
ST600REQ												
ENMEDREQ												
FERMEDRQ	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
ASPENBAL												
SEA1BALN												
SEA2BALN												
SEA3BALN												
SEA4BALN												
SEA5BALN												
SEA6BALN												
SEA7BALN												
SEA8BALN												
SEA9BALN												
SEA10BAL												
SEA11BAL												
SEA12BAL												
SEA13BAL												
SEA14BAL												
SEA15BAL												
SEATOTAL												
PETROBAL	-1	-1	-1	-1	-1	-1						
WSREMBAL												
WIPENTBA												
WIHEXOBA							-1	-1	-1	-1	-1	-1
HEXPENBA												
XYASEBAL	-0.09	-0.18	-0.09	-0.18	-0.09	-0.18	4.5	9	4.5	9	4.5	9
CLASEBAL												
FURBALAN							0.15	0.2	0.09	0.09	0.18	0.23
BDIOLBAL												
BUTANBAL	0.06	0.08	0.11	0.14	0.07	0.09						
ACTONBAL	0.03	0.04	0.06	0.07	0.04	0.05	0.03	0.04	0.018	0.018	0.036	0.046
ETNOLBAL	0.01	0.013	0.055	0.07	0.035	0.045						
LIGNINBA												
CHF1INHB												
CHF1BALN												
CHF2INHB	1	1	1	1	1	1						
FURLIMIT												
BDLLIMIT												
BUTLIMIT												
ACTLIMIT												
ETHLIMIT												
FURSALES												
ENOLSALE												
BTDLSALE												
BTOLSALE												
ACTNSALE												
LIGNSALE												

Optimum

Reduced cost 142.8496 120.1165 64.49252 28.17207 116.8843 90.68845 188.0909 155.2369 236.9086 244.7361 111.8547 79.00074

	H3D55N5B	H3D15N5B	H3B52N3B	H3B12N3B	H3B55N3B	H3B15N3B	H3B52N5B	H3B12N5B	H3B55N5B	H3B15N5B	H3E55N2B	H3E55N4B
(max profit)												
SEACAPAC												
H2SO4CAP												
DRYCAPAC												
WWCAPACT												
ENPRDCAP												
CHF1CAPC												
CHF2CAPC												
CHF3CAPC	5	5	3	3	3	3	5	5	5	5	2	4
ASPAVAIL												
H2SO4REQ												
POWERREQ	68.9	68.9	68.9	68.9	68.9	68.9	68.9	68.9	68.9	68.9	68.9	68.9
COWATREQ	2.53	2.53	2.53	2.53	2.53	2.53	2.53	2.53	2.53	2.53	2.53	2.53
PRWATREQ	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
STM15REQ	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
ST200REQ												
ST600REQ												
ENMEDREQ												
FERMEDRQ	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1		
ASPENBAL												
SEA1BALN												
SEA2BALN												
SEA3BALN												
SEA4BALN												
SEA5BALN												
SEA6BALN												
SEA7BALN												
SEA8BALN												
SEA9BALN												
SEA10BAL												
SEA11BAL												
SEA12BAL												
SEA13BAL												
SEA14BAL												
SEA15BAL												
SEATOTAL												
PETROBAL												
WSREMBAL												
WIPENTBA												
WIHEXOBA												
HEXPENBA	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
XYASEBAL												
CLASEBAL	4.5	9	4.5	9	4.5	9	4.5	9	4.5	9	4.5	4.5
FURBALAN												
BDIOLBAL	0.11	0.14										
BUTANBAL			0.15	0.2	0.09	0.09	0.18	0.23	0.11	0.14		
ACTONBAL			0.08	0.01	0.05	0.05	0.09	0.12	0.06	0.07		
ETNOLBAL	0.022	0.028	0.025	0.033	0.015	0.015	0.03	0.038	0.018	0.023	0.015	0.21
LIGNINBA												
CHF1INHB												
CHF1BALN												
CHF2INHB												
FURLIMIT												
BDLLIMIT												
BUTLIMIT												
ACTLIMIT												
ETHLIMIT												
FURSALES												
ENOLSALE												
BTDLSALE												
BTOLSALE												
ACTNSALE												
LIGNSALE												
Optimum												
Reduced cost	168.8087	152.2273	135.4269	142.6699	204.1209	211.9483	52.22606		129.5604	106.0144	328.6286	180.3365

mol

	H3E15N2B	H3E15N4B	H3E35N2B	H3E35N4B	H3E25N2B	H3E25N4B	H3E51N2B	H3E51N4B	H3E11N2B	H3E11N4B	H3E31N2B	H3E31N4B
(max profit)												
SEACAPAC												
H2SO4CAP												
DRYCAPAC												
WWCAPACT												
ENPRDCAP												
CHF1CAPC												
CHF2CAPC												
CHF3CAPC	2	4	2	4	2	4	2	4	2	4	2	4
ASPAVAIL												
H2SO4REQ												
POWERREQ	68.9	68.9	68.9	68.9	68.9	68.9	68.9	68.9	68.9	68.9	68.9	68.9
COWATREQ	2.53	2.53	2.53	2.53	2.53	2.53	2.53	2.53	2.53	2.53	2.53	2.53
PRWATREQ	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
STM15REQ	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
ST200REQ												
ST600REQ												
ENMEDREQ												
FERMEDRQ												
ASPENBAL												
SEA1BALN												
SEA2BALN												
SEA3BALN												
SEA4BALN												
SEA5BALN												
SEA6BALN												
SEA7BALN												
SEA8BALN												
SEA9BALN												
SEA10BAL												
SEA11BAL												
SEA12BAL												
SEA13BAL												
SEA14BAL												
SEA15BAL												
SEATOTAL												
PETROBAL												
WSREMBAL												
WIPENTBA												
WIHEXOBA												
HEXPENBA	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
XYASEBAL	9	9	13.5	13.5	18	18	4.5	4.5	9	9	13.5	13.5
CLASEBAL												
FURBALAN												
BDIOLBAL												
BUTANBAL												
ACTONBAL												
ETNOLBAL	0.2	0.27	0.25	0.28	0.26	0.3	0.18	0.24	0.24	0.31	0.29	0.32
LIGNINBA												
CHF1INHB												
CHF1BALN												
CHF2INHB												
FURLIMIT												
BDLLIMIT												
BUTLIMIT												
ACTLIMIT												
ETHLIMIT												
FURSALES												
ENOLSALE												
BTOLSALE												
ACTNSALE												
LIGNSALE												

Optimum												
Reduced cost	244.9382	158.4825	228.0311	161.3631	230.9117	159.2967	247.0046	165.4958	225.1506	138.6949	208.2435	141.5754

Products(

	H3E21N2B	H3E21N4B	H3E50N2B	H3E50N4B	H3E10N2B	H3E10N4B	H3E30N2B	H3E30N4B	H3E20N2B	H3E20N4B	SEATOTAL	FURRECOV
(max profit)												
SEACAPAC												
H2SO4CAP												
DRYCAPAC												
WWCAPACT												
ENPRDCAP												
CHF1CAPC												
CHF2CAPC	..											
CHF3CAPC	2	4	2	4	2	4	2	4	2	4		
ASPAVAIL												
H2SO4REQ												4.24
POWERREQ	68.9	68.9	68.9	68.9	68.9	68.9	68.9	68.9	68.9	68.9		20.3
CONATREQ	2.53	2.53	2.53	2.53	2.53	2.53	2.53	2.53	2.53	2.53		
PRWATREQ	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33		
STM15REQ	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19		9.09
ST200REQ												
ST600REQ	..											
ENMEDREQ												
FERMEDRQ												
ASPENBAL												
SEA1BALN												
SEA2BALN												
SEA3BALN												
SEA4BALN												
SEA5BALN												
SEA6BALN												
SEA7BALN												
SEA8BALN												
SEA9BALN												
SEA10BAL												
SEA11BAL												
SEA12BAL												
SEA13BAL												
SEA14BAL												
SEA15BAL											-1	
SEATOTAL												
PETROBAL												
WSREMBAL												
WIPENTBA												
WIHEXOBA												
HEXPENBA	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1		
XYASEBAL												
CLASEBAL	18	18	4.5	4.5	9	9	13.5	13.5	18	18		-1
FURBALAN												
BDIOLBAL												
BUTANBAL												
ACTONBAL												
ETNOLBAL	0.31	0.34	0.11	0.14	0.15	0.19	0.18	0.19	0.19	0.21		
LIGNINBA											1	
CHF1INHB											-1	
CHF1BALN												
CHF2INHB												
FURLIMIT												
BDLLIMIT												
BUTLIMIT												
ACTLIMIT												
ETHLIMIT												1
FURSALES												
ENOLSALE												
BTOLSALE												
ACTNSALE												
LIGNSALE												
Optimum											168.7689	15.07532
Reduced cost	206.1771	139.5091	281.6329	214.9649	269.6728	198.0578	262.6595	205.8853	265.5401	203.8189		

and co-products) recovery ... Sales ...

	ETHRECOV	BDLRECOV	BUTRECOV	ACTRECOV	LIGRECOV	FURSALE$	ETHSALE$	BDLSALE$	BUTSALE$	ACTSALE$	LIGFUEL$
(max profit)						1320	540	760	720	640	10
SEACAPAC											
H2SO4CAP											
DRYCAPAC											
WWCAPACT											
ENPRDCAP											
CHF1CAPC											
CHF2CAPC											
CHF3CAPC											
ASPAVAIL											
H2SO4REQ											
POWERREQ	4.24	4.24	4.24	4.24	4.24						
COWATREQ	20.3	20.3	20.3	20.3	20.3						
PRWATREQ											
STM15REQ											
ST200REQ	9.09	9.09	9.09	9.09	9.09						
ST600REQ											
ENMEDREQ											
FERMEDRQ											
ASPENBAL											
SEA1BALN											
SEA2BALN											
SEA3BALN											
SEA4BALN											
SEA5BALN											
SEA6BALN											
SEA7BALN											
SEA8BALN											
SEA9BALN											
SEA10BAL											
SEA11BAL											
SEA12BAL											
SEA13BAL											
SEA14BAL											
SEA15BAL											
SEATOTAL											
PETROBAL											
WSREMBAL											
WIPENTBA											
WIHEXOBA											
HEXPENBA											
XYASEBAL											
CLASEBAL											
FURBALAN											
BDIOLBAL		-1									
BUTANBAL			-1								
ACTONBAL				-1							
ETNOLBAL	-1										
LIGNINBA					-1						
CHF1INHB											
CHF1BALN											
CHF2INHB											
FURLIMIT						1					
BDLLIMIT							1				
BUTLIMIT								1			
ACTLIMIT									1		
ETHLIMIT							1				
FURSALES						-1					
ENOLSALE	1						-1				
BTOLSALE		1						-1			
BTOLSALE			1						-1		
ACTNSALE				1						-1	
LIGNSALE					1						-1
Optimum	9.113522	45.56761				48.26460	15.07532	9.113522	45.56761		48.26460
Reduced cost											

		RHS	Slacks/ surplus	Shadow prices
(max profit)				
SEACAPAC	>=	0	195	
H2SO4CAP	>=	0	185.4603	
DRYCAPAC	>=	0		-20.14773
WWCAPACT	>=	0		
ENPRDCAP	>=	0	32.129464	
CHF1CAPC	>=	0	506.30681	
CHF2CAPC	>=	0		
CHF3CAPC	>=	0		-25.91366
ASPAVAIL	=	195	195	214.36102
H2SO4REQ	=	0		52.34
POWERREQ	=	0		0.046
COWATREQ	=	0		0.073
PRWATREQ	=	0		0.65
STM15REQ	<=	0	-34.80477	
ST200REQ	=	0		4.8
ST600REQ	=	0		5
ENMEDREQ	=	0		16.38
FERMEDRQ	=	0		
ASPENBAL	=	0		-229.3610
SEA1BALN	=	0		-218.5880
SEA2BALN	=	0		-218.0323
SEA3BALN	=	0		-250.2997
SEA4BALN	=	0		-245.7481
SEA5BALN	=	0		-251.2376
SEA6BALN	=	0		-200.4563
SEA7BALN	=	0		-227.5840
SEA8BALN	=	0		-225.9953
SEA9BALN	=	0		-226.1110
SEA10BAL	=	0		-217.7075
SEA11BAL	=	0		-200.4563
SEA12BAL	=	0		-262.4133
SEA13BAL	=	0		-226.0435
SEA14BAL	=	0		-200.4563
SEA15BAL	=	0		-200.4563
SEATOTAL	=	0		-200.4563
PETROBAL	=	0		-207.9750
MSREMBAL	>=	0		
MIPENTBA	>=	0		
MIHEXOBA	>=	0		
HEXPENBA	=	0		-376.4802
XYASEBAL	>=	0	455.43516	
CLASEBAL	<=	0		1.7394380
FURBALAN	=	0		-1274.693
BDIOLBAL	=	0		-714.6910
BUTANBAL	=	0		-765.1056
ACTONBAL	=	0		-594.6910
ETNOLBAL	=	0		-494.6910
LIGNINBA	=	0		35.30894
CHF1INHB	>=	0	168.76893	
CHF1BALN	=	0		200.45637
CHF2INHB	>=	0		
FURLIMIT	>=	0	15.075320	
BDLLIMIT	>=	0	45.567613	
BUTLIMIT	>=	0		-90.41454
ACTLIMIT	>=	0		
ETHLIMIT	>=	0	9.1135227	
FURSALES	=	0		-1320
ENOLSALE	=	0		-540
BTDLSALE	=	0		-760
BTOLSALE	=	0		-810.4145
ACTNSALE	=	0		-640
LIGNSALE	=	0		-10
		Profit		
Optimum		41800.39		
Reduced cost				