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COMPARATIVE ANALYSIS OF COAL USE OPTIONS FOR
REDUCING THE DEPENDENCE OF UTILITIES ON IMPORTED OIL

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SUMMARY

The President and the Congress are finalizing National Goals to reduce the Nation's dependence on imported oil. A key element of these goals is the conversion of utilities from oil-fired to coal-fired to yield an import reduction of 0.75 MBD by 1990. Since these utilities already exist at fixed locations, this element of the National Goals has the focus of Appolo, Polaris, Minuteman and other major successful programs. It is indicated, therefore, that the program development and management techniques employed in these programs may have useful application to the utility conversion program. These techniques include comparative systems and mission mode analysis, and the application of these techniques to the utility conversion program is discussed.

It is observed that the conversions of coal-capable utilities will most likely be achieved in the first half of the next decade, while those for non coal-capable utilities are substantially more difficult and costly, and they will, therefore, be more likely to occur in the latter half of the next decade. More generally, it is noted that time is short at best, and it is therefore suggested that DOE/RA initiate an in-house task force effort to make a comparative analysis of conversion alternatives to meet this goal. This analysis is discussed in some detail and it should consider the coal delivery as well as the conversion elements of the overall coal use system with a view to focusing on problems which must be addressed, and discarding those which are of no consequence to meeting the National Goal.

It is noted in this connection that while the overall delivery requirements for the utility conversion program are a small fraction of the Nation's coal delivery capability, the regional requirements can be relatively large -- like an

order of magnitude greater than current delivery rates in New England. This and other factors' bearing on coal delivery, including end use requirements on the kinds and hence the sources of coal to be delivered, signal the importance of considering this element of the overall coal use system.

The conversion alternatives considered should range from state-of-the-art technologies like direct conventional combustion of coal, through intermediate technologies like Coal-Oil Mixture (COM) combustion, to more advanced technologies like Atmospheric Fluidized Bed Combustion (AFBC) and Integrated Gasifier Combined Cycle (IGCC) Systems. A critical issue in the latter instances is whether the technologies will be available in time to meet the National Goal. In general the mitigation of environmental impacts will be crucial.

The proposed task force effort should reveal at an early date where supportive contractor studies are required to crystalize the limited set of system and subsystem options that are likely to be available to meet the National Goal. These options can then be subjected to in-depth contractor studies to define systems particulars and enable the early development of implementation plans for the utility conversion program. These implementation plans will have to encompass well over 100 utility plants located largely in the east with a heavy concentration in the Northeast, and they will have to account for meeting attendant coal delivery requirements from the source to the user by land or water, or both.

Now to be sure both the development and implementation of these plans must involve the participation of a broad spectrum of government agencies at all levels and industries from coal mining through transportation to utilities. The fact remains, however, that DOE continues to have the lead Federal Department responsibility for providing unified leadership to the Nation's energy policies and programs. This responsibility has a key focus in DOE/RA to facilitate and coordinate

the national effort to meet the utility conversion goal within the framework of approved federal regulations, and this responsibility cannot be well met with less than the comprehensive understanding of problems to be surmounted which will derive from the aforementioned analytical efforts.

It is noted that experience suggests that an early consensus of views of involved participants in the efforts can be developed by aggregating them under responsible and respected leadership in management oversight committee roles for the development of implementation plans. The selective establishment of such planning oversight committees is therefore recommended. It seems clear too, however, that the dominant continuing challenge to successfully implementing the plans will be for the Government-Industry partners to "keep their act together". This means identifying emerging institutional conflicts early and resolving them before they become time-consuming "court cases". To this end, it is suggested that serious consideration be given to establishing "Utility Conversion Coordinating Boards" under the leadership of DOE/RA and constituted with members in appropriately authoritative line positions with the other institutions responsible for the conversion(s). This arrangement would enable decisive institutional follow-up on conflict-resolving agreements reached by the Boards, and only in exceptional cases should conflicts need to be taken to the Energy Mobilization Board (EMB) for resolution. It is noted further in this connection that timely and well informed actions by the Coordinating Boards would certainly be facilitated and most likely be insured with the continuing support of a highly qualified and dedicated System Integration and Evaluation (SIE) contractor.

Finally, it is noted that the goal for utility conversions is of such national import that DOE/RA should not hesitate to seek the continuing counsel of the wisest minds in the country to meet its responsibilities.

INTRODUCTION

On July 16 of last year the President¹ proposed National Goals to be met in markedly reducing U. S. dependence on imported oil.* These goals placed major emphasis on the increased use of domestic coal in place of imported oil. Specifically,^{1,2} some 2 MBD of a total 4.5 MBD oil import reduction by 1990 was targeted to be achieved by increased use of coal as follows:

<u>Coal Use</u>	<u>Oil Equivalent</u>
Utility Conversions	0.75 MBD
Coal Gases	0.25 MBD
<u>Coal Liquids</u>	<u>1 MBD</u>
Total	2 MBD

The Administration and the Congress are now "finalizing" these goals, and while it is to be expected that they may be somewhat altered in the ultimate consensus, the essential fact is that hard targets are emerging against which the nation can harness its capabilities and address its efforts to achieve the longer range objective of "energy self-sufficiency."

Clearly these capabilities include many institutions ranging from government agencies at all levels to utilities, other industries and universities. Indeed, pursuant to achieving his proposed goals, the President has proposed two new national institutions, the Energy Mobilization Board (EMB) and the Energy Security Corporation** (ESC). The EMB is intended to expedite the development of critical non-nuclear energy production capacity, and the ESC is intended to direct the recoverable investment of federal funds in the production of synthetic fuels and unconventional natural gas. These institutions will complement the

1 - All superscript numbers refer to references which are identified in Appendix 1.

* Current events which are further straining U. S. - Iran relations and which have already led to the second cessation of oil imports from Iran (0.7 MBD) may well strengthen these goals.

** The Congress may change the name of this institution to the Synthetic Fuels Corporation.

Department of Energy with its several research, technology and commercialization activities (e.g., ER, FE, NE & RA) and its regulatory functions (e.g., ERA), among others. The DOE will continue, however, to have the primary Federal Department responsibility for providing unified leadership to the nation's energy policies and programs. This responsibility can only be discharged if DOE is fully knowledgeable and supportive of the spectrum of initiatives which must make up the National effort to meet its goals.

There is good reason to believe that this leadership can be substantially facilitated and focussed with the identification of the constrained set of coal use options available for meeting the "hard targets" to reduce our dependence on imported oil. These options are constrained by what can realistically be done and where in the time available between now and 1990. Thus, for example, certain potentially attractive new conversion and storage technologies (like advanced MHD and fuel cells) may be unavailable in time, and certain potentially attractive old transportation technologies (like the Milwaukee RR and Conrail) may be unusable in time. Likewise certain capital formation requirements (e.g., for a major Utility or MFBI^{*} conversion) may be unmeetable in time, and certain environmental impacts (e.g., from direct burning of high sulfur content Eastern coal) may be unmitigable in time. All of these factors and many more can bound the options available for solution of the problems. By the same token if these limited options are identified, then the actions required to implement them take on a whole new level of specificity in terms of people and institutions required to do definite things in prescribed places on a determined schedule to meet the national goals. In short, required action and decision milestones emerge and the proven planning and large-scale management techniques of Appolo, Polaris, Minuteman and other successful major national programs have unmistakable application. Comparative systems and mission mode analysis appear to be well suited to the

* Major Fuel Burning Installation

identification of the constrained set of coal use options available as will be discussed below with particular attention to utility conversions.

BACKGROUND

The elements of a coal use system are shown in simplified form in the following schematic diagram:

The overall system has some 6 elements starting with coal mining which may be by surface or subsurface production (figure 1)³; proceeding then to mine site preparation or beneficiation of the coal which may include both sizing and washing (figure 2)³; then to coal transportation which may be by rail, water or motor vehicle (figure 3)³; or by slurry pipelines; then to plant site preparation which may include further coal cleaning and sizing (e.g., with chemical comminution)⁴ plus storage; then to plant utilization of coal alone by direct conventional combustion⁵ (figure 4)³; or mixed with oil (COM)⁵, or with an AFBC^{5,6} or IGCC⁵ or other conversion systems⁷ (e.g., MHD); and finally to the waste handling element(s) which may include precipitators and scrubbers et al to remove particulate and gaseous pollutants^{7,8} from the flue gases and, of course, slag and ash removers from combustors or reactors as the case may be.⁷ Aggregated at a higher level the Coal Use System consists of a Delivery Sub-System and an End Use Sub-System. The elements of these subsystems are interdependent - for example, medium sulfur ($> 1\%$) and high sulfur ($> 3\%$) coals mined from Appalachia and the Eastern Interior U. S.³ may pose more severe and costly mine site and

plant site coal preparation and waste handling problems, while low sulfur coals (< 1%) mined from the North Western Great Plains¹³ may pose more severe and costly transportation problems, rail or water or otherwise, to eastern plants. The elements of these subsystems also have problems in common including the mitigation of environmental impact⁹ due to coal mining (e.g., acid run offs from surface mining), and due to plant utilization (e.g., acid rains from sulfur in stack gases), and due to the disruption in local transportation because of the tedious through-town transit of long coal bearing unit trains.¹⁰ The elements of these sub-systems also have in common financial problems which may require government incentives^{11,12} to overcome the added costs of opening new mines or expanding old mines to enlarge coal supply, of upgrading existing railroad beds or installing new lines to handle increased tonnage of coal transport, to reconvert or replace oil burning boilers of utilities and MFBI's* with coal burning boilers,¹³ and to develop new synthetic fuel producing plants.^{1,2}

In the light of these many factors to be considered, it is no surprise that numerous federal agencies in addition to DOE have important authorities and responsibilities in the maintenance and development of coal use systems. These agencies include EPA in the area of environmental regulations, DOI in the area of land and water use including mining, the Department of the Army in the area of projects under the Corps of Engineer's authority, DOT in the area of surface transportation, the ICC in the area of interstate commerce rates, Treasury and Agriculture (REA) in the area of financial incentives, and their counterparts at state and local levels. It is not surprising either that with these many government institutions at all levels involved in the decision-making process on coal use initiatives, the progress of utilities and other industries has been painfully

* Major Fuel Burning Installations. (Those subject to the "Fuel Use Act" including individual units consuming 100 million BTU's of fuel per hour or more, or combinations of units consuming 250 million BTU's of fuel per hour or more).

slow in implementing this use. This fact has, of course, figured importantly in the President's steps to create the EMB and the ESC. These steps alone, however, do not suffice to rigorously constrain coal use system options to be considered and implemented in a prescribed future time frame. This constraint is provided by the proposed National Goals for increased coal use noted earlier. It is instructive now to consider the applications of comparative systems and mission mode analysis within this constraint as it applies specifically to utility conversions.

UTILITY CONVERSIONS

As noted earlier, the proposed National Goal for converting utilities from oil to coal burning is to complete these conversions with a net reduction in imported oil of 0.75 MBD by 1990. Since these utilities already exist, they are at specified geographical locations and in fact they are largely concentrated in the Eastern United States¹⁴ including Federal Regions 1-4 extending from New England south through the Mid-Atlantic and South Atlantic states (See figure 5)¹⁵. Thus the hard targets for conversion are fixed in space and limited in time for completion. It is unlikely and indeed unreasonable to suppose that these conversions could be achieved in a narrow time frame between now and 1990. Rather, as will be discussed, the completed conversions as a function of time are likely to vary as shown below.

There are two general types of utility conversions. The simplest, the least costly and most likely the earliest to be completed are conversions of utilities already equipped with coal-capable boilers and other coal handling capabilities including stockpiling facilities. The New England Power Company, Brayton Point Plant (3 units) is an example¹³ of such a conversion which is planned to be completed in 1981 at a cost of \$114M ($\approx$ \$100K per MW of generating capacity, or $\approx$ 10% of total utility replacement cost). More generally it has been estimated^{16,17} for the President's Commission that some 50 existing utility power generating plants now burning oil are coal capable.* These plants have an aggregated rated output of approximately 16,000 MW, they consume something over 0.3 MBD of oil, and the majority of them are located from Virginia through Maine with the heaviest concentration in the New York/New England area. Accordingly it seems reasonable to project that the first half of the utility conversion goal will be largely achieved by converting coal-capable plants. The establishment of the specific requirements which must be met to achieve these conversions is of the highest priority with emphasis on those concentrated in the Northeastern U. S.

The second general class of conversions involves non coal-capable utilities which may well require the replacement of oil burning boilers with coal burning boilers among other major alterations. The Jacksonville Electric Authority Unit #3 is an example of such a conversion¹³ which it is estimated would cost \$300M ($\approx$ \$600K per MW of generating capacity or $\approx$ 60% of total utility replacement cost). The aggregated MW output of non coal-capable utilities and their total oil consumption are estimated to be^{16,17} over 30 percent higher than those of

*These estimates are preliminary and based on limited data obtained in part from telephone surveys of utilities. More definitive estimates will require in situ surveys of utilities to fully document their coal conversion capability and limitations including essential constraints on emissions to satisfy appropriate environmental regulations (e.g., SIP's NAAQS, and PSD).

the coal-capable utilities discussed earlier. Taken together therefore, their conversion should yield the national goal of reducing imported oil by 0.75 MBD. The expense and complexity of converting non coal-capable utilities are likely to be much greater, however, and therefore their conversions are more likely to make up the latter half of the projected thrust over the next decade to achieve the national goal. Indeed the expense, complexity and potential time consumption of these conversions is of sufficient portent to alert us to consider other options than direct conventional coal combustion, including the application of new technologies like COM, AFBC and IGCC in converting non coal-capable utilities.

It is evident from the foregoing observations that the first step in the application of comparative systems and mission mode analysis is the examination of the existing oil-fueled end use subsystems to determine the constraints under which coal-fueled alternatives must operate. These constraints are determined by physical, financial and institutional considerations, as well as reliability and quality assurance considerations of the use of coal with alternate conversion technologies. The overall analysis initiates phased development of the utility conversion program as shown schematically in figure 6. More details of the analysis including specific recommendations are summarized in Appendix 2. R4QA

It is required first to describe and classify all existing oil-fueled utilities as end use subsystems in terms of their pertinent characteristics as follows:

1. Physical (e.g., coal-capable or non coal-capable boilers; coal handling capability including transportation ingress, on-site storage and pre-prep. facilities; pollution abatement* and waste handling capabilities including on-site

*Included here are scrubbers, precipitators, and bag houses with their attendant space requirements.

storage, transportation egress and off site disposal facilities.

2. Institutional (e.g., regulatory/permitting institutions and kinds and times of permits required, including environmental, at local and state as well as federal levels; other decision influencing institutions including state and local energy offices).

3. Financial (e.g., current and projected operating costs in status quo mode; unaided financing limits for capital costs of conversion;* utility management/PUC policies on electricity rate limits after conversion - pass through capital costs re pass through fuel costs).

4. Reliability and Quality Assurance (e.g., required reliability of coal delivery rate (TPD) and delivery duration (decades); required quality of coal (% sulfur et al) and invariance of environmental impact standards (ppm of pollutants et al); required R & QA of coal conversion technologies (MTBF of subsystems et al) and field service/spare parts for subsystems).

With these characteristics established^{5,10} by end use site and in aggregate by region, one of two key inputs is available for carrying out mission mode analysis of converted end use subsystems. (See figure 6 and Appendix 2). The other key input is the identification and characterization of the candidate coal use subsystems for this function. Much has already been done here^{5,7,10} as was noted earlier, and these candidate subsystems certainly include direct conventional combustion, probably COM¹⁸, possibly AFBC and IGCC, and perhaps others like PFBC and MHD¹⁹. If the latter candidates are to become certain candidates, then their program plans for technology development, demonstration and commercialization will have to be expanded and accelerated (See figure 6) as will be discussed later.

*These costs are particularly troublesome for a utility to bear because they occur some years before they can begin to be recovered through a revised rate structure. Thus problems of capital formation (e.g., through bond issues) may have to be alleviated through government sponsored financial incentives (e.g., loan guarantees).

Be this as it may, with the inputs from existing oil use subsystems and candidate coal use subsystems, mission mode analysis of converted subsystems can be undertaken. The purpose of this analysis is to identify those converted subsystems which offer reasonable promise of being developed, demonstrated and commercialized in time to help meet the national goal within environmental, financial and other constraints. Such analysis is a zeroth or first approximation to rigorous analysis of the spectrum of subsystems that could be considered for conversion. To illustrate, to convert utilities with coal-capable boilers from oil to coal burning operation appears achievable in specific instances without the requirement of federal financial incentives within the time limits allowed to help meet the national goal ($\leq$ 1990). This fact is attested to by the conversion of the New England Power Company facility which is expected to be completed in 1981 as discussed earlier. In addition Con Ed has recently announced* its intent to convert 3 oil burning utilities to coal burning operation on the premise of EPA approval of environmental measures to be employed. More generally it may be noted that the New England and Mid-Atlantic regions in which these utilities are located completed their previous conversions from coal to oil in some 10 years (1966-1976: see figure 7) under earlier environmental pressures and economic persuasions.** It should be remembered too that these are the same regions in which the large majority of coal capable utilities continue to reside. It is therefore suggested that there is reasonable promise that most if not all of these utilities can be converted from oil back to coal in some 10 years (1980-1990) under continuing increasing oil-uncertainty pressures and with relatively minimal economic stress (i.e., with minimal if any federal financial

*New York Times edition dated November 2, 1979

**It is interesting to note (see figure 8) that at the end of this period (1976) the official Federal perception (FPC) continued to indicate zero or relatively small growth in the use of coal to provide electric power through 1985 in these regions.

destabilized again with expensive change orders by government(s) (environmental impactwise or otherwise) in the foreseeable future. This means too, for example, that environmental pollution control technologies (scrubbers, et al) must have proven long term acceptability and reliability, and therefore the full establishment of these technologies must be absolutely assured if the national goal for utility conversion is to be met. This may require increased government intervention in the development, demonstration and commercialization of those technologies. In any case, the mission mode of achieving near half of the national goal for oil import reductions through utility conversions using direct conventional combustion in coal-capable plants appears reasonably promising, and it should be vigorously pursued. Pursuant to this and it is noted again^{20,21} that the program plans of OCRM⁵ (see figure 9) and OCSD¹⁰ (see figures 10 and 11) address important issues of site specific fact finding and analysis. It is essential, however, that these plans and the initiatives evolving therefrom be fully coordinated and consolidated (e.g., OCRM contractor initiatives and OCSD in-house staff initiatives with utilities/PUC's et al) to insure maximum contributions to achieving the National Goal for utility conversions.

Turning to the conversion of existing non coal-capable utilities, it is noted first, as pointed out earlier, that these comprise over half of the targets to reach the National Goal. Now it is to be expected that the inputs from the examination of these utilities may well reveal that certain of them are unreasonable to convert at any cost because of unalterable physical site limitations on

*The New England Power Company is financing its Brayton Point conversion with a tax exempt bond issue¹³, and evidently Con Ed is planning to achieve its planned conversions by similar self sufficient means.

incentives).* This promise will prove reasonable, however, only if there is categorical and unequivocal confidence on the part of these utilities that the recovery of cost will be long-term (depreciated) and that they will not be

coal handling (e.g., transportation ingress, storage, pre-prep.), coal utilization (e.g., boiler replacement and pollution abatement) and/or waste handling (e.g., collecting, storage, and transportation egress). In this event the COM mission mode may be applicable rather than any of the alternative modes for total conversion to coal use. This possibility suggests itself because it permits in principle the off-site location of coal handling functions, and alteration of on-site functions (e.g., COM storage and burning in boilers plus waste handling) may be relatively minimal and physically as well as financially acceptable. Two things should be remembered however, in analyzing this option. First it will at best, if exercised, reduce a utility's oil consumption by only about 1/2 its existing rate.¹⁹ Second, it is not projected¹⁹ to achieve commercialization before the mid-1980's, and in this event it is uncertain that it could achieve significant market penetration before the end of the 80's. In order to reduce this uncertainty the COM development, demonstration and commercialization schedules^{5,19} will need examination for further opportunities to accelerate them and they should be exploited where possible. Again, however, application of the COM option will make only limited contributions to meeting the overall utility conversion goal by 1990, and it should, therefore, be adopted with caution. Indeed it should be further remembered that its adoption pre 1990 could preclude the application of proven new alternative technologies for full coal conversion of the same utility in the post 1990 period.*

In the case of non-coal capable utilities which are physically suitable for conversion, the issues are cost, complexity and time required for conversion as was noted earlier. These issues are interdependent, but it is instructive to consider time requirements alone at the outset. Even in the absence of the time required for development, demonstration and commercialization of new conversion

*Furthermore the probability cannot be automatically discounted that coal derived synfuels could be substituted for oil derived fuels to fire utility boilers. This possibility surfaces the interfacial features of the utility conversion, coal gas and coal liquid goals to reduce imported oil, and these features need careful examination.

technologies, these time requirements are substantial and growing. Remembering that conversion of a non coal-capable utility may have many of the requirements of building a new utility, it is useful to summarize recent experience in the latter case.

In 1970, a typical coal-fired power plant needed just two permits and 4-6 years to plan, construct, and begin operation. Since that time the permit process has evolved into a complex, cumbersome and expensive exercise primarily as a result of environmental protection legislation.²² A coal-fired power plant built today would require about 40 permits and would take between 7 and 10 years from start to finish. In the next decade the permitting process may well become even more complex as new legislation is implemented including the Resource Conservation and Recovery Act, the Safe Drinking Water Act, and the Toxic Substances Control Act. Now the proposed EMB should reduce the time expended in meeting these requirements, and they should be somewhat fewer in the case of the subject conversion than in the case of a whole new utility. Nevertheless it is not unreasonable to expect that the order of 5 years would still be required from start to completion of the major conversion and operation of an originally non coal-capable utility. This would be with the established technology for direct conventional combustion in the boiler. With the additional front end time required (the order of a year or more)^{5,10} for the existing oil use subsystem examination discussed earlier, it is easy to see why major conversions of non coal-capable utilities are not likely to occur in quantity until the latter half of the next decade.

In general it is projected that alternative new technologies like AFBC and IGCC will not even be demonstrated^{5,16} before the mid-1980's, and therefore it is not expected that significant market penetration would occur before the early 1990's (see figure 12)²³. These technologies offer the attractive potential however of reduced environmental impact and waste handling problems²³ by comparison to conventional coal combustion technologies and they should therefore be pursued

aggressively. Indeed they should be examined with great care to determine the possibility of substantially accelerating their development, demonstration and commercialization schedules. If this possibility exists, it should be exploited pursuant to helping achieve the national goal for utility conversions by 1990 and the increased usage of coal in the years beyond. At this time, however, the reasonably promising coal use sybsystems for achieving this goal appear to be direct conventional combustion of coal, and COM in those non coal-capable utility cases where the former is not applicable.

Because of the relatively high expense and complexity noted earlier in converting non coal-capable utilities, it is particularly important to develop aggressive and effective federal programs for procedural (e.g., permitting) assistance and financial (e.g., loan guarantee) incentives. Good progress^{5,10} is already being made in these directions and it should accelerate with strengthened coordination of the overall effort.

It is appropriate to turn now to consideration of coal delivery subsystems (see figure 6 and Appendix 2). Essential inputs to mission mode analysis of these subsystems are provided by the inventory and assessment of existing coal delivery subsystems, the identification and evaluation of potential new coal delivery subsystems, and the coal requirements that evolve from the mission mode analysis of converted end use subsystems - i.e., utilities. These requirements are in the form of kinds and quantities of coal to be delivered to specific locations in particular regions at prescribed rates in a reliable and consistent long-term manner. The question is what are the reasonably promising mission modes and associated subsystems for meeting these requirements? Clearly the potential modes include land transport or water transport, or both.

Land transport is currently dominant in the overall movement of coal, and rail is the majority of this mode, with truck and tramway conveyor making up the

remainder (figure 13)³. Water transport is by river, the Great Lakes and tide-water (figure 13), and the reduction in tonnage rate in the latter modes in the post 1966 time period ($\approx$ 35 MTY by 1976) correlates with the conversion of utilities/industries in the Northeast from coal to oil burning in this time period. The no-growth portion of rail transport during this time period also correlates with the conversion, and this is a reminder that the large coal transport to the Northeast (pre 1966) was by both land and water. Now it might be expected that with a thrust towards reconversion to coal use in the Northeast in the 1980's, pursuant to achieving National Goals for utility (re) conversion, there would be a corresponding resurgence of coal transport to this region in the proportions by rail and by water experienced earlier. This may not necessarily prove to be the case for the following reasons. First "clean" coal requirements are more stringent now than in earlier times for environmental reasons (e.g., lower allowable sulfur content) and second, large reserves of such coal are required to insure long-term reliable delivery of the coal to the end users. Thus there may well be increased emphasis on drawing this coal from the large, low sulfur content reserves located near the surface in the Northern Great Plains states (figures 14 and 15)³. In addition this coal is substantially cheaper to mine than its underground counterpart in the eastern U. S. due to the higher levels of surface mining productivity* relative to underground mining productivity (see figure 16)³. Alternatively, Western coal is somewhat lower in rank**

* This is due largely to the development and application of large excavating equipment thereby achieving greater economies of scale.^{3,24}

**Another factor of importance in converting coal-capable utility units using existing boilers is the rank of the coal to be used. These boilers in the east were largely designed to use eastern bituminous coal rather than the lower rank subbituminous western coal. This latter coal has lower heating value (up to 30%) and may not be well suited to existing eastern utility boilers.

and substantially more expensive to ship to the East than its underground counterpart already located nearby. Thus, the trade-offs must be made between the overall costs and complexities of delivering and utilizing Western and Eastern coals to achieve the national goals for utility conversions.* These costs must include the cost of meeting all health safety** and environmental standards/regulations (see figure 17) by the alternative delivery modes, including the costs of upgrading associated transport systems (see, e.g., figure 18).

Now much information is clearly available on the various components of these delivery systems; however, there does not appear to be a focussed effort (ongoing or planned) to aggregate and analyze this information as it relates specifically to existing coal delivery subsystems (figure 6 and Appendix 2) for meeting the National Goal for utility conversions.*** It is important, therefore, that such an effort be initiated and coordinated²⁸ with the corresponding efforts^{5,10} on coal use subsystems. In this manner two of the three required inputs to effective mission mode analysis of delivery subsystems will be available. The third input is provided by an examination of potential new coal delivery subsystems. This examination must also be initiated and it should include, but not be excluded to slurry pipelines using water as well as other "carrier" mediums like CO₂²⁹, and of course oil from COM in the local transport mode.¹⁶ Now with these three inputs, the mission mode analysis of delivery subsystems can be carried out. As

*A highly informative account of the many and diverse dimensions of such a trade-off analysis is provided in reference 25 for the conversion and enlargement of the Crystal River Plant of the Florida Power Corporation. The "bottom line" of their analysis was to go with a mix of Western and Midwestern/Eastern coals to best meet their needs.

**The drop in coal mining productivity starting near the turn of this decade (see figure 16) is attributed in significant part to the strengthening of these health and safety standards^{3,24} (OSHA et al).

***An important step in this direction was made in FEA in 1975 in two projects^{26,27} under the direction of I-Ling Chow. The results of this work provide building blocks for required follow-on studies.

in the case of end use subsystems, this analysis must cover all basic characteristics of the delivery subsystems including their physical, institutional, financial, and reliability and quality assurance characteristics. In addition, it is important to integrate and analyze reasonably promising delivery and end use subsystems to insure their essential compatibility (figure 6 and Appendix 2). This analysis should be selectively site specific as well as regional in nature. The New York/New England region appears to deserve early attention in this connection because of its important role in meeting the National Goal for utility conversions.

Now be this as it may, it is important to note that there is a broad spectrum of expertise and in-depth knowledge in DOE/RA regarding the basic characteristics of the delivery and end use subsystems. It is suggested therefore that an approximate mission mode analysis of these subsystems and corresponding overall systems could be carried out with a task force* made up of these key talents in DOE/RA. This would facilitate and expedite the identification of reasonably promising subsystems and systems, and it would thereby enable focussed contract studies to validate and/or elaborate on these in-house perceptions at an early date. This would in turn facilitate early decision making on follow-on actions required to complete the data acquisition and initiate contracts for in-depth analysis of the most attractive subsystems and systems (Fig. 6). Following therefrom are the decisions on subsystems and system options to be implemented, and the development of the management and resource plans to achieve this end.

As noted in Figure 6 this overall effort should be completed in the order of 2 years and the implementation proceeds through the remainder of the decade to 1990. This implementation will involve the conversion of well over 100 oil

*This corresponds to the approach used in NASA in the formative period of the Manned Space Flight Program. It has also, of course, been used successfully in other Program Development Activities.

burning utility plants* to coal burning plants and an increase in coal delivery of some 70 million tons per year(MTY)**. While this increase is only about 10% of the current total delivery rate of coal per year in the U. S., its impact can be sizeable in the regions where conversions will take place. For example, the increase in coal delivery to New England will be from less than 1MTY currently to over 10 MTY by 1990.

All of this serves to emphasize the fact that time is short to meet the national goal for utility conversions, even taking into account voluntary conversions like those noted earlier which are in the process of occurring. In the light of these considerations it is important to identify pacing items in the conversion process as it is projected to occur over the next decade. The mission mode and systems analysis activities discussed previously are intended to clearly highlight these items, be they technology or otherwise in nature, and the resulting management plan must be geared to deal with them in a specific and timely fashion. Even at this early stage, however, we can identify a pacing item that will persist throughout the entire endeavor. This item is maintaining the essential relations between government and industry at all levels involved in the conversion process. In essence the problem is for government and industry to "keep their act together" so that conflicts are recognized at an early stage and dealt with before they need to be taken to the EMB, or before they become confrontations or "Court Cases." If the latter happens in other than rare instances, the loss of time alone in resolving and regrouping can defeat the fundamental purpose of the undertaking - i.e., meeting the goal on time. In order to minimize this possibility in the implementation phase (see Figure 6), it is suggested that consideration be given to establishing "Utility Conversion Coordinating Boards" under the leadership of DOE/RA and with

*This corresponds to converting well over 300 oil burning units to coal burning units.

**1 Ton of Coal $\approx$ 4 Barrels of oil (Heating Value)
0.19TPD $\approx$ 0.75MBD

membership drawn from authoritative line management in the other key government agencies and industries involved in the Utility Conversion Program. These boards could be established at federal and regional levels, and at local levels as required. It would be their responsibility to meet regularly (e.g., once a month) and as required to deal with emerging inter-institutional problems - first identifying them, then agreeing on specific courses of action to deal with them, and finally each authoritative member of the board discharging his responsibility for the part of the action that must be taken in his own institution. This type of management mechanism worked well in maintaining effective management control of interdependent Aerospace programs under DOD and NASA*, and it could have comparable application in the implementation phase of the Utility Conversion Program. In addition it is noted that timely and informed implementation actions by the Utility Conversion Coordinating Boards would certainly be facilitated and most likely be insured with the continuing support of a highly qualified and dedicated Systems Integration and Evaluation (SIE) contractor. (See figure 6).

It is also noted in figure 6 that the overall Coal Use Systems responsibility centers on Systems Integration and Analysis in the planning phases (pre-implementation) of the Utility Conversion Program. This responsibility clearly resides with DOE at the federal level, and the focus is in DOE/RA. In the case of subsystems, the lead responsibility at the federal level resides with DOE for end use/utility conversion, while in the case of Delivery Subsystems this responsibility resides with DOI and DOT, among others. Ultimately, of course, these responsibilities reside with the affected Utilities, Railroads and Mines, et al. Thus the overall lead role of DOE is somewhat like being "first among equals" and this fact places the highest priority on developing and

*It was designated the Aeronautics and Astronautics Coordinating Board + Committees) and it was jointly chaired by the Deputy Administrator of NASA and the Director of DDR & E (Under Secretary of DOD).

maintaining strong consensus views among the responsible participants early in the course of action to achieve the national goal. Experience shows* that this consensus can be importantly aided with the selective establishment of planning oversight committees having authoritative representation from those participants through the planning phases of the utility conversion program. These phases include the mission mode, subsystems and systems analysis activities preceeding implementation as shown in figure 6. It is recommended that consideration be given to the early establishment of planning oversight committees for these activities. It is noted further that the committees would pave the way for and become natural forerunners of the Utility Conversion Coordinating Boards in the implementation phase of the Utility Conversion Program.

In closing it is noted that the Utility Conversion Program is clearly of great importance to the future well being of the United States. Taken together with other initiatives to reduce U. S. dependence on imported oil, it may indeed be the key to the future of the United States. For this reason alone DOE/RA should not hesitate to solicit the best wisdom the country has to offer in meeting its challenges. It is certain that there are many people in the image of James E. Webb³⁰ who would gladly respond to such a solicitation.

*A notable example of the effectiveness of this interinstitutional program planning technique is the Texas Energy Policy Study which was guided in 1973-74 by a State Energy Council headed by Lt. Governor William P. Hobby. The study was jointly funded by the Federal Government through NSF and by the State of Texas. The Council Membership included the heads of all involved state agencies and legislative committees plus authoritative representatives of involved utilities, other industries, public interest groups and universities. The study made a number of energy policy recommendations to maintain energy supply and promote conservation. The majority of these recommendations were enacted into state laws in 1975.

APPENDIX 1

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APPENDIX 2

Comparative Mission Mode Analysis

As noted in the main body of the report, the first step in this mission mode analysis is the identification of the constraints on coal conversion that are imposed by the existing oil use subsystems or utilities. These constraints are determined by survey and analysis of the existing utilities in terms of their physical, institutional, financial, and reliability and quality assurance characteristics. These constraints must in turn be satisfied by any candidate coal use subsystem if it is to be classified as being reasonably promising to help meet the utility conversion goal. This determination requires a comparative analysis of coal conversion constraints and coal use subsystem characteristics. This comparative analysis is depicted schematically in Diagram A, and it is clear at the outset that the multiplicity of conversion constraints and subsystem characteristics must be categorized in identical formats to facilitate the analysis.* More specifically it is noted that the necessary condition for reasonably promising coal use subsystems is that their physical, environmental and financial characteristics not exceed the conversion constraints, whereas their R&QA characteristics (e.g., MTBF) must at least equal the performance constraints.

Substantial data are already available in DOE on existing oil use utilities, and a contract has been initiated to augment and analyze these data to identify conversion constraints and incentives to convert utilities in Regions 1 through 4. This activity should be expanded at an early date to cover the other regions of the country. Substantial data are also available in DOE on candidate coal use subsystem characteristics. It is recommended³¹ that on-going efforts be strengthened wherever required to analyze these data in the

*Since time to convert is an overall constraint, the institutional constraint appears in this comparison as an environmental constraint on the amount of gas, liquid and solid pollution that is permitted under environmental protection regulations.

Necessary Conditions for Reasonably Promising
Coal Use Subsystems
Physical, Environmental & Financial
Characteristics $\leq$ Constraints
R&QA
Characteristics $\geq$ Constraints

same format as those for the conversion constraints to facilitate their early comparison and the identification of reasonably promising coal use subsystems. The aggregate of these subsystems is the first approximation to the constrained set of subsystem options.

The other output of this comparative analysis is the identification of delivery subsystem constraints in terms of the rate, duration, quality and cost of the required coal delivered to the users (See Diagram A). These constraints must be compared with the characteristics of existing and potential new coal delivery subsystems as shown on Diagram B. Again, as in the case of end use subsystems, the formatting of delivery subsystem constraints and characteristics must be the same to facilitate comparative analysis. The output of this analysis is the constrained set of delivery subsystem options including the sources and mining of the coal, the pretreatment of the coal, and the transportation of the coal to the end user. Strictly speaking this analysis cannot be undertaken until the delivery subsystem constraints are available from the end use subsystem analysis. Effort can and should be initiated, however, on surveying and analyzing the characteristics of existing and potential new delivery subsystems that may be applicable to meeting the end use coal requirements of the utility conversion program. These requirements may become more severe on delivery subsystems from a regional point of view (e.g., New England) than from a site specific point of view, and early visibility on this potential problem area will be important to obtain. Effort to obtain this visibility should be initiated within DOE/RA31 and supplemented as required with contract support. In this manner the comparative analysis (in house and under contract) of coal delivery subsystem characteristics and the site specific constraints imposed by the end users should be expedited when the latter information comes available. The resulting constrained set of delivery subsystem options

Diagram B

Coal Delivery Subsystems

is then compared with the earlier derived set of end use subsystem options to validate their overall system compatibility and thereby provide the basis for follow-on in-depth system studies as shown on figure 6.

The ultimate test of system compatibility lies, of course, in completing the required conversions of utilities from oil burning to coal burning by 1990. Thus while it is a necessary condition that candidate coal use subsystems must satisfy coal conversion constraints, this is not a sufficient condition. The sufficient condition is that the candidate subsystems (end use and delivery) must satisfy the coal conversion constraints in operation by 1990. It is for this reason that AFBC and IGCC do not appear to be reasonably promising coal use subsystems at this time. Correspondingly, long (interstate) slurry pipelines are marginal candidate transportation subsystems (see figure 6). This leaves direct conventional combustion and COM as the reasonably promising coal use subsystems, and rail or barge (or short haul truck) as the reasonably promising transportation subsystems at this time. With the possible exception of COM and waste handling/environmental impact mitigation, none of these subsystems is likely to stress the state of the art technologywise. Taken in the aggregate of all the utility units which must be converted, however, achieving timely actions on these subsystems may well stress the state of the art in terms of establishing and maintaining government-industry partnerships to organize, manage and finance the many activities involved.

A case in point is Region 1 in New England where there are over sixty utility units which are candidates for conversion. Some 60% of these units are coal capable and the remainder are non-coal capable.¹⁷ It might therefore be expected that a utility conversion program plan for this region would target for over half of the conversions to be completed in the first half of this decade with the remainder being completed in the latter half

Appendix 2

of the decade. In all probability, however, the centroid of action of this plan will be shifted to the mid-80's due to the time required in the early 80's to analyze and organize the effort (see figure 6). Thus during the period of peak action in New England it may be required to convert the order of 10 utility units per year and simultaneously inaugurate operations of the supporting coal delivery subsystems. In the east overall the required conversion rate may be more like 50 utility units per year during the peak action period plus attendant delivery subsystem activation. Inevitably then there will be a high level of interdependent concurrent activity and this in turn will be synchronized and effective only with the finest kind of continuing government-industry teamwork in guiding the efforts as discussed in the main body of the report.

FIGURE 3
BITUMINOUS COAL PRODUCTION

* Excludes refuse
Source: Minerals Yearbook

FIGURE 2
BITUMINOUS COAL BENEFICIATION TRENDS

Source: Minerals Yearbook

* Includes mine mouth generating plants, coal used by mine employees, taken by locomotive, tenders at tippie, used at mine for power and heat, transported from mine to point of use by conveyor or tram, made into beehive coke at mine, shipped by slurry pipeline, or otherwise used at mine.

FIGURE 3
BITUMINOUS COAL MOVEMENT FROM THE MINE

Source: Minerals Yearbook

FIGURE 4
NATIONAL BITUMINOUS COAL CONSUMPTION TRENDS

Standard Federal Regions

FIGURE 5

Source: Minerals Yearbook

* See Coal Consumption Regions in Glossary

FIGURE 7
REGIONAL BITUMINOUS COAL CONSUMPTION TRENDS*

1976 CONSUMPTION OF COAL IN STEAM-ELECTRIC
GENERATING UNITS AND PROJECTED 1985 DEMAND
FOR NEW UNITS BY FEDERAL POWER COMMISSION
REGIONS

FIGURE 8

FIGURE 9

MANAGEMENT PLAN

FY80 OBJECTIVES AND ACTIVITIES

OBJECTIVES/ACTIVITIES	OCT 79	NOV	DEC	JAN 80	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1. Meet with EEI, REA, and CIBO	△											
2. Meet with: 10 utilities 5 MFBI's 5 state energy offices 5 PUC's 2 regional innovation groups		△	-----	-----	-----	△						
3. Meet with 5 financial analysts							△	-----	△			
4. PROGRAM PLAN (detailed)								△	-----	△		
5. Draft PR's										△	-----	△

No FY80 procurement actions or contract decisions.

CCAL CONVERSION INCENTIVES PROGRAM

MANAGEMENT PLAN

FY81-85 OBJECTIVES

OBJECTIVES	FY81				FY82				FY83				FY84				FY85				
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	
1. Program Feasibility Report	△																				
2. Notice of Intent		▲																			
3. Draft legislation/regulations		△	▲																		
4. Environmental assessment		△	---	▲																	
5. Regulatory analysis		△	---	▲																	
6. Special program studies			△	---	▲																
7. Procedures/documents study				△	---	▲															
8. <u>Projects</u> :preliminary studies				△	---			▲													
9. Authorizing legislation								▲													
10. Publication of draft regulations								▲													
11. <u>Projects</u> :applications/decisions									△	---	---	---	---	---	---	---					
12. GOAL: substitution of coal for oil at a rate of 400,000 barrels daily																				▲	

Reconversion of coal-capable utility

Figure Penetration Model for Advanced Coal-Fired Electrical Generation

FIGURE 12

Source: Minerals Yearbook

* Excludes Canadian Great Lakes commercial docks, U.S. Great Lakes and tidewater dock storage, coal used at mines and sales to employees, net change in inventory and overseas exports.

FIGURE 13
SHIPMENTS OF BITUMINOUS COAL TO ALL DESTINATIONS
IN THE UNITED STATES, CANADA, AND MEXICO,
BY METHOD OF MOVEMENT*

Source: Coal Facts

* See Coal Production Regions in Glossary

** Did not include Idaho

FIGURE 14
RESERVE BASE BY SULFUR CONTENT

GLOSSARY

Coal Consumption Regions

New England (N.E.): Mass., Conn., Maine, N.H., Vt., R.I.
Middle Atlantic (M.A.): N.Y., N.J., Pa.
East North Central (E.N.C.): Ohio, Ind., Ill., Mich., Wisc.
West North Central (W.N.C.): Minn., Iowa, Mo., N.D., S.D.,
South Atlantic (S.A.): Del., Md., D.C., Va., W.V., N.C., S.C.,
Ga., Fla.
East South Central (E.S.C.): Ky., Tenn., Ala., Miss.
West South Central (W.S.C.): Ark., La., Okla., Tex.
Mountain (Mtn.): Colo., Utah, Mont., Idaho, Wyo., N.M.,
Ariz., Nev.
Pacific (Pac.): Wash., Ore., Cal.

Coal Production Regions

Northern Appalachia (I): Penn., Ohio, W.Va., Md.
Southern Appalachia (II): E.Ky., Va., Tenn., Ga., Ala.
Eastern Interior (III): Ill., Ind., W.Ky.
Western Interior (IV): Iowa, Mo., Kans., Okla., Ark.
Gulf (V): Tex.
Northern Great Plains (VI): N.D., S.D., Mont., Wyo., Idaho
Rockies (VII): Utah, Colo.
Southwest (VIII): Ariz., N.M.
Pacific Northwest (IX): Wash., Alaska

MINE LABOR CATEGORIES (S - surface mines, U - underground mines)

Skilled:

Auger-machine operators (S)
Blacksmiths (U)
Bonders-wiremen (U)
Bulldozer operators (S)
Carpenters, maintenance (U)
Continuous-mining-machine operators (U)
Cutting-machine operators (U)
Drillers, machine (U,S)
Electricians, maintenance (U,S)
Engineers, stationary (U)
Hoistmen (U)
Loading-machine operators (U)
Longwall-miner-operators (U)

FIGURE 15

FIGURE 16
LABOR PRODUCTIVITY TRENDS

TABLE 12
ENVIRONMENTAL STANDARDS/REGULATIONS
(as of March 1, 1979)

Activity	Mining (Includes Exploration & Reclamation)	Beneficiation	Transportation
Air	<p><u>OSM</u> (Surface Mining Control & Reclamation Act of 1977)*</p> <p>1. Air emissions protection (fugitive dust)</p>	<p><u>EPA</u> (Clean Air Act Amendments of 1970)</p> <p>1. Thermal Dryers</p> <p>a. 0.070 g/dscm (0.031 gr/boof) for particulates</p> <p>b. 90% opacity for particulates</p> <p>2. Pneumatic Cleaners</p> <p>a. 0.040 g/dscm (0.016 gr/boof) for particulates</p> <p>b. 90% opacity for particulates</p> <p>c. Monitor temp., scrubber pressure loss, water pressure</p> <p>3. Associated Areas (storage, transfer, handling, etc.)</p> <p>a. 90% opacity for particulates</p>	<p><u>DOT</u> (Hazardous Materials Transportation Act)</p> <p>1. Ground Coal-stored for 5 days or shipped in tightly closed containers</p> <p>2. Ground & sized Coal-packed in horizontally sealed or air-tight containers</p>
Water	<p><u>EPA</u> (Federal Water Pollution Control Act Amendments of 1972)</p> <p>1. Acid Drainage</p> <p>a. Total iron: 7.0 mg/l (1-day max.); 3.5 mg/l (30-day avg.)</p> <p>b. Total manganese: 4.0 mg/l (1-day max.); 2.0 mg/l (30-day avg.)</p> <p>c. Total suspended solids: 30 mg/l (1-day max.); 15 mg/l (30-day avg.)</p> <p>d. pH: within the range 6.0 - 9.0</p> <p>2. Alkaline Drainage: same as for acid drainage except for manganese (no limit set)</p> <p><u>OSM</u> (see above), <u>BLM</u> & <u>USFS</u> (Mineral Leasing Act of Feb. 25, 1920; Mineral Leasing Act for Acquired Lands)</p> <p>1. Control of effluents</p> <p>2. Diversion of flow to prevent degradation (non only)</p> <p>3. Control of sediment</p> <p>4. Control of acid & toxic drainage</p> <p>5. Observation of standards for impoundments</p> <p>6. Monitoring of surface & ground waters</p> <p>7. Transfer of wells to alternate uses (OSM only)</p> <p>8. Maintenance of water rights</p> <p>9. Prevention of discharge to other mines</p> <p>10. Rehabilitation of impoundments, etc.</p> <p>11. Protection of existing streams</p>	<p><u>EPA</u>, <u>OSM</u>, <u>BLM</u> & <u>USFS</u> (same as for mining)</p>	
Land (Solid waste)	<p><u>OSM</u>, <u>BLM</u> & <u>USFS</u> (see above)</p> <p>1. Proper construction & protection of waste banks</p> <p>2. Prevention of slides, erosion & subsidence</p> <p>3. Proper disposal of wastes</p> <p>4. Prevention of air & water pollution</p> <p>5. Approved utilization of wastes</p>	<p><u>OSM</u>, <u>BLM</u> & <u>USFS</u> (same as for mining)</p>	
Reclamation	<p><u>OSM</u>, <u>BLM</u> & <u>USFS</u> (see above)</p> <p>1. Assurance of surface stability over deep mines</p> <p>2. Approximate restoration of original contour by backfilling (compacting if necessary) & grading</p> <p>3. Topsoil replacement</p> <p>4. Revegetation</p> <p>5. Restoration of productivity of surface & underground mines</p> <p>6. Protection of fish, wildlife & related environmental values</p> <p>7. Cover for underground openings</p> <p>8. Assurance of maximum possible coal recovery</p> <p>9. Procedures for cessation of operations</p> <p>10. Reclamation for post-mining land use</p>	<p><u>OSM</u>, <u>BLM</u> & <u>USFS</u> (same as for mining)</p>	<p><u>OSM</u>, <u>BLM</u> & <u>USFS</u> (see above) - construction, maintenance & removal of roads & other transportation facilities</p>

* Titles in parentheses show enabling legislation
OSM - Office of Surface Mining (DOI) - formal regulations yet to be approved
EPA - Environmental Protection Agency
DOT - Interstate Transportation Bureau (DOT)
BLM - Bureau of Land Management (DOI)
USFS - U.S. Geological Survey (DOI)

Figure 17

How Conrail's routes (thin black lines) cover the Midwest and Northeast

Why Conrail might derail

By Brian Sullam
The Baltimore Sun

CONRAIL IS approaching a financial crossroads. It is possible the corporation that arose out of the remnants of the bankrupt Penn Central and six other railroads could face the fate of its predecessors — bankruptcy.

In response to recommendations that the federal government pump more money into Conrail in order to keep it operating, the Carter administration has indicated it may such a step.

Although the administration would like to hold down expenditures next year in order to lower the federal budget deficit, it appears that even if it declines to cover the railroad's operating deficits, it still will have to spend more money on Conrail just to keep the railroad operating.

During its 3½ years of existence, Conrail, the govern-

ment-subsidized private railroad that took over the operations of seven Northeast and Midwest railroads, has lost money every quarter except the second quarter of this year, when it reported a profit of \$29.4 million.

Reverting to its old pattern, Conrail reported recently that it lost \$40 million during the third quarter, which, it said, was \$8.5 million less than the loss during the same period last year. So far this year, the railroad has lost \$138.3 million — on top of the \$957 million of accumulated losses of previous years.

Some analysts noted that the quarterly profit reported in August is illusory, because Conrail would have shown a loss if it had followed the standard accounting methods of the Interstate Commerce Commission, which the nation's other railroads must use.

But switching accounting methods is not going to solve Conrail's fundamental problem. The railroad is running out of both money and time. Conrail has nearly exhausted its

into a recession.

The Conrail management has recognized its vulnerable financial condition and has developed an updated five-year business plan that is intended to insure that Conrail continues operating.

However, to the United States Railway Association, the federal agency responsible for investing the government's funds and monitoring Conrail's performance, the business plan is fraught with risk.

The Conrail plan is based on two key assumptions: First, Conrail will need no additional funding beyond what has already been authorized, and second, the federal government will reform railroad tariff and service regulations.

"At first glance, Conrail's strategy may appear attractive," said Donald Cole, president of the USRA. "But, a closer inspection of the underlying assumptions reveals certain risks inherent in this approach."

Should the federal government approve deregulation for railroads, Conrail's business plan says the railroad's net income through 1994 will total \$1.3 billion, which means the corporation will become economically self-sustaining and will require no additional federal funds.

The other key element of the plan is the reduction in the capital expenditure and plant rehabilitation programs in 1980 and 1981, in order to stretch out the remaining federal dollars. Those cuts will come during years "in which the full realization of the benefits of regulatory reform are not anticipated by Conrail," the USRA staff pointed out.

According to Conrail's plans, the deferred maintenance and capital programs for years beyond 1981 would be financed from improved cash flows resulting from regulatory change, enhanced operating efficiencies and other improvements.

Since it began operations April 1, 1978, Conrail has used \$2.4 billion of the \$3.3 billion the federal government authorized to upgrade the deteriorated physical plant and equipment of the seven Northeast and Midwest bankrupt railroads and to cover the railroad's operating losses during its early years.

Conrail is proposing to defer maintenance and repair programs and to postpone rehabilitation and capital improvement programs that have already been scheduled, in order to stay within the funding limit of \$3.3 billion. Officials at the USRA believe this is a potentially dangerous strategy.

"The rehabilitation programs won't suffer if Conrail cuts back its capital program for one year, but if there are cuts that continue for two years, it looks like the type of situation we had with the Penn Central," said Cole.

A USRA study said that "inadequate investment in maintenance and capital programs would accelerate the erosion of Conrail's traffic base."

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