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TECHNOLOGY ASSESSMENT OF ALTERNATIVE
TRANSPORTATION FUELS

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MASTER

A. Research Program

SRI International is performing a study entitled "Technology Assessment of Alternative Transportation Fuels." This study consists of three phases: Phase 1 was an extension and refinement of previous SRI work on the impacts of developing synthetic liquid fuels from coal and oil shale for transportation use; Phase 2 is a technology impact assessment of electrification of road and rail transportation; and Phase 3 is concerned with articulating and analyzing public policy options for all the future transportation propulsion alternatives based on the solid fossil fuel resources (coal and oil shale). Figure 1 shows the linkages between the tasks in these phases.

Phase 1 (which consisted of Tasks I-A to I-E, II, and III shown in Figure 1) has been completed. Considerable time has been given to two workshops for Task V. We are now under way on the electrification studies of Task IV.

As indicated in the last progress report, Barry Walton, at the request of Dan Maxfield and Ken Wilson of ERDA/TEC presented an hour long overview of our Phase 1 work at the Union College (Schenectady, N.Y.) course on the Effects of Energy Constraints on Transportation. We covered the expense of this dissemination activity out of our "workshops" budget although it does represent an expansion of our scope.

B. Accomplishments

1. Electric Vehicles

a. Japanese Consultant

We have concluded that foreign--especially German and Japanese--interest and technical achievement in electric vehicles is so far advanced compared to U.S. efforts that we need added perspective on the Japanese outlook towards electric vehicles. Accordingly, we have asked SRI's Japanese office to locate a possible Japanese consultant who would be able to prepare (within a two-day consulting arrangement) written material for us concerning:

- Japanese government perspective on the advantage and disadvantage
 - transportation system
 - environment quality
 - energy supply
- Japanese auto industry perspective
 - domestic sales
 - foreign sales
- Public perspectives
 - personal use
 - national need
 - receptivity

If we can locate a qualified consultant, we will approach the ERDA project officer with a specific request to approve a consulting agreement. We have forwarded copies of the systems charts showing Japanese government/industry linkages in the electric vehicle area (gratefully received from Ken Wilson) to our office in Japan.

b. In earlier discussions, we indicated that there are two important policy issues involving existing regulations that may affect U.S. manufacturers' interest and the market for electric vehicles:

- How will internal combustion engine air pollution emissions regulations apply to hybrids? Will the emissions be averaged over both the electric and engine portions of the duty cycle or only on the engine portion? If the former interpretation applies, Clean Air Act regulations may encourage the making and marketing of hybrids by The Big Three.
- How will mandated fuel economy standards apply to battery/electric and hybrid vehicles in the fleets sold by U.S. manufacturers? If they can be averaged in on the basis of the amount of liquid fuel they use, then this would provide a significant encouragement for battery/electrics and hybrids.

In a telephone conversation with a staff member at EPA's Ann Arbor facility concerned with automotive emissions, Barry Walton determined the EPA has not yet considered the hybrid issue and would not give the issue formal consideration unless requested by ERDA.

Accordingly, we ask that Dan Maxfield initiate a formal request from ERDA to EPA for some preliminary interpretation of how EPA would enforce existing air quality and fuel economy regulations in the case of hybrids and battery electric vehicles. We suggest that Dr. Eric O. Stork, Deputy Assistant Administrator for Mobile Source Air Pollution Control, Environmental Protection Agency, would be an appropriate person to receive ERDA's request.

C. Final Report Outline

We have been working on a very detailed outline for the final report on the impacts of electric vehicles. While the organization is sure to change somewhat as the material is actually written, we feel comfortable with the organization that is given below. We are striving to produce a short, tight, crisply written document that will be useful to decision makers and their assistants. Accordingly, we will avoid bogging readers down in excessive technical detail and will place the unavoidable deeply detailed technical information in Appendices. Bearing in mind the audience and presentation orientation, we desire ERDA to comment on this outline (with estimated chapter lengths in parentheses).

Suggested Title: "Electric Vehicles in America's Future--An Assessment of Prospects and Impacts"

Executive Summary (7 pages)

Chapter 1. Will the United States ever have many electric vehicles? What and who will determine this? (10 pages)

- A. Consumers--their key concerns
 - 1. Convenience

A. Consumers--their key concerns (continued)

2. Cost
 - a. purchase
 - b. operating
3. Performance
4. Safety
5. Reliability
6. Energy availability

B. Manufacturers

1. The categories
 - a. Automakers
 - (1) domestic
 - (a) small
 - (b) large
 - (2) foreign
 - b. Components suppliers
 - c. Aftermarkets
2. Their concerns
 - a. Manufacturing costs
 - b. Market size
 - c. Investment requirement
 - d. Compatibility with existing infrastructures

C. Government regulators

1. Air pollution
2. Fuel economy standards
3. Electric utility pricing
4. Insurance
5. Traffic
6. Taxation
7. Licensing
8. Import duties

It is the purpose of this report to examine all of these issues and to indicate to decision makers what would be the consequences of a transition to electric cars and what will be the governmental policy needs and options to deal with the consequences.

Chapter 2. Electric Vehicles--What are they? What aren't they? (30 pages)

- A. Limits to the discussion
 - 1. Two forms of electric vehicles are of concern
 - a. Battery/electric
 - b. Hybrid engine/electric
 - 2. Several body and use models
 - a. Two-passenger special purpose car
 - b. Full size, full-use car
 - c. Van trucks
- B. Applications where electrics might meet people's needs
 - 1. Low payload requirement
 - 2. Low speed requirement
 - 3. Frequent stops and pauses
 - 4. Short-term rental cars
- C. Potential major uses of electrics
 - 1. Commuting to work
 - 2. Shopping/visiting
 - 3. Delivery
 - 4. Short term rental cars
 - 5. Special places (parks, central cities)
- D. Competition for electrics from
 - 1. Improved efficiency, superior performance ICE cars
 - 2. Established ICE sales/maintenance/repair networks
 - 3. Used ICE cars
 - 4. Known insurance and depreciation histories
- E. Key facts about present and potential battery/electric cars
 - 1. Batteries (characteristics of various kinds and time frame of availability of each)
 - a. Energy
 - (1) amount stored
 - (2) rate of withdrawal
 - b. Materials
 - (1) kinds
 - (2) weights
 - (3) abundances

- E. Key facts (continued)
 - 2. Performance of vehicles using these batteries
 - a. Size/weight/power
 - b. Acceleration
 - c. Maximum speed
 - d. Range
 - e. Hill climbing ability
 - 3. Costs of battery/electrics (now and future time frames compared to ICEs)
 - a. Purchase price
 - b. Operating cost
 - (1) electric power
 - (a) on-peak
 - (b) off-peak
 - (2) battery replacement
 - (3) maintenance
 - (4) repair
 - (5) insurance
 - c. Resale (depreciation rate)
- F. Key facts about potential hybrid vehicles
 - 1. Range of possibilities, description of the one chosen for analysis
 - 2. Comparison of hybrid with battery electric
 - a. Advantages
 - (1) range extension
 - (2) performance improvement
 - (3) outgrowth of existing ICEs
 - b. Disadvantages
 - (1) complexities
 - (2) only partial avoidance of liquid fuels
 - (3) difficulty of standardization within range of possibilities
 - 3. Performance attributes (as for battery/electric)
 - 4. Costs (as for battery/electric)

- F. Key facts about potential hybrid vehicles (continued)
 - 5. Likely effects of safety requirements
 - a. Performance
 - b. Cost
- G. Comparison of present and future ICE, battery/electric, hybrid vehicles
 - 1. Performance under different conditions
 - a. Temperature
 - b. Terrain
 - c. Snow
 - d. Wetness
 - e. Humidity
 - 2. Infrastructure needs
 - a. Fuel sources
 - b. Battery charging
 - (1) at home
 - (a) building codes for electric car electricity outlet
 - (b) electricity service capacity
 - (c) off-street parking
 - (2) away from home
 - c. Battery discard, recycle

Chapter 3. Who are the stakeholders? What is their stake? (50 pages)

A discussion of the individuals and institutions involved in the complex U.S. system of making, financing, using, supporting, regulating, and fueling cars. (For each stakeholder group, besides giving the information in the outline below, we will indicate the size and locations and influence of the group.)

- 1. Public at large
 - a. Accidents
 - b. Air quality
 - c. Noise
 - d. Energy availability
 - e. Consumer protection

Chapter 3. (continued)

2. Private owners
 - a. Mobility and performance
 - b. Cost (as portion of disposable income)
 - c. Safety
 - d. Convenience
3. Small electric car manufacturers
 - a. Market size/share
 - b. Financing
 - c. Safety regulations
 - d. Competition (foreign and big manufacturers)
4. Foreign car makers
 - a. Access to U.S. market
 - b. Market size/share
 - c. Competition
5. Big car makers (GM, Ford, Chrysler)
 - a. Market size/share
 - b. Import competition
 - c. Government regulation
6. American Motors Corp
 - a. Continued existence
 - b. Market size/share
 - c. Financing
7. Maintenance/repair businesses/sales/aftermarket
 - a. New knowledge, skills requirements
 - b. Parts availability
 - c. Added inventory
8. Workers (blue collar, white collar)
 - a. Job security
 - b. Skills acquisition
 - c. Job safety

Chapter 3. (continued)

9. Oil companies
 - a. Reduced demand for fuel
 - b. Reduced need for costly synfuel, exploration investments
10. Financing institutions
 - a. Viability of small firms entering electric car arena
 - b. Loans to consumers (resale value)
11. Rental car companies
 - a. Suitability of vehicle to their market
 - b. Resale value
 - c. Vehicle reliability
 - d. Vehicle accident experience
12. Insurers
 - a. Actuarial data
 - b. Rates
13. Fleet owners
 - a. Cost
 - b. Reliability/maintainability
 - c. Safety
 - d. Resale
14. Component manufacturers
 - a. Structure of industry
 - b. Battery R&D success
15. Electric utilities
 - a. Energy sales
 - b. Load profiles
 - c. Capacity additions
 - d. Electricity rate structures
16. State governments
 - a. Tax revenue losses from reduced fuel sales
 - b. Vehicle registration fees
 - c. Driver training/licensing requirements
 - d. Traffic regulation
 - e. Electric utility regulation

Chapter 3. (continued)

- 17. Local governments
 - a. Tax revenue losses from reduced fuel sales
 - b. Traffic and parking regulation
 - c. Recharging facilities
- 18. Federal government
 - a. Department of Energy
 - (1) ERDA
 - (a) demonstration act
 - (b) R&D on batteries
 - (2) FEA
 - (a) electric utility rate structures
 - (b) oil company regulation U.S.
 - (3) Federal Power Commission
 - (a) electric utility regulation
 - b. Environmental Protection Agency
 - (1) reduced urban air pollution
 - (2) increased power plant pollution
 - (3) pollution effects associated with mineral and coal extraction and processing
 - (4) regulations of hybrids
 - (a) air pollutant emission
 - (b) fuel economy
 - c. Department of Transportation
 - (1) safety standards
 - (2) highway design standards to accommodate lower performing vehicles
 - d. Treasury Department
 - (1) fuel tax revenue losses
 - (2) import duties
 - (3) U.S. balances of trade and payments
 - e. Department of Commerce
 - (1) standards setting
 - (2) fostering small business activity
 - (3) consumer protection

Chapter 3.18 Federal government (continued)

- f. Department of Labor
 - (1) number and location of U.S. jobs in auto industry
 - (2) imports
 - (3) worker health/welfare
- g. Department of Justice
 - (1) antitrust outlook as industry matures and grows

Chapter 4. When might the U.S. have electric vehicles--How many, how fast? (20 pages)

A scenario for implementation/deployment reflecting stakeholders' values, objectives, responses.

- A. Importance of the supply/demand interplay and time lags
- B. Present outlook and activities of the major stakeholders
- C. Results of market analyses
 - 1. EPRI
 - 2. Wharton
 - 3. EPRI/SRI
- D. Manufacturers process of decision making to enter the market
 - 1. Small "serial" manufacturers
 - 2. Major "mass" producers
 - 3. Foreign
 - 4. Battery producers
- E. The SRI scenario
 - 1. Purpose as an analytical tool to organize analysis and give reasonable depiction of how things interact to determine the future course of events
 - 2. Scenarios
 - a. Battery/electric
 - b. Hybrid, engine/electric

Chapter 5. The consequences of having electric vehicles (according to the scenario) (100 pages)

In this chapter, we will return to the named stakeholder group and describe the effects on them of acting out the scenario. We will relate how stakeholder groups react to one another's actions. (This chapter will be refined as our analysis finishes up.)

Chapter 6. The role of government (15 pages)

A. Existing U.S. values, goals, policies

1. Description of how values give rise to goals which give rise to policies that specify courses of action to realize goals
2. Existing goals and indication of their relationship to electric vehicles
 - a. In harmony with electric vehicles
 - (1) overall energy conservation
 - (2) petroleum conservation
 - (3) urban air quality improvement
 - (4) free foreign trade
 - b. Conflicts with electric vehicles
 - (1) electric power plant emissions reductions
 - (2) vehicle safety
 - (3) electric utility load leveling (unless time-of-day pricing, or forced night time charging is instituted)

B. Federal government policy options

1. Improve electric vehicles through R&D
2. Stimulate more big industry involvement and interest in R&D
3. Undertake a large government/industry cooperative program as in Japan and Germany
4. Cut back electric car programs and emphasize alternatives (e.g., synfuels)

C. What is the proper role of government; what level of government is best involved; which agencies; are new institutions required?

(This is the pay-off of the study and will be expanded as our analysis matures.)

Appendix A--Details of the Electric Utility Model (60 pages)

- A. Objectives and approach
- B. Description of the model
 - 1. Organization and structure
 - 2. Demand sector
 - 3. Production sector
 - 4. New capacity planning sector
 - 5. Generating capacity sector
 - 6. Cost sector
 - 7. Regulatory sector
 - 8. Financing sector
- C. Inputs to the model
 - 1. Demand
 - a. Electric vehicle battery charging demand scenarios
 - b. Other demand
 - c. Elasticity of demand
 - d. Utility load factors
 - 2. Operating characteristics
 - 3. Unit costs
 - 4. Initial electrical generation capacity planned and on-line
 - 5. Regulatory and financial inputs
- D. Results--outputs of the model
 - 1. Base case--no electric vehicles
 - a. Dynamic behavior of major interactions
 - (1) demand, production and price interaction
 - (2) capacity, production and financing interaction
 - 2. Electric car requirements added case
 - a. Generation capacity effects
 - b. Utility financial effects
 - 3. Off-peak electric vehicle charging case
 - a. Load management effects
 - b. Financial effects

D. Results--outputs of the model (continued)

4. Peak-load pricing case
 - a. Demand distribution
 - b. Load management
 - c. Capacity requirements
 - d. Financial effects

E. Sensitivity to assumptions

1. Peak period length and load factor
2. Inflation rate
3. Demand growth rate
4. Fuel costs
5. Regulatory delay
6. Cost of capital

Appendix B--Description of the SRI modifications to the EPRI Crow-
Ratchford Electric Vehicle Demand Model (5 pages)

2. Railroad Electrification

a. Meeting with the Federal Railroad Administration

Irv Yabroff (accompanied by Richard Alpaugh of ERDA) met with John Harrison and Richard Novotny of FRA to describe the present form of the railroad industry model. The meeting was very well received and FRA appears to be quite eager to see the model results for our electrification scenarios and to have future access to the model for their use.

b. Status of the railroad industry model

The model is running and several trial calculations have been made. As we normally expect in the first runs of a complex model, we found room for improvement in the model structure and the input data assumed. These are being made now and additional runs and improvements will be made in the near future.

c. Final report outline

We have been working on an outline for the impact study of railroad electrification and present the following preliminary one for ERDA comment. Its form differs from the one on electric vehicles.

Suggested Title: "The Electrification of American Railroads--An Assessment of Prospects and Potential Impacts"

Executive Summary (7 pages)

Chapter 1. Electrified rail transportation--what is it? (10 pages)

A. A general description

1. The nuts and bolts differences between all-electric and diesel electric
2. Operational differences, performance characteristics that affect how well the system functions

The description will include costs, capital and operating for the roadbed and locomotives, and performance comparisons. Energy-use comparisons will be made, emphasizing the nearly equal overall efficiency and the fuel-flexibility of the all-electric mode.

B. Systems aspects of implementing electrification

1. Selection of high-volume links, end-points
2. Financial constraints and risks that mandate a piecemeal schedule
3. Rationalization of the current network; competition

The financial context of the heavy demand for capital for electrification will be described, emphasizing competing demands and the effects of underinvestment in these alternative applications of capital in rail transportation.

C. The transportation context for railroads

The nature of goods hauled and quality of service compared with competing modes--waterway, trucks, pipelines. Energy-use, national security, and similar national policy considerations described as issues that motivate the study of electrification of railroads.

Chapter 2. Who are the stakeholders? What is their stake? (20 pages)

A. Itemization of the stakeholders and description of their stakes in railroad electrification. Items are not mutually exclusive--they are selected as a basis for a simplified description of the nature of the stake.

1. Users--shippers and their customers (frequently the same)
2. Carriers--the road to be electrified, that road's rail competitor, truck and other competitors (water, pipeline)
3. Suppliers--manufacturers of materials and equipment for railroads and their competitors
4. Labor--railroad, competing carrier, and construction labor
5. Utilities--suppliers of electrical energy to railroads
6. Public--as consumers, taxpayers, property owners along right-of-way, highway users
7. Financial institutions--holders of equity and debt on railroads, current prospective
8. Government--federal (Congress, DoE, DoT, DoL, Treasury, EPA), state and local (public utilities regulators, air quality control boards, highway safety)

B. Transportation system impact stakeholders that extend beyond mere substitute locomotion.

Chapter 3. When might we have electrification? How much, how fast? (20 pages)

A. Our scenarios for electrification

We present the (simplified) mainline U.S. map, identifying route segments by our terminology. We show a time schedule for implementation, and identify the assumptions underlying this and any alternative scenarios we exhibit. We describe the constraints and impetus for the scenarios in words.

B. We distinguish between scenarios that would result from decisions by only the railroads and financial institutions (with or without federal assistance) with minimum regulatory interference, and those that would result from a strong federal intervention to rationalize the system, or even to own part of it (Electrofac).

C. We describe the capital requirements and limitations in some detail, and spell out capital requirements of the railroads exclusive of electrification. We relate the Fishbein analysis that concludes that the traditional capital markets will suffice if the economics are attractive, and that enumerates alternative financing schemes for (basically) private investment.

D. We list the uncertainties that affect electrification:

1. The threat of the coal-slurry pipelines
2. The scale of western coal development
3. The ability to preserve acceptable debt/equity ratios in major new financing
4. The maintenance of regulatory policy that fosters competition on each route segment
5. The intent of the government to rationalize the system

E. This chapter sets the stage for discussion of the consequences of electrification--it mentions most of the important considerations that facilitate or delimit implementation without exploring all the consequences.

Chapter 4. The consequences of electrification of railroads (50 pages)

- A. What happens to the users (shippers and their customers)?
 - 1. The quality of service and cost of service for all-electric versus diesel-electric operation for rail traffic similar to the current mix.
 - 2. Intermodal shifts resulting from the offering of higher quality service of electrified rail, and from secondary system changes (responses) because of electrification.
 - 3. Secondary impacts on service and cost to users on non-electrified segments of the system.
- B. What happens to the railroads and competing carriers?
 - 1. Impacts on the finances of the carrier electrifying a segment; his debt structure, revenues, competitive posture. (Uses the railroad industry model.)
 - 2. Changes in operations and markets for the carrier electrifying a segment. (Uses the model.)
 - 3. Effects on directly competing rail carriers, on weaker rail carriers in the network that are affected, and on competing modes of transportation in the major markets.
- C. What happens to the suppliers of materials and equipment?
 - 1. The two major U.S. manufacturers of locomotives are characterized here--General Motors as the dominant force in the market for diesel-electrics currently, General Electric as a prospectively more competitive force in an all-electric market. The significance of the General Motors import from Sweden, the ASEA locomotive is discussed.
 - 2. Impacts on suppliers of diesel fuel for locomotives, and on suppliers of other fuels used to make electricity are described.
 - 3. Impacts on other incidental suppliers are compared.
- D. What happens to labor?
 - 1. Impacts on jobs for the craft unions. Declining need for diesel manufacture and maintenance. Rising opportunities in the electrical crafts.
 - 2. Revisions in operating procedures and the resulting effects on jobs.
 - 3. Impact of electrification on system demand and use, and resulting secondary effects on labor as a whole.

- D. What happens to labor? (continued)
4. Impacts on construction labor and secondary impacts on labor in competing modes of transportation.
- E. What happens to the electric utilities?
1. Additional load that rail electrification would place on affected utilities--a relatively small addition nationally but possibly significantly large in certain remote areas with small capacity currently.
 2. Characteristics of the load--its diurnal and seasonal shape, relative to a single substation and to all substations in the region of a given utility; its single phase nature.
 3. The waveform of the load, the problems it presents to the utility (and to the communications of the railroad and others, discussed here for simplicity). We relate this feature to the earlier technological descriptions.
 4. Regulatory problems as they relate to the ability of the utility to recover costs equitably while serving a load that is unique in several respects, and which generally presents the utility with more problems than most customers.
 5. Systems effects--the fact that a given segment will usually have substations in several utility areas and states, complicating the rate-setting and other arrangements.
 6. Ownership the problem of the electrical facilities--transmission lines, substations, catenaries--by utilities and by railroads.
- F. What happens to the public at large (consumers, taxpayers, property owners, highway users)?
1. Indirect (secondary) impacts on consumers--competition for petroleum products and electricity, service or cost improvements passed on by railroad users, and the like.
 2. Impacts on taxpayers at three levels:
 - a. The local level, affected by property taxes based on value of land and improvements or equipment value.
 - b. State level, affected by income taxes based on revenue, fuel taxes, and the like.
 - c. The federal level, affected by various forms of federal assistance--subsidy, loans, loan guarantees--as well as income taxes based on revenue, fuel taxes, and the like.

F. What happens to the public at large? (continued)

These impacts are secondary, assuming that government has a given revenue demand that is met by the individual taxpayer plus the industrial taxpayer over the long term.

3. Impacts on owners of property nearby the track that is electrified--direct impacts such as appearance, noise, and air pollution, and indirect (secondary) ones such as induced increases in traffic.
4. Impacts on highway users that result from right-of-way conflicts--denial of level crossings, building of overpasses and underpasses--and from lessened truck traffic where the market share for the railroad increases.

G. What happens to financial institutions?

1. Current railroad debt/equity structure. Consideration of the demand for capital that would exist without electrification. Examples of recent financing that suggest that healthy, well-run railroads can attract capital.
2. The capital that will be needed to meet the needs of the postulated electrification scenario, both for direct construction and that required to reinforce the capacity of the electrified segment and other affected segments.
3. The capitalization options for electrification. We analyze the attractiveness of the options to the private capital markets, and examine the need for federal assistance or guarantees, or other federal participation to make the debt sufficiently attractive to clear the market.

Chapter 5. The role of government (20 pages)

A. What are the current regulatory goals and policies?

1. The policies of the FRA in recent years. Focus on present efforts under the 4R Act.
2. The goal of competition for each mainline route between major points.
3. The goal of rationalizing the present mainline system.

B. How are these goals and policies affected by electrification?

1. Impact on competition when one road between two points electrifies, and traffic is not sufficient to support two electrified roads or more.

2. The seemingly "golden opportunity" that electrification presents for rationalizing the present system--eliminating excessive duplicity of routes and structuring a network that avoids bottlenecks.
3. The goal of exclusively private ownership of rail facilities impacted by the need for massive financing assistance.

C. What are the policy options?

1. Competition. If continued private ownership of all rail facilities is maintained as a goal, then the effects on competition must be anticipated in the regulatory framework. If an Electrofac (part public ownership) concept is adopted, competition will be manifested differently, and require a different regulatory approach.
2. Financial.
 - a. Loan guarantees
 - b. By analogy to government owned and maintained highways, waterways, and airway facilities, there could be government ownership of the roadbed and other fixed facilities with use by locomotives and trains that belong to the rail companies.

Appendix A. Details of the SRI Railroad Industry Model

Financial Status

The project financial status as of August 6, 1977 is the following:

No change from Last Report

Phase 1 (Tasks I-III)	\$215,666
Subcontract [*]	60,606

Changed from Last Report

Task IV	\$161,359
Workshops (Task V) [†]	47,424

Additional Work

We have received (September 12, 1977) from ERDA suggested work statements for three additional tasks and a request to submit a written cost estimate. We anticipate submitting the estimate by September 16.

^{*}To the Traverse Group Inc.; \$760 are still being withheld from the final invoice pending final audit.

[†]Barry Walton's presentation of our Phase 1 research findings at the Union College (Schenectady, N.Y.) course on the Effects of Energy Constraints on Transportation. This presentation was requested by Dan Maxfield and Ken Wilson of ERDA.