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POTENTIAL BENEFITS OF R&D
DIRECTED TOWARD INCREASING THE
COST-EFFECTIVENESS OF ENERGY USE

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POTENTIAL BENEFITS OF R&D
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I wish to express my sincere appreciation for the opportunity to testify before the Subcommittee on Energy Development and Applications. We at the Oak Ridge National Laboratory are doing a study on energy R&D needs and opportunities to provide a basis for our internal planning. Although this work is not complete, I would like to share with you some preliminary results which, I hope, are both interesting and relevant to the budgetary issues you are trying to resolve.

Why Do Energy R&D?

It is our view that energy R&D should provide social benefits that are recognizable as benefits by the mainstream of the American public. Energy goals should be subservient to social goals — not the other way around. There is no a priori reason to assume, for example, that reducing energy use, developing the breeder, or producing a certain fraction of energy from the sun are good things to do. They may be good but, then again, they may not. The point is that energy goals need to be judged on the basis of societal benefits. We have chosen the following five social benefits by which R&D activities are to be judged:

- Economic Benefits. The market benefits realizable by society as a whole as a consequence of successful completion of an R&D activity.
- Environmental Benefits. The possible improvements in environmental indices related to air, land, and water.
- Health and Safety Benefits. Possible reductions of deaths, injuries, and disease.

- Energy Security Benefits. Reduction in dependence on imported oil within the next 20-25 years.
- Long-Term Options. Technologies in the formative stages that offer substantially different approaches to energy supply or end-use service in the long-term, and which are potentially acceptable on the basis of the preceding four attributes.

Although we are examining various areas of both energy demand and supply in relation to all the above attributes, I will limit my remarks to economic benefits from R&D on the demand side (i.e., energy end-use sectors).

Reference Level of Energy Demand and Cost

The benefits from energy R&D need to be separated from the benefits of non-R&D actions. For example, most people believe that many cost-effective improvements in energy use could be made using technologies already in hand. Actions directed toward accelerating this movement may be beneficial, but such actions are not R&D and it is not legitimate to ascribe the benefits to R&D. We were careful to exclude the non-R&D benefits from our study.

To get a measure of the economic benefits achievable from a technological innovation, we estimated potential savings from the innovation relative to a reference energy scenario which did not include it. The reference scenario was based on an earlier ORNL study* which considered energy supply and demand to 2020. This study assumed the use of available technologies or modest extrapolations of such. Thus, it formed a reasonable frame of reference from which the benefits of R&D could be judged.

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*R. S. Livingston, T. D. Anderson, et al., A Desirable Energy Future, Franklin Institute Press, Philadelphia, PA, April 1982.

End-use energy demand levels for the reference case are shown in Table 1. The corresponding energy bills paid for end-use energy are given in Table 2. In 1980 we paid approximately \$400 billion for energy distributed as follows: 39% for transportation, 35% for buildings, and 26% for industry. By 2020 the total energy bill is expected to increase to about \$900 billion (1980 dollars) with 33% for transportation, 37% for buildings, and 30% for industry. Although industry will have the largest growth in energy use, the buildings sector will experience the largest growth in energy bill. It should be noted that the estimated increase in total energy bill reflects a very large increase in the level of energy service. Even without major breakthroughs in energy supply or demand technologies, energy cost per unit of GNP can decline if the country makes rational energy choices.

The present lump-sum equivalent of all energy bills over the next four decades is estimated to be about \$14 trillion (1980 dollars) as shown in Table 2. To get some feeling for the economic opportunities afforded by R&D, let us suppose that a five-year R&D program could result in a 1% net reduction in the cost of energy over the next four decades. Further, let us require that each dollar spent for R&D must return \$10 in benefits to society. What could be afforded for R&D each year for the five-year program? The answer is over \$3 billion per year! The message is that even small improvements in the cost-effectiveness of energy use can justify significant R&D. The reason, of course, is that energy represents a substantial cost component of our economy, and even a small fraction of energy cost is still a large number.

Table 1. Energy to End-Use Sectors

End-Use Sectors	End-Use Energy (Quadrillion Btu/year)	
	Actual(a) 1980	Projected(b) 2020
Buildings		
Space Heating	11.8	10.1
Water Heating	1.7	2.3
Lighting	1.0	2.1
Air Conditioning	1.2	2.7
Other(c)	2.3	3.8
Subtotal	<u>18.0</u>	<u>21.0</u>
Transportation		
Cars & Light Trucks	12.1	9.6
Medium & Heavy Trucks	3.5	5.4
Aircraft	1.6	3.0
Other(d)	2.6	5.9
Subtotal	<u>19.8</u>	<u>23.9</u>
Industry		
Feedstock	6.0	8.5
Process Heaters & Boilers	8.0	11.0
Other(e)	10.0	14.3
Subtotal	<u>24.0</u>	<u>33.8</u>
Total End-Use	61.8	78.7

(a) 1980 information derived from EIA data.

(b) R. S. Livingston, T. D. Anderson, et al., A Desirable Energy Future, Franklin Institute Press, Philadelphia, PA, April 1982.

(c) "Other" for buildings includes cooking, refrigeration, food freezing, laundry, and miscellaneous appliances and entertainment devices. The first three of these uses accounted for half of the "Other" total in 1980.

(d) "Other" for transportation includes ships, trains, pipelines, buses, motorcycles, etc.

(e) "Other" for industry includes machine drive, electrolysis, on-site generation of electricity, road asphalt, and other miscellaneous uses. Up to one-third of this category (machine drive and electricity generation, especially) probably involves the generation of steam as a first step in the process.

Table 2. Total Cost for End-Use Energy(a)

End-Use Sectors	Estimated Energy Cost (Billions of 1980 Dollars)		Present Worth of(b) Energy Cost 1981 to 2020
	Actual 1980	Projected 2020	
Buildings			
Space Heating	70	150	2700
Water Heating	12	34	500
Lighting	16	39	500
Air Conditioning	16	50	700
Other	24	66	900
Subtotal	<u>138</u>	<u>339</u>	<u>5300</u>
Transportation			
Cars & Light Trucks	102	137	2800
Medium & Heavy Trucks	26	74	1000
Aircraft	9	35	400
Other	14	55	700
Subtotal	<u>151</u>	<u>301</u>	<u>4900</u>
Industry			
Feedstock	20	60	800
Process Heaters & Boilers	25	99	1200
Other	56	110	2000
Subtotal	<u>101</u>	<u>269</u>	<u>4000</u>
Total End-Use	390	909	14,200

(a)The values shown represent the total cost of end-use energy forms delivered to consumers. For example, they include the total cost of gasoline (excluding taxes), electricity, natural gas to industry and buildings, etc.

(b)This represents the lump sum equivalent in 1980 dollars of all end-use energy bills over the next four decades. A discount factor of 3% (real) was used to get present worth.

Justifiable Expenditures for End-Use R&D

We examined each end-use sector to gain a better understanding of the magnitude of the potential savings to society that is possible through modest improvements achievable by R&D. It should be emphasized that we did not do a detailed technical and economic evaluation of all R&D opportunities across each sector. Rather, we looked at specific examples and from these results made judgements about the potential for broader opportunities.

It was judged that a ten-year R&D program could result in net savings of up to 15% of the end-use energy bill as shown in Table 3. Lest these percentages seem low, it should be remembered that a large reduction in end-use energy does not necessarily result in a large reduction in the cost of energy service. Saving energy usually requires an investment of capital; the figures in Table 3 are net values reflecting this tradeoff.

If it is required that each R&D dollar spent return \$10 in benefits to society, it is our conclusion that the nation could justify spending over \$13 billion per year over the next 10 years for R&D on the demand-side of energy. It is emphasized that this is a national expenditure (not necessarily government) and that it is for market benefits alone. It does not include justifiable expenditures for R&D to gain other social benefits such as reduced oil imports, reduced health and safety risks, and a wider choice of options for the long-term. Neither does the estimate include supply-side R&D. Our estimates indicate that the potential supply-side benefits are of equal magnitude, but the benefits tend to be somewhat farther in the future than end-use benefits.

It is our judgement that the nation could probably afford to spend a total of around \$20 billion annually (or about 5% of our total energy bill) for all aspects of energy R&D.

Table 3. Justifiable Annual Expenditures for
End-Use Energy R&D

End-Use Sectors	Judgement of Net(a) Cost Reduction Achievable Through Modest Improvements	Justifiable(b) Annual R&D Expenditures (Billions of 1980 Dollars)
Transportation	15%	6.4
Buildings	10%	4.5
Industry	8%	<u>2.8</u>
Total for End-Use Sectors		13.7

(a) The estimated net reduction in the cost of energy service is expressed as a percent of the energy bill for the reference energy scenario.

(b) Assumes a ten-year R&D program which results in \$10 of benefits for every R&D dollar spent.

In view of the size of the justifiable R&D expenditures, it is reasonable to ask what is actually being spent on energy R&D. Although available figures are not very precise, it appears that the country spent a total of about \$7 billion on all energy R&D in 1981. Roughly half the total was funded by the private sector and half by the federal government. Our conclusion is that the nation is spending far less on energy R&D than it could justify spending.

Implications for the FY 1983 Budget

Simply because the country can justify spending \$20 billion per year for energy R&D, does this mean that we should immediately try to spend that much? Most definitely not, for one simple reason: the nation does not have the energy R&D capability to efficiently use anywhere near the amount of funding that can be justified based on opportunity. We do not have the facilities, the researchers, or the experienced R&D managers necessary to take advantage of our opportunities in an effective way. We learned (or should have learned) in the 1970's that it is much easier to increase R&D budgets than it is to increase effective R&D; research and development cannot be switched on at will but requires time, effort, and patience to establish a strong national capability. But this should not deter us from the long-term goal of having a much stronger energy R&D capability than we have at present. For the present, we should avoid destroying the modest capability we already have. This, in my opinion, should be the guideline in formulating the FY 1983 budget.