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ENERGY-CONSERVING SITE DESIGN
CASE STUDIES:
PROCEEDINGS OF THE SECOND WORKSHOP
September 14 and 15, 1978

ARGONNE NATIONAL LABORATORY

**ENERGY AND ENVIRONMENTAL SYSTEMS
DIVISION**

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1 INTRODUCTION

Mr. J. Kaminsky, Program Manager for Community Planning and Development within the Community Systems Branch of the Department of Energy, opened the workshop with a brief synopsis of the history of the case studies to date.

The Site and Neighborhood Design case studies are roughly midway through the process of identifying and evaluating various options for increasing energy conservation in current design stages of their development and marketing schedule. The five contracts were awarded between April and the end of May 1978, and the purpose of this workshop is to review and share the experience gained to date.

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2 EXECUTIVE SESSION

2.1 BURKE CENTRE - MR. HALL

Our first few months of activity could be typified as saying there have been numerous changes in direction. Like many of the other study teams, we described a rather pure process of our initial proposal about a year ago. This included a way we were going to develop options initially, develop our screening methodology, and go through the whole process, which would all flow in a very logical order.

The process has not worked that way. With no apologies, I would like to describe briefly what we have been through. Later, in the technical presentation, we will discuss the details of those areas in which we have concentrated our efforts.

The first month of our effort was spent in compressing our study schedule. Because of our developer's priorities, we were asked to concentrate on the 58-acre town center site, which contains a large mixture of uses, as I described in the previous workshop. We compressed a schedule of option generation, screening methodology, modeling techniques, etc., so that we could start to deal quickly with the developer's project.

We became involved in the town center project to the point of refining our base case and then entering the first phases of developing an energy-conserving plan. About that time -- for various business reasons -- the developer was forced to shift directions -- not because of things that were happening on the Burke Centre site, but rather because of his other business interests in the region. Because the developer was unable to give this particular project the kind of concentration that was needed to proceed in an orderly fashion, we were asked to shift our direction into other areas.

These areas were a village center site of approximately 11 acres and a light industrial area slightly larger than that. We began to do some preliminary investigation into the light industrial area, which at that time was being considered as a rail-served site that the developer would own and be involved in the long-term operation. Midway through this process, some changes occurred, and the developer determined it to be a conventional industrial site,

i.e., not rail-served. For various business reasons, it became a bulk sale situation, without any long-term interest on the developer's part for the ownership and operation of the site. At this point, it was no longer in our best interest to continue to work on it because we did not have the necessary incentive to warrant additional effort.

We then shifted our emphasis to the village center site, which will be the subject of our technical presentation. Our first efforts have tended to concentrate more on building options than on the site. Beyond that, we began to develop our relationships with the Virginia Electric and Power Co. (VEPCO), and with Fairfax County to determine what kind of cooperation was appropriate and to assess which activities they were involved in that might complement the kinds of things we were trying to do. This relationship has progressed well, and we will share these experiences with you later.

Because of other delays that have occurred in the project, we have not been able to initiate work in our residential parcels until recently. We now have at least one major builder to work with us in both a fourplex and a single-family program. We are looking forward to proceeding; however, we have no progress to report in this area today.

2.2 GREENBRIER - MR. McCLURKIN

The nature of the business we are in is simple: straight development. Our single success standard is *profit*; nothing is even second in measuring how we are doing.

Our primary motive for becoming involved in this process was to improve our knowledge of the current state-of-the-art; we have certainly accomplished that in this first half of the project. We have been able to quantify and rank the priorities of energy conservation options generally available; in the second half we hope to implement the valid concepts that we have identified. I believe we have benefited from our involvement in this project, and I believe the Department of Energy also has benefited from our involvement and that of the professionals we have selected.

Some inherent conflicts exist when the private sector developer enters into this kind of relationship with this or, I would presume, any other government agency. It is extremely difficult to contract pre-agreed creativity on a

time schedule and on a budget. Although, in general we have achieved this, there has been a greater degree of slippage in this project than I would normally accept from professionals that I was retaining. This occurred because I generally direct the professionals much more closely than I could in this case; for I was looking to them for sources of ideas as opposed to executions of concepts.

Although the afternoon presentation is fairly technical, I encourage you to attend it because some of the ending conclusions are quite dramatic. Based on these conclusions, which are, in some respects, preliminary, but in other respects very firm, we have a ground for going forward, and I believe the last half of our contract will be a reasonably exciting period for us at Greenbrier.

2.3 SHENANDOAH - MR. BIRCHFIELD

I would like to go over the research program that we are following. Our original process was to develop a conventional plan and an energy and dollar budget: *What it is going to cost to develop that plan, and what the energy consumption is going to be?*

To generate a maximum number of options, we are looking at three general levels of plans. The first level is what we term "passive design," which is simply the least perturbation on the present design philosophy that will give some significant energy conservation. The second level is that passive design modified by some decentralized active systems, such as individual solar water heaters and the type of technology that can be put on individual structures and not tied together in some grid fashion.

The third, and most sophisticated, level of design, and that which is probably most interesting from a research standpoint, is the use of central utilities and the problems that derive from the consideration of central utilities, namely, ownership and management -- the old condominium problem.

In these three plan levels, we are moderated by the input from two committees: the *Marketing Committee*, and the *Financial Committee*. The *Marketing Committee* consists of builders, those who know what will sell, and they have had a rather significant impact on what our landscape architects want to do, such as burying houses. The *Financial Committee* has a somewhat smaller influ-

ence, but probably a more important one, because it must supply the funds. To date, we have met once with each of these groups. We also have institutional constraints that modify each of the three tiers of plans, but which impact most strongly on the central utility program.

To date, the conventional plan is complete, as is the base-line energy budget; the dollar budget -- the estimate of costs for that plan -- is about half way to completion. We have defined our conceptual approach to the comparative methodology, and we have a rather complete site characterization for the passive design, which has been initiated.

On the second tier, we have developed a list of options that will be pared down by the evaluation and marketing criteria.

Because the central utility has such a long lead time, we initiated work a little ahead of the other plans, and we have cataloged our options and initiated an extensive utility interface. The site is impacted by four utilities and a public service commission. We have had extensive meetings with each of these organizations, and each has provided us with a liaison person who supplies us with data, buy-back rates for on-peak and off-peak production, etc. We are also served by gas at the site, and thus we have to look at the options of the gas utility.

An industrial plant is located about a mile away from the study site, and the potential for utilizing waste industrial heat in the residential area is there. In general, we have compiled a long list of end-user options, but we have not yet begun to trim it, which is the next step in our approach.

In addressing the utility interface we have created, we have in essence, commitments from the Oglethorpe EMC to work with us on a small cogeneration facility. Depending on capital availability, the Georgia Power Company will probably do likewise.

In summary, we are a little ahead of schedule with the central utility options, and not quite as far along as I would like to be with the end-user options.

2.4 THE WOODLANDS - MR. BROWNE

We have a project area that is somewhat unique as compared to the others, i.e., we have a very large and very urbanized project area, the Metro

Center portion of The Woodlands, which our marketing people tell us will become the downtown or the urban area for a population base of well over a million people, sometime in the 1990's. Currently, the base is well over a quarter million people, although, for the most part, the acreage is vacant. We do have several hundred thousand square feet of office buildings and technology centers, either built, occupied, or under construction, but this is nowhere near the planned goal. We are looking for development in that particular area of well over 17 million square feet, of which the project study area comprises somewhere between 12 and 14 million square feet.

In addition to office, commercial, and retail activities, we plan to have eight to ten thousand residential units. Within this 600-acre area, scheduled for development over the next 15-20 years, we have a real opportunity to develop energy conservation options that we think should be considered, and which, without this program, would not be considered and would stand very little chance of implementation.

Through this study, we have generated estimates of the total energy requirements of this tremendous area from now until the end of the century, based on the conventional plan. This is being done on both a construction and construction materials point of view and on operation and use demands as well, including not only physical buildings and their use, but also transportation.

We will distribute a summary booklet in our presentation tomorrow. Included in this is a task sequence schedule that defines our work program in a logical process. We are on schedule and are developing a complete and very thorough understanding of the conventional plan and its criteria. In assembling our group of professionals in the first five months of the project, we organized our team to create an understanding of the very complex project in the conventional plan and its opportunities, and to evaluate the conventional plan with a set of criteria that we have established, including: marketability, functional planning, environmental concern, socioeconomic issues, legal and political aspects, technical feasibility, development economics, financing methods and possibilities, and the aesthetics.

With these plan evaluation criteria as a test, we are developing measuring system for each of those disciplines to evaluate conventional vs. alternative concept planning. The most existing part of the project will be the next six months where we seek out the alternatives to the conventional plan, evaluate them, and test them.

Taking the four headings in our work program, we have moved ahead and established the consolidation and description of the conventional plan. We have identified and documented the evaluation criteria, and currently we are analyzing and evaluating the conventional plan. Over the next five to six months, we will be identifying potential energy conservation methods.

We have tried to quantify the conventional plan in terms of a site-specific manner, and we have physically set forth the building coverages and orientations to traffic linkages in a real way so that all the criteria can be measured in hard arithmetic. When we get into an energy-conserving plan, this will enable us to get a very good evaluation of one plan against another by applying the nine tests described earlier.

Texas A&M has computerized an evaluation of conventional systems; we have been able to evaluate energy demand in Btus from now until 1999 based on the energy required to build and operate this portion of the Metro Center. We have also prepared an evaluation of passenger trips and transportation issues, so that we will be able to test alternative transportation systems and their possible energy efficiencies over a blind adherence to previous systems. The evaluation of the entire 12 million ft² of construction is broken down into types of materials to be used in buildings and energy consumption been plotted, based on the computer modeling of the conventional plan.

... we get into the energy alternatives, we will be applying this to alternative concept summaries to quantify the differences in the savings and, hopefully, to come back to you for help in possibly implementing the alternatives.

2.5 RADISSON - MR. CRANDALL

I would like to briefly discuss a status report of where we are, some of the problems we have identified, and then what can be anticipated as far as review this afternoon. To date, we are approximately 50% of the way through Task D, development of a conceptual master site plan for energy conservation. We have gone through data collection, state-of-the-art review, review of conventional alternatives, and conventional plans that had been developed for Radisson site inventory and analysis and the development of conceptual site plans.

Currently, our conceptual site plan for the residential section is considerably further along than for the town center. The construction schedule

for these panels has changed since the last workshop, where we anticipated a spring construction schedule for both sections. At this point, the earliest residential construction looks like fall 1979; so we have a little more time for this study and the contract documentation for the energy-conserving plan. The town center has moved somewhat in the other direction. Because there has been a tremendous demand from people who are interested in getting in the town center, Radisson anticipates moving the schedule up as early as late winter 1979 for the preparation of development plans. However, construction is still anticipated for next spring because in our climate it is difficult to initiate construction during the winter.

To date we have met with Radisson officials and the Urban Development Corporation (UDC) of New York State in a series of meetings to present our findings during the site analysis. We have also presented our conceptual plans developed, in part, to determine how far Radisson can go with energy conservation in the residential and town center sites.

We have also met with builders at Radisson. Although Radisson is developed by the UDC, including the basic roadway network and utility systems, UDC is dependent on a small group of builders that actually do the single- and multi-family developments. In the town center, which is considered unique, they also anticipate a small-scale builder development. No major front-end development of the town center square footage is envisioned; rather, it will be parceled out to individual smaller developers, and it will grow in that fashion. The builder reaction to our residential concepts such as cluster housing, higher densities, and innovative construction techniques has been very positive to date in our opinion, although they expressed concern over whether the Syracuse area market would absorb or even be interested in certain techniques.

In describing the procedures we have used to develop our conceptual plan, we have essentially tried to identify a more energy-conserving built form for the residential development and the town center. Subsequently, we compared that form with the conventional development, followed by review and meetings with the developers; this had led to our current modifications in the energy-conserving plan.

We have also made a presentation to the Lysander Planning Board, which reviews and approves all development plans at Radisson. The Board is viewed

as fairly conservative, although we received a very positive response at the end of the meeting, including considerable discussion afterward and considerable enthusiasm for our efforts.

We have also gone to various public agencies in the Syracuse area and presented them with materials covering the case study. These agencies have asked to participate in our work sessions and to be kept informed. The New York State Department of Energy also has developed interest, as has New York State ERDA, and we have been asked to discuss the progress at Radisson with them. They are also interested in further pursuing energy conservation in land planning and design and have asked to participate in our team workshops and to be advised as to the project status for the duration of the study.

In the technical presentation, we will discuss the methodology we have used and the options we have considered applicable to the town center and residential sites. We will also present the preliminary base-line that we have developed for quantification and evaluation of the two site plans.

3 TECHNICAL SESSION

Each of the case study teams was requested to present a more detailed technical discussion of its current activities to facilitate a more in-depth transfer of information to the other study teams.

3.1 BURKE CENTRE - MR. GORMAN, ET AL.

We will be presenting an interim report on our work in the village center site that was described earlier. Midway into the project, this site was identified as a good opportunity to explore energy conservation with a fast-paced, very successful builder of conventional-type retail centers who was already developing preliminary plans for the site.

The project was broken into two major areas: (1) regional and community energy conservation options we could identify for the center; and (2) architectural detailing, conservation methods, and site-specific techniques. As is the case for most centers of this type, marketing, financial, and cost considerations are the primary determinants of location. Because a supermarket or retail food outlet is typically the primary tenant, it exerts the most influence on the location. Energy conservation plays only a minor role in determining location.

The design program includes a 40,000 ft² supermarket, a drug store, retail shops, a bank, fast-food outlet, and a service station -- a very typical conventional convenience retail center oriented to the main road with parking in front and service in the rear. To date, the builder has built approximately twelve such centers in the Washington, D.C. area.

We prepared four different plans to manipulate building structures, circulation, and parking in identifying approximately 30 different conservation options that were practical. All had reasonable initial costs and payback periods. These options were almost evenly split between siting techniques and architectural modifications. This included such building program modifications as reduction of the northern exposure, provision of earth berming, reduction of service drive lengths, and increased planting and vegetation in the parking area without a reduction of parking requirements. Additional options considered included retention of natural landforms, use of plant materials for shading and wind channelization, priority parking for compact cars and two-

wheeled vehicles, and some parking reductions. We also attempted to minimize and simplify storm drainage and encourage pedestrian and bicycle access to the site.

Some architectural modifications included berming on the north, east, and west walls, operable canopies for optimal summer shading and possible winter solar gain, weatherization, insulation, and selective placement of glazing -- both double and triple -- for natural light and ventilation. We also investigated the programmatic use of office space over the retail shops, and its ability to share parking requirements. Within the structures, we investigated temperature zoning.

For computer modeling, we selected increased insulation, lowered ceilings, stacked floor space to minimize roof areas, increased south-facing windows, operable awnings, and earth berming. On an annual basis, this resulted in a 75% reduction of energy costs per square foot. Through this analysis we found the use of stacked office space did not produce viable energy savings, we eliminated it, resulting in a reduced annual heating and cooling cost of \$21,000 instead of \$82,000 in the conventional center design. Fifty percent of the savings were due to the increased insulation alone, which is now a state performance standard requirement. The other four options combined to result in the remaining 25% savings.

In selecting these options for presentation to the builder, we identified those that would have the most impact. Many others, especially site-related options, were omitted from this preliminary analysis because of our uncertainty of their effectiveness and the need to create a favorable first impression on the builder as to the viability of passive energy conservation techniques without requiring dramatic changes in the building program or use of sophisticated hardware. Because of the developer's business plans, it was inappropriate to approach the builder at the outset, which might have been more productive for us under other circumstances.

Following our presentation, the builder was very specific in evaluating our concepts. For example; the following observations were made:

- Changes in the building location on the site would not meet the requirements of the major tenant, the supermarket, which needed a central location. From the builder's perspective, if the major tenant did not come into the center, the center would not happen.

- In all cases, rear service was necessary, and the county required fire access completely around the center.
- The use of shade trees in the front of the center would block the visibility of the merchants' signs, which they would interpret as undesirable when considering locating in this center as opposed to another one.
- Operable awnings were viewed as a continuing maintenance problem.
- Insulated glass was too expensive to justify. The builder would not realize a return on that investment, and he was able to meet the state performance code by using insulation alone.
- The use of earth berms was too expensive in terms of application to the standard wall sections, and might cause design problems related to egress requirements.
- Combined retail/office usage would not be marketable, and the local regulations would probably not allow use of shared parking.

These are the builder's points of view. It is possible to point out examples within the region where many of these criticisms have not materialized. In Columbia, and other new towns where we have worked, shared parking has amounted to a 40-50% sharing ratio. However, this is the builder's business, and he is financially responsible for his decisions. It is one thing to say that we question these points, but we are still dealing with his business judgment. He is going to build the center, and if he doesn't like a particular option, that is a part of the screening process of trying to identify things that he will accept as a real builder in this situation.

Although the builder will own and maintain the center over the anticipated 20-year payback period, he will not derive the benefit of reduced energy costs, except for possibly site lighting, parking maintenance, etc. The benefits will accrue to the tenants, and the builder believes he would take all the risks and still not be able to convince the tenants that they should pay a higher rent because they will be paying lower energy costs.

The builder did, however, indicate that if he had more previous experience in this area, he might have been willing to go further. This is the first center in which he has done anything more than put an inch and a half of insulation in the roof. The builder indicated additional inhibitions in-

cluding outdated and inflexible building and safety codes, normal resistance to change by consumers and business decision-makers, reluctance of insurance companies and lending institutions to deviate from proven formulas in construction, the inability to sell energy conservation as an extra front-end cost to a potential tenant with the promise of some savings in the future, and primarily the lack of a financial incentive on his part, since he is not paying for the energy.

After this meeting, we analyzed the builder's plan and identified energy-conserving options that would provide an initial incentive for the builder in terms of site development costs and long-term operations and maintenance of the center itself -- not necessarily the energy costs of the tenants' spaces. These options were incorporated into a revision of the builder's plan that included no change in the building massing, but did address visibility, increased shade on paved surfaces, tentative reduction of required parking into an overflow situation, and other paving reduction techniques. We replaced grass areas with a no-maintenance plant material cover, and reduced site lighting on a time-of-day basis. Deciduous shading was retained on the east and west sides; on the north side, evergreen plantings provided wind protection in the rear.

From preliminary cost estimates, these techniques resulted in a \$45,800 savings in installation costs. Lawn, asphalt, lighting and maintenance savings, amounted to roughly \$3,500, or a total of nearly \$50,000 in the first full year of operation, out of a site development budget of approximately \$300,000.

We also prepared a similar package of techniques that tenants might wish to employ. Among these were air lock vestibules, natural lighting, lowered ceilings, better interior lighting reflectivity, internal heat pumps, and solar gain. Because of the depth of the typical spaces relative to their width, natural lighting and ventilation and solar gain did not produce a significant savings. The two most significant techniques appear to be lowered ceiling height to reduce the interior volume, the more efficient HVAC systems.

At a recent meeting, a major builder in the residential portion of the site expressed an interest in working with us on quadruplex and single-family home projects that will be developed over the next 18 months. Virginia Elec-

tric and Power Company has been interested in monitoring any demonstration house that might be constructed. We also have a major opportunity to return to the 58-acre town center, which would enable a better analysis of multi-use and community-scaled options and more site-related issues.

At this point, we would like to invite our representatives from Fairfax County and VEPCO to describe briefly some of their activities that are related to our project.

3.1.1 Fairfax County Government - Mr. Blanchard

The reason that we are in contact with the Burke Centre group, and the reason I am here today is that we are actively seeking to improve many of the covenants and laws that are currently on our books. We would like to work fairly closely with Burke Centre to see what can be done.

An active energy management program since 1973 within the internal operations of the county has improved our building efficiency, fleet operations, etc. In May of 1977, the Board of Supervisors of Fairfax County expanded the existing program and appointed a Citizen's Task Force to make recommendations for a comprehensive energy management program that could be implemented in both the public and private sectors of Fairfax County.

In April 1978, the Task Force submitted a report containing 63 specific recommendations for the county government. Some major recommendations included: (1) channeling of future growth into development centers that provide mixes of land use, (2) incorporating energy conservation into the nine criteria presently used to determine the range of density within the goals of our comprehensive plan, and (3) requiring an energy impact assessment as a part of all plans submitted for a large scale development within the county.

This report has been referred to county staff for review and comment, and a staff analysis of the document is now in the county executive's office and will go to the Board of Supervisors by October.

Our planning staff, environmental management staff, and energy management staff has met with the Burke Centre group, and wants to proceed. We would like to determine what there is in the county in the way of overly restrictive local covenants that can be changed. If we encounter state requirements that would inhibit the flexibility of developers in energy-conserving designs, we

would consider discussing those, as appropriate, with the state. We are trying to develop this sort of working relationship at present.

3.1.2 Virginia Electric & Power Co. (VEPCO) - Mr. Kramer

VEPCO serves Virginia east of the Blue Ridge Mountains, and a portion of North Carolina and West Virginia, with about 1.2 million customers.

Formerly, we used to promote electric usage. In January 1977, we re-organized and incorporated load management into our marketing services, and we are trying to cut back unnecessary usage. Our goal is to reduce 500 MW from our system peak by 1985. This marketing effort will have a great impact on our future, where we are looking for incremental energy-use efficiency through energy audits of existing commercial buildings and energy proposals in new construction. We stress wise usage of electricity.

Soon we shall begin a program of residential auditing, which will place a tremendous work load on us, particularly here in the northern Virginia area. Of the 14,000 or so new customers annually, 85% have been all-electric users, most of which were already using heat pumps -- not resistance heating.

We have a summer peaking demand based on air-conditioning, although we are now approaching two demand peaks -- summer cooling and also winter heat-~~ing~~. This has required us to apply for what would be one of the largest rate increases in the history of the United States, caused by the combined effect of inflation and demand growth. Where formerly we received over 60% of our revenues from rates, currently we receive slightly over 35%.

We are approaching load management through our auditing program and are entering experimental time-of-usage pricing for our customers. This will include automatic metering, possible residential water-heater load shedding or interruption, and radio-control. Time-of-usage pricing is a voluntary program, although we are also requiring the top 1% of high-use customers -- those using over 3500 kWh in any one summer month -- to participate.

Time-of-day pricing is broken from 9:00 a.m. to 9:00 p.m. five days a week, based on a basic customer charge and demand charges -- 2 1/2¢/kWh on peak; 1 1/2¢ off-peak, and a seasonal demand charge of \$4.50/kWh summer and \$2.50/kWh winter. We are just now installing this system and are finding that, in some cases, customers are saving money with this rate structure with-

out adjusting their consumption habits. These customers have been asked not to make any changes in consumption at first, and we are sending them comparative billings so they can see the difference and allow us to work with them to reduce portions of their load. Seventy-five percent of the customers in this program have received it favorably and understand its objectives.

Returning to the Burke Centre project, it is our intention to cooperate in every way we can with this study. We would be pleased to cooperate in test metering any portions of the project where this kind of metering would be appropriate.

3.1.3 Synopsis of Discussion

One of the possible causes of trouble in calculating payback periods is the use of electric rate, or rate for service delivered, times an actual energy savings. In most cases, the fixed investment of the utility will probably not be impacted by energy savings from reduction of end-use over the first 15-20 years, resulting in real savings only in terms of energy cost, because the utilities operate on a revenue requirement basis. If usage goes down substantially, the unit rate will have to offset that difference in revenue requirements. It is necessary to address this fact in dealing with utilities so that accurate estimates of energy savings over the first five to ten years can be made.

As can be easily seen, the actual energy savings is much smaller than what would be predicted by the cost of service charge, which includes all costs of utility operation. The cost of energy portion of this charge is much smaller, and much of the additional cost of service will not be impacted by the amount of energy consumed. For example, plants currently entering into service have an energy charge of roughly 11-20 mills/kWh, depending on plant type. In the same area, the actual customer rate may be 4-8¢/kWh. Therefore, we cannot assume that a reduction in energy is going to correspond to a straightline reduction in costs. The case studies must work closely with their utilities to determine appropriate estimates of actual energy cost savings.

However, if an energy-conserving development were built adjacent to a conventional one, there would be a substantial comparative savings, and this savings would be the number that would cause a developer or builder to favor

an energy-conserving design. Furthermore, a large, fixed demand that is being served by a given utility is not likely to experience the kind of reductions that have occurred with water conservation programs, where, with minor modifications, every user will cut back substantially. In metropolitan Washington, D.C., most of the voluntary measures have probably been made already, and current cost-of-service estimates will likely be accurate for the next three to five years. This is what today's shopping center developer will consider.

A later portion of the study will examine local and regional policy and governmental requirements. If an actual measurement of the energy saved were generated in this study phase, the study then could proceed into the dollar amount, and subsequently any policy modifications that might be made regarding utilities could be isolated. Whether this would be a Btu or other unit, this would enable comparison of one study to another and examine independently the local areas in terms of district-specific solutions that would relate to governmental changes in the way utilities are regulated.

As was pointed out earlier, many of the study teams described approaches where certain criteria would be applied to lists of options to determine their future viability. The Burke Centre study has considered some options, and these have been tested with the developer. For the record, it is desirable to evaluate all options that are physically possible -- first in terms of their economic feasibility, and then in terms of the reasons why they were not adopted in a given setting. To sharpen the issues as much as possible, it is important to see why the builder, the developer, or the local utility has problems with a given option. From this point of view, it is just as important to document thoroughly all options -- particularly those that do not reach the final plan -- as it is to implement as many as possible, because it is only through this kind of documentation that the knowledge gained in the case studies can be transferred. In this way, it is possible then to adjust some of the criteria that went into a particular decision as constraints and gain some insight as to what might occur under a different set of circumstances.

A major concern also was expressed over the need to quantify the kinds of savings that were achievable at the site and community scale beyond any savings that had been achieved through buildings modifications.

3.2 RADISSON - MR. CRANDALL, ET AL.

Radisson is basically a new town that is being developed by the Urban Development Corporation of New York State. It has an anticipated population of 18,000, including major industrial uses and a significant commercial development program. Our work has focused on two areas: a current residential development adjacent to existing development; and the town center.

We have approached the problem of energy conservation on these sites from a conceptual viewpoint of first addressing land planning techniques that do not require extra costs to the builder or the developer, and then working in more detailed design refinements of these concepts. We are currently in the conceptual stage regarding land use distribution, relationships among land uses, and circulation patterns.

Because of Radisson's location in central New York, one of the most significant parameters was the pattern of cold air flow, during both the day and night. We have identified the northwest winter winds as the predominant design consideration on site. Because of the low incidence of solar radiation during the winter months, solar applications and respective slope orientation were heavily discounted very early on. The effects of existing vegetation as a buffer or modifier of wind patterns, especially in conjunction with building placement, massing, and building envelope modifications have been identified as the most feasible options for our consideration, particularly in light of the 6,750-7,000 heating degree-day requirements of the Syracuse region.

We have also approached Niagara Mohawk Power Corporation in an effort to ascertain how to interface the utility with site design and site development that can optimize efficient energy distribution patterns. From previous studies with Niagara Mohawk, we had established as much as a 5-10% reduction of winter energy usage attributable to the effect of vegetation and orientation. A second study that had greatly influenced the current design work examined the effect of vegetation buffers and building orientation on observed infiltration rates in the dwelling units of a townhouse project in Twin Rivers, New Jersey. Cumulative differences reported in this study amounted to as much as a 40% reduction in infiltration, with further savings achievable through the addition of five-foot fences and inter-unit spacing of up to 60%.

Using the existing development adjacent to the residential study site as a baseline, we analyzed the existing units in terms of their response to energy conservation design techniques described in the two studies. Only 22% of existing units achieved wind protection. Only 31% of the existing units have the preferred slope and solar orientations. One major contributory factor, in our evaluation of the phenomenon, was that the wide building space of the residential units around the cul-de-sacs effectively inhibited any inter-building wind protection and reduced the adequacy of existing vegetation as a windbreak. With the cooperation of Niagara Mohawk, we hope to be able to translate this into heating cost and heating use data.

The 92-acre residential site we are working with has been inventoried in terms of the development constraints it presents. Among these are the Seneca River flood plain, an existing marina development, proposed lake site and golf course alignments, major pedestrian desire lines, and a proposed road right-of-way.

From the input of our engineering and climatological consultants, we prepared a composite site analysis looking at existing vegetation, wind, building constraints, climatic considerations as to slope, aspects, program requirements, utilities connections, etc. Because of the relatively flat topography, there are few slope constraints, and little topographic modification of prevailing wind patterns. Existing vegetation was identified as the most advantageous site element with which we had to work.

We then prepared a series of site plans in which we tried, as much as possible, to free ourselves from preconceived marketing and regulatory constraints and respond to the site in terms of our analysis and what we had learned from our state of the art review regarding an optimum approach for the Syracuse region. We relied very heavily on clustered housing for reducing road lengths and increased flexibility in unit siting. From our earlier meetings with the builders and the developers, the relative inflexibility in siting the conventional house fronting on the required dedicated road within the usual lot sizes was identified as a major constraint to optimal orientation of a house for passive energy conservation. The advantages of clustered housing, including reduced building mass to the northwest exposure, increased internal wind protection, and creation of an improved streetscape through designed inter-building relationships, present one marketing approach to this problem that does

not violate the programmatic constraint of equal numbers of housing types (one-third single-family detached; one-third town house, and one-third multi-family housing).

By applying the same general clustering principles to the town houses and multi-family units, we produced a tentative conservation plan that had 506 dwelling units, giving the highest density of any alternatives, 5.5 DUs/acre, or about 150% of current Radisson density. This density begins to meet the projected density of the Radisson master plan. Aside from improved building orientation and siting characteristics, this plan brings other advantages. For example, it allows the developer to amortize the development costs over a greater number of units, thereby decreasing the cost of development to the individual purchaser, which is a desirable marketing incentive in terms of increasing the acceptability of any energy innovations.

3.2.1 Conservation Plan #1

The conservation plan has 10,000 lineal feet of road, or 20 lineal feet per dwelling units, as compared to 42 in the baseline existing development. We hope to address the energy implications of this later in the study. Also, given the snow removal conditions in the Syracuse area -- conditions that are almost constant between Thanksgiving and Easter -- any possible reduction in surface plowing requirements will result in substantial long-term operations savings. In summary, this first plan presents definite advantages of increased density, flexibility of orientation, more protected units in terms of wind buffering, decreased site development costs, and an overall reduction in fuel-dependent operation and maintenance for snow removal.

3.2.2 Conservation Plan #2

We also prepared a conventional development plan for the study site to serve as an illustrative baseline for comparative purposes. It contains 361 dwelling units at a density of 3.9/acre, and includes 12,500 lineal feet of road, or about 35 feet per dwelling unit. This plan still represents an improvement over the existing condition, and through energy conservation features in buildings, additional conservation savings can be achieved, although not to the degree of the first plan.

3.2.3 Composite Plan

From a marketing viewpoint, the Radisson developers felt that there was no way the extensive number of clustered houses presented in the first plan would be acceptable to the general market in our area. Nevertheless, there is a commitment to try to implement an energy-conserving plan, and an agreement to accept a limited number of housing clusters on an experimental basis, so we prepared a composite plan containing several clusters in addition to the single-family lots in the conventional plan. In the composite plan, we realized 435 dwelling units at a density of 4.7/acre, which is a significant improvement over the conventional plan. Although the same 12,500 ft of roadway remains, the per-unit length is reduced to 29 lineal feet through reductions in subcollector roads. We have begun to quantify some aspects of these plans by looking at wind exposure; however, the figures cited can be significantly increased by final building placement and inter-building wind buffering in the design stage. Presently, in the schematic concept stage, we have been able to identify building lots with protected and undesirable exposures. In the conventional plan, 49% of the units had unfavorable wind exposure as compared with 36% in the conservation plan. The remaining lots had a protected (or favorable) exposure. In the composite plan, 52% of the lots were protected, even without considering additional plantings and building-to-building relationships.

Turning to the Town Center site, which to date has not been carried as far as the residential site, there is some spotty, second-growth vegetation, although the site character generally is open. There has been some difficulty in defining the development program for this site, which has varied between 100 and 225 thousand ft² of commercial and office space, and from 400 to 500 dwelling units. We finally performed an onsite feasibility study to determine a program that is compatible with the site and which also has been adopted by the developer so that it is generally comparable to our work for this study. We then performed a similar composite analysis of this site and identified the prime building areas and major site constraints -- including two steep embankments on the north side and the northwest prevailing winds.

We also have a very conservative town planning board with stringent parking requirements (10 spaces/1000 ft²) for this center. Parking requirements, as with the community public facilities such as a library, are separated. The town board felt that given the longer-term nature of community oriented parking

there was no need to combining this parking with short-term commercial usage, and in fact found it desirable to separate the parking to prevent unnecessary pedestrian distances.

The development program for the conventional site place contains 150,000 ft² of commercial space, 15,000 ft² office space, and 400 dwelling units. The conventional plan's concept accommodates the marketing requirements of Radisson, which does not intend to develop the property, but rather to market it to individual builders in a strip-mall context, thereby creating a linear space with parking on the south side. The residences are clustered away from commercial, with emphasis on south-side parking and entrances.

The approach used in our energy-conserving Town Center plan reflects the residential concept. We have attempted to open the development to the south as much as possible, minimize north and northwest wall exposure, and to create a fairly tight building pattern for building-to-building wind protection. This design yields a much tighter integration of uses with a peripheral residential area and a commercial core that penetrates into the residential areas. We envision a building-height modulation across the site to increase the wind screening effect and to prevent encroachment of southern exposures. The details of this plan have not been finalized at the concept-level presented here.

Applying a similar exposure analysis to this site, the conservation plan has increased the ratio of favorable southern exposure over unfavorable north/northwestern exposure by about 64% over the conventional plan. We believe that the building relationships of the energy-conserving plan can be significantly improved by increasing southern exposure, minimizing and protecting northern exposures, and creating more common walls when we move into the next-larger scale of investigation.

3.2.4 Architectural Analysis

Moving to an architectural analysis of the energy conservation plan concepts, we attempted to relate building-type analysis as closely as possible to the site-planning criteria rather than focusing on building hardware. We established a measuring system and a series of criteria for evaluating different building types in terms of their siting response and applied this system to prototypical units being built at Radisson by various builders. Combining the

results of this analysis with our findings from the state-of-the-art review, we produced a series of recommendations to the developers as to how various builders could increase the efficiency of their typical units. Contrary to some of our apprehensions, several of these recommendations were well received at our meeting with the developers and builders.

From this analysis, we developed some additional prototype buildings that would be applicable to Radisson from both the efficient energy usage and from marketing considerations. The site was divided into six zones based on micro-climatic, slope, and other characteristics, and we then analyzed each of the building types in terms of these six zones, and the building's orientation on the site within the zone. This process led to a series of considerations or guidelines for siting within each zone, and included a determination of which unit type was particularly well suited to each zone.

We also examined the internal characteristics of the individual units, relating them as much as possible to siting within the zones, and their potential for variation in siting to achieve additional energy savings. Some of the factors we investigated, in both plan and section, that influence the siting, building form, and construction in terms of orientation include:

- Orientation of entrance facade and prime view direction;
- Use of utilitarian rooms such as bathrooms on external walls to reduce the energy consumed to meet mechanical ventilation requirements;
- Deflection of winter winds with controlled roof pitches; and
- Use of external wind screens and buffers.

This mode of analysis is also being developed from the Town Center site, although it is obviously not yet as far along, particularly in the non-residential portion of that program.

3.2.5 Summary

As a general summary, the energy conservation issue of Radisson is not really one of using solar techniques, but rather of controlling and using air movement for summer cooling, and most importantly, controlling and restricting air movement during the extreme winter heating conditions. It is this area of design that the Radisson case study will make a unique contribution when compared to the others.

3.2.6 Niagara Mohawk Power Corp. - Mr. Cahill

Niagara Mohawk also has been participating in the case study since its inception. Under present methods of site design, our situation in the utility business is quite similar to that of the engineer who is given an architectural design and instructed to place the necessary mechanical systems into a structure already designed. When we were approached at the beginning of this study, we felt we had a unique opportunity to become involved from the outset of the community planning process.

First we developed three criteria for the project study team to use for efficient use and design of the electrical distribution system as it coordinated with the overall project: 1) possible energy savings; 2) desirable load mixes from the system standpoint; 3) and possible savings in plant facilities necessary to actually provide service to the required number of customers. This last item is not a large conservation item except as to first cost of installation, which of course adds to the overall cost of energy.

We looked at energy conservation primarily from reductions in line losses benefiting from the direct energy savings and also balancing the loads. Our studies indicate line losses range from 6-10% of the total system load. These losses occur on the customer site of the substation.

These are not short-term losses; they are continuous. We have computer analyses that take existing feeder records and examine portions of our system for possible redesign. Reductions in line losses resulting from this redesign often drop from approximately 10% down to 6-7%. Until we got into the Radisson project, we had never had the opportunity to apply this technique to new installations.

Application of other criteria involved the overall design consideration for the way major loads came on, and their location within the development. We suggested the most efficient use of the utility design would be to bring the backbone of the feeder right through the development in the most accessible pattern possible; in effect, to bring the three-phase main trunk lines right through the middle of the development and place the major commercial and high-density loads near them.

Radisson does this quite effectively. The Town Center is at the junction of the two main trunks entering the development, and even though the loads

may shift around a little, we can serve anything in the Town Center area with no difficulty because we were able to plan the best overall community approach from the start. A second benefit of this pattern is the ability to balance the system load between the commercial, residential, and possibly light industrial loads, which prevents the separate classes of loads from coming on in spikes. This produces a much smoother profile.

Feeding off of the backbone trunk line, we will pick up the town houses and garden apartments with single-phase circuits, and ultimately the fingers of the system will pick up the single-family detached housing. Along with the system backbone, these fingers present opportunities for increasing line efficiencies.

Returning to line losses, we examined their implications to the kind of residential design concepts being developed. We will do a computer analysis in the near future for each of the plans that have been prepared. In this conceptual analysis to date, we have dealt with standard utility installations and existing regulatory constraints such as required placement of utilities on public rights-of-way.

Figure 3.1 portrays a standard single-family design and the way it would normally be serviced, with the primary distribution system following the right-of-way and dropping off at transformers which would feed across the road and to

Fig. 3.1 Standard Single-Family Residence Electrical Design

the houses in a secondary system. In the eight prototypical residences, there were 400 lineal feet of primary distribution (156 ft/d.u.) and 540 feet of secondary (67 ft/d.u.). Extending this to 48 houses, which is what one feeder would normally supply in an electrically heated development of 76 to 80 amps, the line losses amount to 23.5 MWh/year, or \$940/year based on 4¢/kWh electricity. This averages out to \$19.60 per house. The customer does not see this cost except as indirectly reflected on all utility bills. However, it is a real energy cost to the system.

Before analyzing the cluster service, it is important to recognize some of the standards under which Niagara Mohawk must operate. In all cases, we work on a loop feed. We do not like a situation where we could expose a customer to a 72-hour (or longer) service outage which could occur with radial feed installations. If a bad section of cable exists, we attempt to feed from both sides of the section and isolate it from the grid, enabling 3-4 hour restoration of service and allowing us to take a week or more, if necessary, to repair the bad section without interrupting any customers other than those mentioned.

To feed the cluster design under existing constraints (see Fig. 3.2), we would have to run up the r.o.w., feed in, feed back, and go on, amounting to 850 ft of primary (106 ft/d.u.). Roughly the same amount of secondary as above

Fig. 3.2 Cluster Residence Electrical Design

is needed. The line losses in this system amount of 48 MWh/yr, or about \$1,920 (\$40.00/unit). Looking at the typical 48-house feeder with existing constraints and using the conventional plan, we would save enough energy to give one house in 48 free service.

Next, we looked at the possibility of using an easement, which we felt could be used if there were an accessible walkway and if the easement were public (see Fig. 3.3). This results in practically the same design as the first one as far as the line losses are concerned. The example shown in Fig. 3.3 can be improved by tightening up clusters and so forth. However, it is important to recognize that some municipal constraints would have to be changed to permit this, and we would have to get regulatory approvals to allow us to service clusters in this manner.

Fig. 3.3 Cluster Residence Using Special Easement Electrical Design

3.2.7 Synopsis of Discussion

From the majority of the presentation, a definition of efficiency is occurring at the end-use point. Energy efficiency, other than line losses, is therefore being considered synonymous with a reduction of building demand. From a community standpoint, siting and orientation has a very small maximum conservation potential. However, through clustering mixes and by functional relationships, one can affect what supply and distribution systems will be employed to deliver energy, which can have a varying degree of impact on efficiency energy from 30-50%.

However, as the work to date at Radisson indicates, the concept of clustering buildings is quite contrary to what is practical in terms of market desirability, even if it is the only way to realize the kinds of energy efficiency increases that have been attributed to systems considerations. In the Syracuse area, the actual units themselves and marketing considerations will in the end determine the site plan at least as much as any other single factor.

Some of the additional conservation options that have been explored but that are in too preliminary a state of development to have been included in the presentation include the use of wells, groundwater and groundwater loops as thermal sources, a central reservoir as a storage device coupled with excess capacity during off-peak hours, and the use of a water-source heat pump in the adjacent Seneca River. This last option has some clearly identifiable problems including the drop of inlet water temperatures below 40° in the winter and the excessive pumping necessitated by flood plain set-back requirements.

The study team has also had some preliminary contact with a major heat pump manufacturer who is very interested and has been doing some research into possible applications. There has also been some preliminary examination of utilizing industrial waste heat, particularly from the Schlitz brewery, which has some logistical difficulties, although all these efforts are too preliminary for any firm conclusions.

There are also clear utility and scheduling problems associated trying to implement some of these options. Foremost among these is the question of ownership, which will take time and careful planning to overcome.

Additional discussion was raised on the length of many of the cul-de-sacs, which were shorter than what would be optimal from a development cost

standpoint, and the related issue of including this amount of paving in overall road length and cost comparisons between alternatives.

3.3 GREENBRIER - MR. McCLURKIN, ET AL.

Our presentation will first attempt to familiarize you with the terrain and some of the characteristics of the site and the material for our base case model. After that we will present our study technique and the findings of our base case energy model, followed by some of our conclusions at the mid-point in the study. We will then address the activities which we envision for the balance of our program.

The facts we are going to present today are the highlights of our efforts. A substantial amount of material has been produced, reviewed, and rejected, and this is part of the filings we have made with DOE; but insofar as they are not applicable, we have elected not to include them.

3.3.1 Location

Greenbrier began about 200 years ago as a small farm on the edge of the Dismal Swamp, which is the area south of the project. Over the next 200 years, approximately 3,000 acres were put under cultivation by the Thrasher family, which more recently has become the largest wholesale nursery in the United States. It is located in the standard metropolitan area known as Norfolk, Portsmouth, and Virginia Beach which has about an 800,000 population. The major road systems in the area are Highway 13, or Military Highway, which is a principal commercial access, Interstate 64, starting at Portsmouth and coming through our project, through Norfolk, and onto Richmond and beyond; and the connector between Norfolk and Virginia Beach. If you fly over this area, it is a single area of full development; you cannot tell that one town starts and another one stops. The project is located approximately 15 minutes from the financial district downtown part of Norfolk, 20 minutes from the airport, and about 15 minutes from Virginia Beach.

The land use plan currently in effect is the sixth land use plan that we have had. We view land use plans as having principally two functions: 1) as a zoning matter, it is our zoning document with the City of Chesapeake; and 2) it is a preliminary planning tool. We have been involved with the project only two years, and we have been through four iterations of this plan. Probabl

we would produce one of these every six months as imperfections in the plans become obvious.

The variation in elevation in the project is two feet from one end to the other -- 3,000 acres, very flat and very wet. The surrounding property basically is developed, and there is an inward development pressure, so we were not in the middle of an open area. Our development sequence was different from the normal development sequence of a large-scale community. We actually started with commercial and then did industrial and finally residential, as opposed to going the opposite route. The lake systems and the water on the site are a result of having to drain the site initially for agricultural purposes. When we began to put in sewer and streets, the drainage requirements were substantially higher, so that the impoundments now fulfill our storm water run-off requirements, because the run-off rate from our site is allowed to be very little more than the normal, even during a 100-year rain storm. These impoundments currently contain about 300 million gals. of fresh water, and will handle an additional 11-foot depth of water over the 160-acre surface area.

We have dammed these lakes to control the levels during the development. After development is complete, the dams will be removed to improve the navigability and allow it to become a recreational amenity. These water canals are quite beautiful after they have been planted and add to the aesthetics of the property. They increase the value of the property as well, so that while the front-end cost of doing the drainage system was substantial, it will be recovered over a period of time because we have waterfront lots.

The City of Chesapeake, formed 11 years ago, comprises the entire unincorporated area of what was then Washington County. As a result of it being a new political subdivision with relatively new laws, the city has hired mostly young and very professional people to operate the City's business. This has been a blessing to us in the sense that we have basically worked with them in writing the planned-unit development ordinances for 10,000 ft² lots, 7,500 ft² lots, 5,000 ft² lots, and shopping center ordinances -- ordinances that will govern Greenbrier and development in the City of Chesapeake.

3.3.2 Area Development

Development work, that has been completed in the past year, includes homes on 10,000 ft² lots in the selling price range from \$75,000 to \$120,000

with the more expensive lots on the water. In addition to having the onsite personnel, our group in Atlanta consists of about five and the balance of the work is done by outside professionals. Outside consultants do our land planning, engineering, etc. The houses on 5,000 ft² lots are in a price range of \$45,000-\$55,000; houses on 7,500 ft² lots are in the \$55,000-\$65,000 range; so basically we have the market covered from \$45,000-\$125,000. Lot costs for the patio housing lots average \$8,000 for the 64 that we developed to date, \$11,000 for the 7,500's, and about \$17,000 for the 10,000-12,000 square foot lots. Incidentally, although the houses are small and they are not expensive, they are using double glazing, heat pumps, reasonably good vapor barrier systems around the windows, and so forth, so the builders in this area are beginning to be pretty sensitive. We are not going to get credit for introducing some of the things we initially thought we would because the builders are already doing it.

A major problem and constraint that we have from a development standpoint is the handling of water, both from run-off and from the water table itself. Our other major problem from a development standpoint (although not a cost problem) is that everything is very flat so that when we go through the tree cover we have to come back and do planting and berming and other types of things.

At the outset of the project, we spent a considerable amount of time trying to figure out exactly what a base case was and how to put it together. We decided early that, regardless of what it was, the way we wanted to put it together was to be expressed in terms of individual units. This was so that when we began to look at future conservation options, we could evaluate them in terms of the incremental cost and benefits. This dictated that the base case be expressed in terms of square foot of wall and certain amounts of walls per unit. This approach also was necessary to allow a projection of the total quantities of material contained in the entire 550 acres from the portions of the site that were currently either developed or for which there were engineering drawings.

We did this by looking at the two types of energy consumed at the site. The first, of course, was the embodied energy contained in the materials themselves. We produced detailed estimates of the quantity of materials contained in each element within the site infrastructure. For example, roads were ex-

pressed in square feet of various slab thicknesses for each unit type. This makes it possible to multiply each estimate by the total number of units in this category and arrive at a total amount for the entire site. This process includes storm sewers, water pipe, PVC sewer, concrete walks, curbs and gutters, etc., which we disaggregated down to its lowest level using data that we found in a publication published by ERDA and written by the Center for Advanced Computation, University of Illinois. The second step then was to look at the individual buildings and to do the same thing for them.

The next step was to look at the operating energy, including the heating, lighting, cooling, and miscellaneous loads. There were four ways that we accomplished this. The first was through the standard Manual J calculation. We also developed a relationship with one of the regional VEPCO staff personnel for the Chesapeake area and, given the development program, he modeled actual consumption in similar buildings in the Chesapeake area and gave us actual data. Then we cross-checked these data with the design loads computed by our engineers on the Manual J method and cross-checked that with computer load simulation TRANSYS and the Air Force 88 method. Fortunately, the figures were very close, so we felt we had substantiated a set of reliable estimates. Next, we converted the annual operating energy usage to Btus.

The bottom line of this operation showed that the fixed or embodied energy amounted to roughly 1.8 trillion Btus and the total annual operating energy was approximately 262 billion Btus, not including any system inefficiencies from the fuel source to the end use. The end use figure should really be multiplied by three to get the annual load estimate, including system inefficiencies and line losses.

As an exercise, we added these two together so that a single number represents the fixed cost in energy of developing 500 acres, added to what it takes to heat and cool, run the dryers, washing machines, and other appliances, etc. for a year. Although the embodied energy is substantially larger than the annual operating energy (which really should be multiplied by three), the embodied energy is a fixed cost that, when amortized over something like 30 years and broken down into a per-unit basis, is not very much energy per unit. However, the operating energy use increases over 30 years--its margin continues--and based on this, it confirmed our early opinion that the greatest

savings would not be obtained in the embodied energy but rather would be obtained on the marginal side, and resting with the consumer.

While this base model was being developed, we began to identify possible conservation options--mechanical, architectural, site, etc. We examined the feasibility from a technological standpoint, an energy-conserving standpoint, a performance standpoint, and from the developer's position. The next step was to evaluate these options, to modify them if possible, and to document the unacceptable alternatives. We have looked at about 25 or so; about 13 or 14 of them currently are going through this cycle. Most of the options we will present today are going to be on a mechanical side, although some of the options that we hopefully will present at the next meeting will consist of more site-related things such as trees, microclimate, etc.

3.3.3 Alternative Methods of Energy Conservation and Utilization

Because Greenbrier is motivated by profit, we were somewhat biased in our approach to the program in that we wanted to consider all possible methods of reducing energy. Nevertheless, we wanted to concentrate on the ones that had the near-term use and the most immediate application, so the first thing we looked at was possible sources of energy and alternative methods of conserving or receiving energy.

- *Wind Energy*

Wind is a special source of solar energy, but from a relative contour map of the United States, the Greenbrier area is not the best-suited in the country, although it is not a poor location for a wind power plant. It may be possible to generate as much as 40 kW from a wind-power plant on an annual basis.

- *Solar Energy*

We next looked at solar energy, per se. We took insolation contour maps for each month of the year and synthesized data for each month for several collector tilts. Although we have looked briefly at the solar total energy system and solar total electric systems, we feel that our data are not quite sufficiently developed to present at this time. We also examined how one would size solar collectors, using two different collectors for comparison purposes. We considered three different collector areas for each collector and the percentage that each would supply per month and annually. There is a

substantial difference between the two collectors, and we are currently doing a system study to determine the precise solar contribution from an active system.

- *Air-to-Air Heat Pumps*

Air is another source of energy. Air-source heat pumps currently are being installed in about 85% of the all-electric homes in Virginia. The air-source heat pump is one way of improving or reducing the energy consumption of a home compared to electric resistance heating with air conditioning.

In the typical operation of an air-to-air heat pump, the ambient air crosses the heat exchanger and a compressor, and freon is diverted through the system to extract energy from the ambient air. As it gets colder outside, there is less heat available in the ambient air, and the coefficient of performance (the ratio of the energy delivered to the user divided by the energy input to the compressor) goes down as the outside temperature goes down. One way to improve the system performance as installed in a house is to install the heat reclaimer for preheating domestic hot water, which is very effective. Operating with an air-to-air heat pump which has an annual coefficient of performance (COP) of 2, you can heat hot water for about half of what you would heat it for using straight electric resistance.

- *Water-to-Air Heat Pump*

Another resource at Greenbrier is water. It was discussed previously as being a problem, and we looked at it and decided it might not be a problem after all if we could find a way to use it. We have water in great abundance, not only in the lake systems but also in subsurface water; its ambient temperature of 62° is just about perfect. The 62° temperature remains virtually constant from about 15 feet down to 120 feet in the Norfolk/Chesapeake area. We talked to several well-drillers in the Chesapeake area, and they indicated that it would be no problem to get large quantities of water with a suction pump. In other words, it is not necessary to drop a pump into a well; water can be lifted the necessary distance, greatly simplifying the installation of what we consider one of the more promising energy conservation options - a water-source heat pump, which is very similar to the air-source heat pump except that the heat exchanger is changed from an air-to-freon exchanger to a water-to-freon exchanger.

Other than the heat exchanger, the water-source heat pump is very similar to the air-source heat pump with one major modification that relates to reliability. When the outside temperature falls below about 40° to 45°, an air-source heat pump starts frosting up on the outside. The evaporator starts collecting frost, so to remove the frost from the evaporator, the heat pump switches momentarily and starts heating the outside to melt the frost. That is wasted energy, because energy is extracted from inside the house and back into the outside air for the very short time that this system is in the reverse mode.

The water source heat pump does not have to do that. This valve switch is twice a year unless the weather goes from heating to cooling more frequently. A dozen times a year would be an extreme number of switches for a water source heat pump on a reversing valve; whereas an air-source heat pump may switch once an hour. As with an air-source heat pump, the system efficiency can be improved by adding a heat reclaimer. The annual COP for the air-source heat pump we discussed previously was around 2. One reason is because it has to reverse to defrost the outdoor cold and because it has to operate over such a wide temperature range. In the Norfolk area, it may be operating with air-source of 98° in the summer and 10° in the winter, so the system efficiency has to be sacrificed to permit the pump to operate over such a wide range. For the water source heat pump with a 62° source temperature, a system can be optimized for those temperatures, and a heat reclaimer can be put in, operating with an annual COP of better than 3.

• *Construction of Homes*

Consideration must be given to the way homes are constructed before attempting to provide energy to heat and cool them. From a typical cross-section of one of the homes shown previously, homes presently are being constructed at Greenbrier using an R-11 wall, and R-19 ceiling, and R-19 in the floor. One way to improve dramatically is to go to what is called the Arkansas construction. Although the typical home uses 2x4 construction on 16 inch centers, the Arkansas home uses 2x6 construction on 24 inch centers with 6 inch of wall insulation, (which is R-19 instead of R-11) and two layers of insulation (which is R-38) in the ceiling. It also uses a fiberglass caulking seal along the baseboards, where research has indicated about 25% of infiltration losses in a home occurs. The Arkansas home has shown the capability of reducing

the energy demand by half to two-thirds over the conventional home construction, which is a substantial decrease.

In the Atlanta area particularly, and we expect in the Chesapeake area as well, we found that the builders are reluctant to go to 2x6 construction. We can show them the figures that there is less wood, less cost, less assembly time; yet, they are still reluctant to change. They do not have any experience working with 2x6 construction; so they want to stick with what they have built for the last 10 to 20 years.

An alternative to the Arkansas home is a modified Greenbrier home, which would continue to use 2x4 framing but which would also use 1-inch urathane on the exterior walls and 1-inch urathane above the gypsum board on the ceiling. This has comparable performance to the Arkansas home, although, unlike the Arkansas home, it has an increased cost, because you are essentially adding the cost of the 1-inch urathane, which adds about 80-90¢/ft² to the house cost. Builders in the area are going to be presented with these options to show what they can accomplish.

3.3.4 Summary of Selected Energy Conservation Options

Table 3.1 summarizes the various energy conservation options identified to data for closer analysis.

The baseline for comparison of options is a standard Greenbrier home, (Option 0), of 2,100 ft², electric resistance heat, standard air conditioning, with an annual energy cost for heating, cooling, and domestic hot water of about \$1,100. The first option would be to go to a standard heat pump, which VEPCO says is in about 85% of the systems installed, saving 38%, or about \$409. The estimates for both this option and the next option, the high-efficiency heat pump, do not reflect the energy required for the defrost cycle which will drop these percentages of savings slightly. By going from a standard heat pump to a high-efficiency heat pump, the efficiency is increased substantially, but so is the installed cost, which is real cost. The third option is to go to the water-source heat pump, which does not have the loss associated with a defrost cycle; so in actual operation, it would remain at the 52% annual savings, or about \$560. In the price estimates we have, they actually can turn out to be cheaper, saving about \$500. When you add a heat reclaimer to the water source heat pump (Option 4), savings increase to 67%. However, the

Table 3.1 Summary of Selected Energy Conservation Options

Option	System Description	Reduction in Annual Energy(1)	Savings Per Year(2) \$	Additional Cost of Conservation Option	
				To Contractor \$	Installed \$
0	Standard 2100 ft ² Greenbrier Design, Electric Resistance Heat, Electric A.C.	0 ⁽³⁾	0	0	0
1	Standard 2100 ft ² Greenbrier Design, Conventional Air Source Heat Pump	38 ⁽⁴⁾	409	0	0
2	Standard 2100 ft ² Greenbrier Design, High Efficiency Air Source Heat Pump	53 ⁽⁴⁾	570	+ 500	+ 700
3	Standard 2100 ft ² Greenbrier Design, Water Source Heat Pump	52	559	-500+200 ⁽⁵⁾	-500+500 ⁽⁶⁾
4	Standard 2100 ft ² Greenbrier Design, Water Source Heat Pump with Heat Reclaimer for DHW	67	720	-200+500	0+700
5	Standard 2100 ft ² Greenbrier Design, Central Plant Heated and Cooled	+ 15% ⁽⁷⁾	403		2500-3500
6	Standard 2100 ft ² Greenbrier Design with Flat Plate Solar Collectors Sized to Supply 60% of Annual Energy Requirements	55	591	4000-7500 ⁽⁸⁾	8000-14000 ⁽⁸⁾
7	Standard 2100 ft ² Greenbrier Design with Flat Plate Solar Collectors Sized to Supply 62% of Annual Energy Requirements	12	129	1000-1400 ⁽⁸⁾	1800-2200 ⁽⁹⁾
8	Conventional Energy Efficient Design, Electric Resistance Heat, Electric A.C.	51-57	548-613	0 ⁽¹⁰⁾	0 +1500 ⁽¹⁰⁾
9	Conventional Energy Efficient Design, Water Source Heat Pump	71-73	763-785	-500+200	-500+2000
10	Conventional Energy Efficient Design, Water Source Heat Pump with Reclaimer for DHW	86-88	925-946	-200+500	0 + 2200
11	Standard 2100 ft ² Greenbrier Design, Oriented to Face South	4	43	0	0
12	Standard 2100 ft ² Greenbrier Design, Facing South with North Windows Removed and Added to South Window Area	9	97	0	0
13	Standard 2100 ft ² Greenbrier Design, Facing South With All Windows Moved to South Side	11	118	0	0
14	Standard 2100 ft ² Greenbrier Design, Facing South With All Windows Moved to South Side-Double Glazed	21	226	0	400-800

(1) Energy use in a given house is highly dependent upon the living style of the occupants. Energy calculations are based on the assumption that the occupants are reasonably energy conscious.

(2) Energy costs were based on constant 3.5¢ per kWhr for electricity and 39¢/gallon for fuel oil.

(3) Standard design is a single story 2100 ft² house with 104 ft² of single glazed window on the north side, 72 ft² on the south side with 21 ft² on east and west sides. Ceilings and floors have R 19 insulation with the walls having R 11 insulation. Domestic hot water demand constant at 80 gallons per day heated from 62°-140°.

(4) Energy for defrost cycle not included in air source heat pump calculations.

(5) Cost estimates from equipment suppliers.

(6) Cost estimates from local (Chesapeake) installer.

(7) Central power plant's energy consumption is gross energy whereas the other systems are net and do not include electric power plant efficiency.

(8) Solar contractor cost and installed cost from survey of manufacturers, installers and owners in Georgia.

(9) Survey indicated that the majority of the installations were close to the higher figure given.

(10) Experience with the Arkansas homes and Georgia Power answer houses.

price is even lower if the standard baseline design to the customer varies from zero to plus \$700, depending upon how much extra profit the builder wants to charge for the fact that his home is more efficient.

3.3.5 Central Station Energy Supply

We also looked at the possibility of supplying energy to the homes from a central power plant (Option 5), as is done on a campus such as Georgia Tech, which has a central plant that supplies hot water and chilled water to the various buildings on the campus. Georgia Power also supplies steam to buildings throughout the Atlanta area for heating purposes and for driving absorption chillers. This system looked good, until we saw how the customer is charged for that energy delivered.

If the customer is charged only on the amount of water he uses, it is very easy for each customer to cheat by putting in a bigger fan or bigger heat exchanger. There is really no incentive for the customer to conserve energy because his neighbor may be cheating as well, so if you charge them all a fixed rate, regardless of the amount of water they used, the same thing will happen. One way to get around this is to install what is called a Btu-meter. In other words, by measuring the temperature of the water going in, the temperature of the water returning, and the quantity of the water, the actual amount of energy that is used can be determined. This looks good until one prices a Btu-meter. Although it should not cost very much, the price estimates we have so far are above \$3,000 per home. However, because if there were a big enough demand for it, the cost would drop dramatically and this would become a logical option.

3.3.6 Solar Collectors

Homes with solar collectors, designed to supply 60% of the heating and cooling needs (Option 6), supply only 55% of the heating/cooling and domestic hot water needs because they are designed for the heating and domestic hot water; cooling requirements bring the overall efficiency down. Option 7 is the same thing except for the domestic hot water, which saves \$129 annually, but will cost \$1,800-\$2,200 to install. Option 8 is what happens in the Arkansas, or energy-efficient design, with electric resistance heating. This is the base case except for a more efficient home. By installing water-source

heat pumps instead of the electric resistance in this house, you save 71-73% and still have a cost reduction. By adding a heat reclaimer to this (Option 10), you can realize an 86-88% reduction in energy consumption.

3.3.7 Residential Energy Consumption Model

Options 11 to 14 are preliminary, and they are based on computer studies that are just now being completed.

We have developed elaborate methods of studying residential energy consumption, from both active and passive systems, although we were uncertain at first which one we should use. Available to us on campus were the NBSLD program developed by the National Bureau of Standards, the NASA NECAP program, the 9.2 version of TRANSYS, which also includes building load analysis, and we are implementing the Army-Air Force BLAST program which will handle active and passive building analysis.

In the preliminary work here we have opted to use a highly modified version of the TRANSYS program to include and allow us to evaluate some passive designs. We had to implement the ASHRAE transform program to calculate transmission functions for walls that were not in the ASHRAE Handbook. They give some 90-100 wall sections; unfortunately very few of those sections are typical passive wall constructions, so we have implemented (or in the process of implementing) the computer program for the transfer function that was developed by the National Research Council in Canada.

If we took the standard zero case home, which was facing north, and rotated it to face south (Option 11), we can get a 4% reduction in heating loads. The only difference is that when it was oriented north, it had 104 ft² of window area facing north and 72 ft² facing south. Incidentally, we looked at one of the developments that Greenbrier already has, and some 80% of the buildings are facing south. That is just a coincidence; hopefully it will not continue to be coincidental.

By removing the north windows and relocating them on the south side (Option 12), at no additional construction costs, we achieve a 9% improvement, and by additionally removing east and west windows, we increase the savings to 11% (Option 13). If we double-glaze the windows (Option 14), we get a 21% savings. Therefore, with only architectural changes and orientation on the sites, some 21% in heating costs can be saved.

In summary, the base house has zero savings. The *water-source heat pump* saves 52% with a cost of from \$500 less to \$500 more. By adding a heat reclaimer, savings increase to 69%, with a cost increase of zero to \$700. With the energy-efficient *Arkansas design*, 86% is saved by a cost increase of not more than approximately \$2,200.

3.3.8 Other Options

I would point out that these options are not only state-of-the-art, they're state of the *commercial* art. If one were actually to go to what is state-of-the-art right now, and go to variable speed water-source heat pumps and increased evaporator sizes of heat exchangers, this figure could be increased substantially. Air-source heat pumps already are beginning to reflect this level of technical development. There are not enough locations in the country and the demand on the water source heat pump manufacturers has not been such that they have incorporated these innovations on commercially available models yet, although we expect them to begin to do it very shortly. As an indication of what could be realized, Lennox now has on the market a two-speed air conditioner with an EER of about 9, which is 3.4 times the coefficient of performance in the standard operating mode. When the outside temperatures are relatively low and there is not a high demand on it, it switches to a lower speed and the EER jumps to 13. That is the sort of improvement that really is state-of-the-art right now. If that were combined with what we have here, we would have a substantial savings without going into anything really elaborate.

There are a few summary comments we would like to make from the midpoint of our process. One of the biggest surprises that came out is that, after running various computer models on orientation of houses--especially after anticipating spending a good deal of time changing site plans around to get everything facing south--there was a likely improvement of only 4% over a random facing. It was also a surprise to discover that the money that is required in terms of the infrastructure, the horizontal investments, streets, sewers, and so forth, has a budget from an embodied energy cost is about equal to that of the vertical cost, but more importantly it is only a little over one year's operating budget for the whole design. We have played the game of shrinking streets up to four feet in width and we didn't pick up much. So in

the terms of the actual energy savings that are available to us as a developer, those are not substantial in terms of design changes in our site. We do not have the natural resources or the natural energy of the northwest wind that is obviously a problem up in the upper New York state area. The one resource that we do have is the groundwater, and obviously we are going to work on trying to extract the thermal value from our groundwater. That seems to be, at this point, by far the best resource that we have found. That constant 62° water all winter long is much better than anything else that we have found.

To get over the problem of the discharge, we will look at the loop, which might allow us to transfer our concept to other sites more readily as well. Fundamentally, then if we look at what we can do as developers and neighborhood planners--we are not community builders--3,000 acres is a sizable development, but it is still not a whole city. It became obvious to us that the kind of impact on the annual energy budget that can be made through simply causing energy-efficient construction, in this case, water-source heat pumps with heat-recovery systems, far exceeds any other impact that we can have.

We have concluded that we *can* have an impact in our community, and we *will* have an impact in our community. We are going to prepare a series of little pamphlets that we will give to our builders to try to convince them that it is a good idea to use an Arkansas system or at least to add the one inch of urathane. It is a good idea to put in the water source heat pump with a heat recovery system; if suggestions do not work, we may consider going to the city and suggesting it change some building codes, based on the obvious energy conservation capabilities of some of the systems we have discussed.

In addition to completing the evaluation of about another 20 or so options that we have yet not fully treated, in the second half of the study we will be trying to implement some of the obvious savings, the simple savings, and the state-of-the-art savings, that are available to us today. One final comment--just a footnote--if we were to go the the energy-efficient design with a water-source heat pump and a heat reclaimer for the entire Greenbrier installation, annual savings would amount to 70,000-100,000 barrels of oil a year.

3.3.9 Synopsis of Discussion

No back-up system is required for the water-source heat pumps because the source water is 62°. Just about all air-source heat pumps have to have the back-up system, because, as the ambient temperature drops, the heat pump soon reaches a point where it is unable to meet the load. A water-source heat pump is sized to meet the heating requirements rather than the cooling requirements, as is typically done with an air-source heat pump. You can supply a back-up if you are really worried about it, but a very few installations we have talked to have done so. One installer in the Chesapeake area said that in about 90% of his installations, the owners were electing not to go to electric resistance back-up.

The system is sized for the heating demand, which obviously oversizes it for the cooling demand, which introduces some inefficiencies in the cooling cycle because the system comes on and off. For this reason one must go to two-speed or variable-speed heat pumps that run on high speed in the heating mode and when there is a heavy demand, and cut back to a slower speed when there is a light demand in the heating mode. In the cooling mode, it almost always operates on a slower speed, which is how it matches up the heating and cooling loads to keep the heat pump on the high point of its efficiency and keeps it operating at significant percentages of time. If the operating time is reduced to a very small fraction, it will become unable to supply pre-heat or domestic hot water. The evolution in modern heat pump installation--modern being in the last 5-6 years--has been to increase the flowrate from the water. Today they recommend three gallons per minute per ton. For one of Greenbrier's typical houses, this is a large water volume, and for a subdivision of 100 houses, the total becomes over a billion gallons of water a year, which brings up one of the problems that has to be addressed: the State of Virginia's requirement for discharge permits.

Part of the problem with Virginia legislation is that it is basically groundwater pollution legislation. There are probably several thousand water-source heat pumps operating in Virginia, but the question of whether formerly heated water is polluted has not come up because no one has ever applied to the State for a permit to discharge back into the aquifer. To consider a billion-gallon discharge, Greenbrier will probably have to discuss the situation with the proper state agency, which is one of the things to be addressed

later in the study. One alternative to the problem of having every house with two wells, an intake well, and an output or discharge well, would be a closed-loop for the water system alone to balance the loads between the houses and perhaps burying some pipe or several coarses of pipe for dissipating or collecting energy. In other words, this option would use pipe buried in the ground some 15 ft deep to pick up the temperature in the winter time and to put it out in the summer time. That is half-way between the community system and individual applications in the sense that everybody has his own compressor and heater, but all receive energy from a common source, the earth.

Anybody familiar with so-called ground-loop heat pumps is aware of the problems that are typically encountered where the ground does not have a high conductivity and it becomes saturated. However, we have a unique condition at Greenbrier: a foot and a half in the ground there is water, which is an excellent conductor. Therefore, dropping the heat loop down a couple of feet places it in a conductor that allows it to dissipate or collect energy readily. The developer is actually looking at an installation to supply a number of homes with a loop that would take advantage of this unique characteristic of the location. To date, increments of 10, 20, 50 and 100 units have been analyzed on a preliminary basis, although the figure of 100 units appears to be the minimum necessary to achieve feasible economics of scale in terms of supervision, maintenance, and other considerations beyond engineering computations that add to a system cost.

The Greenbrier study has not prepared any options that modify transportation energy consumption. Basically, the site design--the major infrastructure in the site design which could impact the number of trip miles or any other measure--has been committed. Because it is already partially constructed, we will not tear it out and change it. There are some connecting streets that are going to make very minute differences in terms of the intraproject traffic. They were examined, and, in essence, the study team quickly concluded that there really was not anything to be gained by changing the existing street directions or, for example, the one-way systems, etc., because the major construction arteries are already there at a cost of \$9 million and were not going to be redesigned.

3.4 SHENANDOAH - MR. MOORE, ET AL.

Shenandoah is planned, much as many other new communities, to be a series of villages, that will be developed in stages, one at a time. The current village under construction is adjacent to the general location of the energy-conserving site, a 235-acre area with a mixture of land uses.

3.4.1 Location

In the development of our baseline, our central plan, and the work that has been done on our passive design options, the first thing we analyzed was the site itself. This was necessary to acquire a budget for the site, based on the cost of roads, bridges, sewers, etc. If we choose to modify this infrastructure in the development of an energy-conserving plan, we will be able to accommodate the changes to determine the cost baseline for the modifications. In this process, we have also fleshed-out the layout of the infrastructure, multi-family, and single-family residential areas, and the rest of the developmental program.

Moving from the infrastructure, we began to survey and inventory the site to determine the resources that were available from a passive design standpoint. Data was acquired, including topography, physiography, vegetation, soils, prevailing wind patterns, and slope aspect. These factors were then combined to identify advantageous microclimatic situations, that are a composite of site geology, physiography, vegetation, and wind patterns. This led us to what can be called a sub-optimum passive design, where, based on our best estimation, various structure types are located on the basis of microclimatic site conditions. Included in the more desirable areas are the two commercial centers and higher density residential uses, such as garden apartments, that can take better advantage of optimum slope exposure and wind shading.

3.4.2 Design Options

Part of the structure options and some of the end-user design options we are considering can be described as end-user solar, such as the case in an actual solar home where we are collecting performance data. There are also several Arkansas-design homes that have been built at Shenandoah, and we are

collecting data from these also. These data will then be fed into option packages for consideration in evaluating end-user technologies.

Under the third level of design options, we consider centralized utility systems. From an engineer's perspective, central plant options rank highly in terms of priority for investigation. Developers, however, want to back away from them because of the thigh initial investment. We are fortunate in that Shenandoah Development Corporation is open-minded regarding central utility systems.

3.4.3 Technical Feasibility

The first consideration in central utilities is technical feasibility. The advisory committees impose a certain degree of restriction by demanding that we consider options that are competitive with other housing markets and are actually financeable and buildable. Therefore, in considering the technical feasibility of any options, we do not intend to explore any concepts that have not been at least examined in technical feasibility studies. We are also considering the site-specific energy requirements at Shenandoah-- both in terms of quantities required and the cost of delivery to the site. Conventionally, Shenandoah uses gas heating and electric air conditioning; so both gas and electricity are currently available. We will also be considering departures from the conventional approach, which will have to be evaluated regarding their impact on the *salability* of the community.

3.4.4 Financing and Ownership

Looking at the financing, ownership, and operation of a central utility, it was made clear very early in our considerations that, even though Shenandoah was open-minded about having a central untility, it did not want to become a utility and get into operating a utility system. That constraint has been present from the beginning.

3.4.5 Central Utility System

We are also investigating the phasing of a central utility system. The 7,400-acre development will be developed over a 25-yr period. If this entire area is to be served, there will definitely be a large phasing problem. One of our first steps was to review the feasibility studies that have been made

and the results that could be anticipated in selecting a central utility system for analysis under our methodology.

3.4.6 Total Energy System

Under electrical-thermal options, the first examined was the Total Energy System, where a boundary line is drawn around the site, and the energy requirements are supplied inside that boundary by generating electric and thermal energy for all on-site requirements. Historically, these have met varying degrees of success, although it is extremely difficult to recover waste energy in the quantity necessary to meet the thermal requirements.

3.4.7 Total Integrated Energy Systems

The second concept, TIES, or Total Integrated Energy Systems, would generate electricity and then recover waste heat for thermal uses within the site. TIES is different from the Total Energy System because the electric energy that is generated is contingent upon the thermal requirements of the site, which are met by the waste heat from generation. Excess electricity is then simply sold to the grid, in this case, Georgia Power, which allows the maximum efficiency of the system.

Looking at a Modular Integrated Utility System (MIUS), as a total service scheme, we would operate a central utility plant in either a Total Energy or TIES mode; in addition, however, we would provide services such as solid-waste incineration, industrial water supply, and sewage treatment all in one plant.

Other thermal schemes under consideration include the conventional central heating and cooling scheme of district heating and also some type of distributed heat-source/heat-sink scheme similar to what is being considered at Greenbrier. Unfortunately, there is no natural heat sink or heat source on site, and groundwater is not available in sufficient quantity.

For electric generation, we have also been looking at conventional generation of electric power in a cogeneration-type plant that would provide high pressure steam for industrial uses. We are also considering fuel cells located semi-centrally around the site, and finally, possible combinations of these various generic options that have been enumerated previously.

The base plan we started with has varying types of uses, predominantly residential, with some light commercial and institutional. There are no heavy thermal loads, other than the typical residential requirements, and the conventional plan has already been planned for by the utility companies. Because gas is available on the site, there is no difficulty in projecting base loads. Two electric utility companies on the entire Shenandoah site are the Georgia Power Company and a local EMC, which is a distribution company and the sole supplier of the study site, although Georgia Power supplies the nearby industrial portion of Shenandoah.

3.4.8 Methodology

The methodology that is being taken in developing load estimates for the study site is a departure from conventional developer practices, where the utilities usually perform this function. This methodology takes input from the developer on the types of land use and structures that will be built along with technical assistance from the energy planning team of architectural, landscape architecture, mechanical, and electrical consultants to synthesize and project load profiles. These data are then fed into a building energy simulation, based on latest data for different types of structures and are then summed up into a composite load.

Currently, we are looking at two systems to achieve this. One would be a computerized building simulation program by the Automated Procedures consulting engineers; the other would be to use the Bin Calculation Method, which is readily applicable by other consulting and development firms. The latter option is not something unique to Georgia Tech; rather, it is available throughout the construction industry.

Preliminary indications are that the peak loads are probably 1,800 tons of air conditioning in the summer and 15 million Btu/hr in the winter. Typically, throughout the Shenandoah site, high summer cooling requirements drop off in the winter with the rise of high winter heating requirements. There is a base electrical load of about 650 kW, with the superimposition of cooling requirements if we choose to meet the cooling demand with electricity.

Originally we thought that any central utility scheme would have to be tied to the entire 7,400-acre development because we did not believe a sufficient load existed on the study site alone. The first utility site we con-

sidered was adjacent to the industrial park. We examined a cogeneration-type plant to provide electric and thermal energy to the industrial parcels and then possibly to supply the residential community with low-temperature thermal energy.

The second site we considered was more centrally located with respect to the entire development, and would involve a cogeneration facility that would provide electric energy in a TIES mode and distribute thermal energy throughout the whole site. The third consideration was a MIUS-type plant adjacent to a proposed lake. This impoundment will not be created because current planning calls for water supply and sewage treatment to be handled by the city and county.

Other options were examined and had specific site problems associated with them. There is one major water source on site, White Oak Creek; from preliminary projections, the flow of that creek would be cut in half if a 50-MW conventional generation plant were located anywhere on site. To provide the million gallons of water daily necessary to such a plant would require a retention pond of over 600 acre-feet, creating a severe surface water limitation in addition to insufficient groundwater availability. In terms of primary energy availability at the site, coal probably will cost \$50/ton delivered. The third limitation is the problem of phasing: it will take 25 years to have enough thermal energy requirements to make the proposed plant effective.

Returning to the scale of the study site itself, there are two possibilities that will be further explored. The first is a form of central solar energy plant that provides thermal energy. Within the part of the site that is in the 100-year flood plain, we can elevate the collectors on stilts and utilize this fairly low-value land for heat collection. One promising scheme is a system that could be sized for heating requirements and have electric cooling which would be run off-peak at night and store chilled water for distribution during the day.

The second concept would be a form of TIES-mode central utility plant that would be run on thermal requirements of the site and would take into account electric energy to the grid. We located the plant so we could back up some type of a cooling water requirement and also so that we could radially extend thermal distribution to new development.

Over the three and a half months that we have been working on the project, the main purpose has been to design a case study using the specific site at Shenandoah and to be able to translate the essence of the study to a form where other developers could learn how to combine land-use options with energy-conservation techniques on their particular sites. The following portion of the presentation will address this concern by describing our methodology and going briefly through our analysis of the conventional plan and the three levels of conservation plans that we have.

To date, our efforts have focused on central utilities, land planning, and on collecting data and associated costs of decentralized conservation techniques. To provide a brief scenario of the technique we are going to use, given the conventional plan and the data we have generated, we will generate a demand profile from the load requirements of the conventional plan. The demand profile will generate energy costs. Structure, and infrastructure cost will be estimated from the conventional plan, creating a combined baseline for costing (see Fig. 3.4).

Fig. 3.4 Design Profile of Conventional Design

The site analysis data will enable our landscape architect to assemble an optimal passive design, using such passive techniques as the Arkansas construction, orientation, glazing, etc. From this passive design, a new demand profile can be constructed to generate energy costs, and new infrastructure cost will be estimated to enable an economic evaluation of the passive alternative (see Fig. 3.5).

Fig. 3.5 Design Profile of Level 1 Passive Design

The second level of the conservation plan (see Fig. 3.6) will begin with the passive design and the survey of the decentralized active systems, including active solar heating, solar hot water, heat pumps, etc. All these decentralized options are available with cost figures for installation, operation, etc. Because passive design is good energy design, regardless of what else is attached to it, we will combine the Level 1 passive design with the decentralized options. This will then generate another demand profile, more cost figures, and other economic evaluations, including feedback into the survey of options to optimize returns in this respect.

Fig. 3.6 Design Profile of Level 2 Passive Design with Decentralized Active Systems

The third level (shown in Fig. 3.7), involves a somewhat different flow of events. The demand profile of the conventional plan is combined with our survey of central utility options to produce a centralized utility plan, whether it is on-site only or it includes the entire 7,400-acre Shenandoah development. After we determine what central option(s) will be employed, we will develop a new site design that responds to central utility requirements on the site. This will then generate another demand profile, its associated costs, and another economic evaluation.

Fig. 3.7 Design Profile of Level 3 Centralized Utility Plan

This process will generate three conservation plans through a simple systematic approach. Each plan has different costs and different effects on energy demand, and different incidence of costs and benefits. Next we will analyze the effect of these three options on energy usage and the dollar costs, i.e., initial, operating, and replacement costs. Throughout this process, we are continually dealing with the margin--marginal effects, marginal costs, and marginal benefits.

Payback period is not an accurate technique to determine a cost figure and total energy savings if we want to examine several options together because the analysis and viability of the last option that was added to the list is often lost. Therefore, we are operating under the assumption of starting out with the option that saves the most energy and continually working down with depreciable terms for both energy usage and cost figures. The analysis we hope to use will isolate the dollar and energy effects of each option.

We also want to calculate the degree of variability that the various options have in different situations, as well as the incidence of savings in costs and/or benefits. The establishment of incidence, i.e., who pays for a given option and who benefits from it, is a basic input to another part of the study dealing with institutional and legal barriers. By isolating costs and benefits for the various options, we can see what inducements may be necessary to overcome specific barriers.

The next step is to perform a kind of sensitivity analysis that will take a discount rate, inflation rate, and energy escalation rates and change them through a series of steps to see if some of the options change. Basically we will be using probability functions to calculate the expected value of the rates of inflations and estimated escalation.

Coweta County has a time-of-day rate differential. From noon until 8:00 p.m. the rate is 8.5¢/kWh; from 8:00 p.m. until noon it is 1.5¢/kWh, which will probably have some fairly basic effects on energy usage. We have the demand profiles available on a daily basis, so we are going to try to isolate use of specific end-use items and apply this cost structure to see what the effect would be. County residents currently have a choice of whether to go on the differential rate, so we will see what effect that choice has on the study.

When you set up a model, certain variables define and specify the model. These variables are either endogenous or exogenous. An endogenous variable is one that is determined within the model; an exogenous variable is determined outside the model. In our model, land use density is an endogenous variable. We will input the site characteristics into the model for analysis and give us the appropriate land-use density. The inflation rate is an example of an exogenous variable: nothing we can do in the model will have any effect on the inflation rate.

A second variable that is generally considered exogenous is the utility rate structure. To a great extent rate structures are exogenous, but they can be affected by the model, although not by the 235 acres of our study site. However, if the site were larger, it would have an effect on rates.

From the utility point of view, this effect would be felt through the total cost curve of generation (\$/kW) over a period of time (see Fig. 3.8). If we assume a given baseline growth curve ("A"), by reducing energy consumption through conservation, the demand for new energy in the future will be lessened. Because new plant equipment construction is much more expensive

Fig. 3.8 Utility Cost-Savings Through End-Use Conservation

than old equipment, by reducing the use of energy through conservation, the new plant equipment construction by the utility would be slowed, thereby depressing the entire total cost curve (B). From Fig. 3.8, starting with time, T, and moving through time, T+1, the difference from the baseline Δa to Δb in the depressed cost curve is the marginal cost savings through end-use conservation as viewed by the utility.

To address the relationships that have developed among our study team and the utilities, builders, local development officials, and review bodies, we have formed two advisory committees: one with marketing expertise, and the other with financial expertise. We have met with each of these committees and would like to share their views.

The *Marketing Advisory Committee* had a mixed response to the question of whether people would pay extra for energy conservation in new houses. They did, however, stress the advantages of a public education effort in this area, and one member thought there ought to be a massive campaign at a General Motors advertising level to get more information to the public about the energy savings that are available.

At least one such effort on a national scale is being put forth by National Homes, who is putting out what it calls the affordable solar house. The vice president of marketing for National Homes came to Shenandoah at a DOE seminar and spoke about the impact of this particular program and the way in which the media can be used effectively to do the sales job. The outcome of this campaign was that one of every five houses that they sold in succeeding months was the so-called affordable solar home, which most of you know, is little more than a solar water-heating device.

We have been trying to assist in the education effort as well, where we have taken one builder's houses and features them on the front page of the Homes and Gardens section of the Atlanta Sunday newspapers. One of this occupants of an 1,800 ft² home had a natural gas bill of \$8.84 for the month of November -- heating and cooking. Georgia Power Company advertisements also support conservation. There is one that shows price tags in the lots of two houses. The house on the right is \$2,000 cheaper than the one on the left, but the copy says the house on the right, which actually has a cheaper buying price, will cost the owner more money than the house on the left. By the

Good Cents Program that the power company has, you save in the long run on utility bills; therefore, the more expensive house saves money in the long run.

One of our advisory committee members suggested that the most effective way to educate the public is by comparing the cost, added to a mortgage by energy conservation features amortized over the 30-year life of the mortgage payments, then figuring out the utility cost per month, and finally comparing that particular rate. When you see the savings that you are going to get month by month, he says the buyer will opt for the particular energy conservation house, which is exactly what National Homes is doing.

Some other opinions from the Marketing Committee include:

- Tax credits for installation of conservation and solar options will help (if they ever come about). In southern California, there is a boom in solar housing, due ostensibly to the State's 55% solar tax credit.
- Only a few people will try earth-covered houses; the majority will not. Most people want to live in a house like they grew up in, a single-family detached. Builders cannot get loans for earth-covered houses because there is little market history of their resale value, so government loan guarantees were one method suggested by our advisory committee.
- On passive solar, the trombe walls would be acceptable if there is some light entering from some direction or other, but the cost may not be as low as expected on the basis of two proposals that were submitted in the passive solar competition for Shenandoah houses, which aggregated about \$4,000-\$5,000 in extra cost over the conventional house.
- Builders and buyers would accept central utilities on two conditions: (1) that neither the builders nor the buyers will be responsible for the central utility system; (2) that if an existing or a new utility company is formed and can document savings to the buyer, then the central utility concept might be accepted.

We also have a *Financial Advisory Committee*. When asked whether energy conservation features are a more attractive package for lenders, one of the members gave us a strong *yes*, due, in part, to a number of recent foreclosures on all-electric homes. The committee indicated it felt that lenders are starting to look at energy conservation features of a home and to talk to buyers about the fact. All of them agree that the ultimate resale value of a house

is the key to the lender's attitude. If he discovers that an energy house will sell quicker, it gives him greater assurance that he will get his money back in the event he has to foreclose.

Another banker suggested an incentive of reducing interest rates for energy conservation features by one-quarter to one-half percent off the regular lending rate. In fact, an Atlanta bank tried that for a short time, but we do not hear much about it anymore, and we need to check on how well that did (or did not) work. However, at least two Georgia savings and loan institutions do require energy conservation features in a house now before they will make loans on the house.

The lenders are cautious about solar energy. Most simply do not even include it as a part of the appraisal of the house. They say that the 2x6 Arkansas house has proven itself, but the solar has not--there is not enough history of its dependability and its dollar value. They maintain that they must have a proven record of the resale value of the house before they can put it in their calculations.

Other comments expressed by the Financial Advisory Committee addressed a reluctance to consider overly innovative ideas, such as the earth covered house--as one referred to as "early mole-hill style"--again because of potential resale problems. The long range maintenance and ownership questions associated with centralized utility systems were also seen as problems.

3.4.9 Georgia Power Company - Mr. Hensley

One of the first questions my management asked me was why, as a profit making utility, should Georgia Power be assisting any organization in reducing our sales. This question has probably been asked by every other utility as well.

I will try to answer the question and show why we are interested in becoming involved with a project such as Shenandoah. I would also like to speak briefly about what growth means to the electric utility. The comments I will present are general, and they should be fairly broadly applicable around the country.

An article called *Energy Conservation Rates from Effective Conservation Programs* from the August 17th issue of Public Utility Fortnightly addresses

the question that was asked about the impact of rates and how they can be used in evaluating energy reductions. The author, who is a registered engineer and a lawyer, presented four points:

- (1) conservation means a reduction in the amount of energy sold;
- (2) a reduction in the amount of energy sold means a reduction in revenue;
- (3) reduced revenue under the declining block rate structure now in general use results in lower earnings; and
- (4) reduced earnings are followed by further increases in rates.

The author goes on to say that this is a vicious circle and that this continuous rate-increase cycle would cause the customer to ask why he was being penalized with higher rates even though he had spent hundreds of dollars to reduce his usage. He would still be paying the utility the same as those who did nothing, and neither the Congress, nor the President, nor the bureaucrats would be blamed. Only the utilities would be blamed.

The facts the author presents in this particular article are true, but his conclusions are wrong. A rate reduction from conservation does not reflect back into the rate structure 100%. First, the impact of the variable cost, i.e., fuel, is eliminated and does not have to go back into a new rate. Secondly, the assumption that everyone is going to consider conservation is a fallacy--it is just not going to happen.

Energy conservation is going to take place very slowly, and the impact of conservation can relieve the utility of providing a very high cost marginal plant--or at least delay its construction. Because the reduction in expense reflected back to the customer through the rate structure is less than the marginal cost (it is only the average cost), any earnings reduction suffered because an individual customer reduced his consumption is made up by a rate increase. About 60% of this amount represents fixed costs in the average rate, which will be spread over all customers.

Assuming one to five percent of the customers engage in conservation practices, those customers are still going to see 90% or more of their billing reduction even though a rate increase takes place to recover these fixed costs. In the short run, there is good reason to believe that from the customer's point of view, the consumer who spends these hundreds of dollars for energy

conservation is going to enjoy the benefits. There is also good reason to believe that the long-run marginal cost reduction that the utility is going to experience is even greater than the consumer's benefits.

The second point I would like to address is growth, and our reasons why we should be involved in a project that is obviously going to supplant some of the energy that the utility would normally supply. Our reason is simple: *future growth has to be served out of future plants, and future plants cost more than existing plants.* The rates that are granted to any utility generally are based on existing or embedded plants, with one or two exceptions. Generally speaking, since existing or embedded investment determines the rate level and since the system exists where costs are increasing over time because of growth while prices remain fixed, returns must be assumed to decline. By reducing the rate of growth of its system, the utility can reduce the rate of cost increases and can at least diminish any losses, given constant price levels.

Basically, if the utility grows under the regulated climate that we have today, the faster it grows, the worse off it is; and the slower it grows, the better off it is.

A vital point is Georgia Power's concern as to how all of this relates to the general economy of the state. We are obligated to serve the electric energy needs of the territory to which we are assigned. However, we want to do that with the lowest possible investment. When a new customer comes to the state, we have two sources that can be used to supply the capacity and the energy that customer requires. The first source is to build a new plant and burn additional fuel.

The second option is much better as far as we are concerned. If we can produce the same capacity through conservation by recapturing energy from existing, inefficient uses, we will not have diminished in any way the economic growth of the State, and we will not have punished any customer; in fact, we will have helped the customer to conserve energy and save money. In general, we will be able to hold down total rate increases by conservation.

3.4.10 Synopsis of Discussion

Two general points were made in response to portions of the presentation. First, the alternative view of the effects of marginal costing and growth on

utility marketing strategies has been presented to utilities. The acceptance of the incremental costing idea by the utilities has not been as great as what was originally anticipated.

In confirming some of the market reluctance for conservation referred to by the Advisory Committees, workshop participants, familiar with the California experience, indicated there was a very strong time threshold of at least 5 yrs intended occupancy before an owner was generally willing to invest in energy-conservation features.

Several scales of analysis up to the entire 7400 acre development were used in analyzing central utility options. Land-use mixture was not investigated, because most of the problems encountered were site-specific, such as the cost of energy sources at the site, availability of water, the types of likely energy usage due to the lack of heavy industry, and phasing problems relating to the amount of unusable excess plant capacity. The study team concluded, however, that if some of the land-use phasing could be changed, or if different land-use mixtures, particularly industrial, were feasible, a central utility scheme might become much more attractive.

3.5 THE WOODLANDS - MR. SWANSON, ET AL.

3.5.1 Introduction

Our presentation will cover the methods that we are using in our preliminary analysis. Basically, we have completed our analysis of the conventional plan and are now in the process of examining energy-conservation techniques, based on some tentative quantification we have developed. Later, these methods will be translated into plans, which will be compared with the baseline. We will perform a sensitivity analysis on this comparison and evaluate any constraints on achieving the plan. This information then will be summarized and included in our final report.

The marketing program has been broken down by parcel in terms of different land uses covering building square footages, number of floors, number of employees, conventional parking ratios, parking structures, building coverage, and open space percentages, all of which are input to our energy consumption model. In brief, this breakdown covers some 12 million ft² of building area and over 37,000 parking spaces.

3.5.2 Methodology

Our approach to the baseline plan was to develop a schematic diagram of the Metro Center using marketing data that had been provided. This plan breaks down each marketing parcel into the space requirements for buildings, parking, parking structures, and vegetation, which has been graphically depicted. In many cases, we have made assumptions as to what building prototype will be used on a given parcel using various sources available to us, which will allow us to determine building loads and thus to permit some flexibility in the assignment of the development program to the site marketing conditions. We also have the ability to create additional energy-efficient building prototypes or modify any of the 40 existing prototypes for consideration in the energy-conserving plan.

Our process is characterized mainly by its quantitative analysis, although there are many aspects of the energy analysis program that cannot be quantified. Some of the more important non-energy criteria also are included in our processes--particularly nine that we have defined as especially important. Each will be briefly covered.

- (1) *Marketability* is an imprecise concept dealing with the degree to which a concept is acceptable to the public as a buyer. It is necessarily measured subjectively, but is still quantifiable.
- (2) *Functional Planning*--the relationship between land uses--describes how various activities ideally exist and how they relate. Altered land uses are an option under energy conservation, and we believe we will be able to quantify these relationships on a 0 to 9 basis, and by using a rank difference squared technique to emphasize differences among plans for analysis and comparison.
- (3) *Environmental Aspects* will be evaluated to the greatest quantitative degree possible, including residuals production, surface coverage, etc.
- (4) *Socioeconomic Aspects*, including the man-environment relationship, the effects on human behavior patterns, socioeconomic stratification, human needs, and psychological effects, are necessarily subjective.
- (5) *Legal and Political Criteria* include national, state, and local laws and procedures and the probability of political acceptance of an alternative, which will be made against a check list of regulatory requirements. This analysis can be done more specifically than is possible in the case of the socioeconomic aspects, although it will still remain largely subjective.

- (6) *Technical Feasibility* is a judgment factor based largely on known trends in the energy industry. A subjective analysis will be made on each alternative, but it will be from the basis of a high degree of engineering skills.
- (7) *Development Economics* includes the land development, building development, and utility infrastructure items and will be evaluated with the traditional cash flow model that The Woodlands has been using for some time.
- (8) *Financing* will be evaluated in terms of the possibility of financing through public and private sources or through grants. This will have to be subjective, to some degree, so that we can get input from the advisory group with respect to what its specifications are, how it normally views investments, and how it would allocate monies to those investments. Obviously, the availability of grants, etc. would have to be a subjective analysis.
- (9) Finally, there are the *aesthetic considerations*, which would have to be judged strictly on a subjective basis.

The overall analysis would be done by taking each of these nine characteristics and scoring each plan or energy-conserving plan across the nine variables--zero being unacceptable, four being excellent. In the overall evaluation framework, we will reject the plan if there are any zero scores, if there are two or more scores of one, or if there is a total score of less than 18 out of a possible 36. This procedure will give us a mechanism for determining feasibility of a plan and will aid in choosing among plans. For example, if one has a score of 28 and another has a 20, that will give some idea of the relative acceptability. It is a mechanism that attempts to take somewhat subjective, somewhat nonquantifiable variables and put them into a framework that will allow an analysis on a quantitative basis into a semi-quantitative technique.

3.5.3 Energy Consumers

The energy-related aspect of the analysis is an attempt to document or to outline the energy and material flow patterns through an idealized system. The technique we are using is a modification of one that Howard Odom developed. By identifying the place where energy is converted and used, and by identifying where energy is being stored, one begins to take a first step in identifying where energy can be conserved. Ten components are represented in some form in this analysis network. Extraction and processing of raw materials for

use in the building itself is an energy-consuming item, as is building construction as an activity, and building maintenance.

Energy production and supply is a major consumer of energy. In any type of energy analysis, the 33% efficiency of electrical systems supplied from a central plant must also be taken into account.

Water supply systems, their source, water use and reuse, and the chance for doing something with storm water all affect energy use. Transportation is an important variable, and the end-use equivalent in appliances within the building certainly influences the energy consumption pattern. Environmental conditioning, particularly in Houston, where there is hot, humid weather is an important aspect in the heating and cooling of the building within the shell.

Waste-water treatment and disposal also can be a major energy consumer. As you go to tertiary sewage treatment the energy costs begin to increase substantially. Solid-waste treatment and disposal certainly is important, not only to energy consumers, but to potential energy sources to show where inputs would come from; where the energy could be produced; and how it can be reused within the system itself, we are trying to treat landfill, pyrolysis, anaerobic digestion, and incineration in all its systems. For example, hot water can be produced from any of these systems, except anaerobic digestion, and can be recirculated within the fabric of the Metro Center itself. The network presentation is an important aspect of what we are doing because it presents the analytical framework that will be followed throughout the project as our overall approach to energy consumption.

3.5.4 Energy Consumption Model

The next step for an energy analysis of The Woodlands, would be the work that Texas A&M has done for a computer model that determines energy consumption within the building itself. The gross area, the "U" factor of the walls, ground reflectivities, shadow factors, thermal time lags, etc. are all other variables for which assumptions are made on a generalized basis.

Obviously, all these buildings have not yet been built; so some assumptions will be made by building types. There are as many as 40 different building typologies for which these assumptions would be made. This would lead

to a month-by-month print-out going from January to December of energy consumption with regard to average temperature, average wind speed, total hours, and average daily solar radiation, leading, in turn, to heating energy demand, hot water demand, a cooling energy demand, and light energy, which is used for electric lighting within the building, distinct from the cooling and heating systems, fan energy use, total energy demand, etc. The energy model will be able to identify where we can conserve energy in each building, where our options lie, and gives us a quantified base from which to evaluate any energy-conserving plan that we develop. Electrical demand is added to a total resource demand which adds gas use plus the electrical use converting it back to the source of generation. This takes into account the 33% efficiency you get in the actual generation facility.

You can summarize across all of the land uses, in the case of total winter heating and come up with a total of 441×10^9 Btus, leading to a total analysis of the conventional plan for energy consumption of 3.2×10^{12} Btus/yr. This is an analysis strictly of the use of energy within the buildings for the maintenance of the plan; it does not include transportation. The 3.2×10^{12} is the baseline for the Metro Center and for the overall evaluation of any energy-saving alternative in terms of percent reduction.

The transportation analysis simply takes each of the land uses and makes traffic assignment over the existing road network of the conventional plan. The roadway requirements generated from the trips range from two-lane to six-lane roads. The conventional plan generates the possible need for a bus network for three routes. This energy model category includes propulsion energy, maintenance energy, roadway construction energy, and vehicle manufacturing energy. The total transportation energy use for the conventional plan on a daily basis when aggregated to an annual demand is roughly 1×10^{12} Btus, about 25% of our total energy demand for the conventional plan.

Construction, or the materials used in construction, also have Btu characteristics associated with them. We don't know how much we can affect the energy savings (conservation) through the selection of materials; however, we have developed research coefficients for the various types of materials used. We do not know how successful this will be, but it is certainly an aspect of the analysis we want to study.

The energy consumption profile for the Metro Center was estimated to be about 3.2×10^{12} Btus in 1999 for the full build-out. This total is strictly for buildings and does not take into account the transportation, nor does it take into account the materials or energy used during construction. A cumulative total has not yet been developed.

With regard to certain energy options, we also felt that we wanted to expand the scope of analysis over the entire Woodlands' development to look at options such as utilization of solid waste and materials for energy supplied. An energy consumption profile of the build-out of The Woodlands, excluding the Metro Center, amounts to about 12.5×10^{12} Btus/yr in 1999. It is interesting to note that the Metro Center represents a small fraction (less than 5%) of the total land area of The Woodlands, and approximately 20% of the energy load.

Breaking out materials, and material construction patterns, and looking at the overall use within The Woodlands, we can see what kind of a market we are considering with respect to any type of available generation alternatives. We have a profile of solid-waste generated Woodlands-wide to see what type of energy supply we would have to work with for pyrolysis, anaerobic digestion, or any of these types of alternatives for outside energy production.

3.5.5 Energy Savings Approaches

In looking at the various alternatives we have for saving energy, two approaches have been taken: first, augmenting the supply of energy; second, reducing the demand for energy. We have a conventional system from an electrical power standpoint, and we have also a number of onsite power alternatives that could be utilized to augment space heating and cooling, potable water, wastewater treatment, and transportation alternatives. We have a baseload electrical power need that can be altered, perhaps by different methods of lighting, the manner in which the activities within the household are conducted, various alternatives to reduce the space-heating and space-cooling demand, reduction of hot-water needs, solid-waste generation, and reduction of transportation demand and perhaps reduction of demand through site planning, per se. The idea is to lay out the options we have and try to determine what coefficients are associated with each of them in terms of both dollar value and potential conservation. These are fed back into the network system where we can begin to quantitatively assess the flow of materials and energy through

The Woodlands and can show in each the point where we can reduce the amount of loss by either augmenting supply through reuse of materials, or by reducing demand for the particular item that is identified on the network.

The conventional utility system within The Woodlands includes central plant purchase of electricity, electric resistance heating and gas heating, compressive chillers for cooling and humidity control, a municipal utility district that provides the pumping of water, and a municipal utility district that provides liquid waste treatment. Solid waste is landfilled.

Three alternatives currently are being considered as overall supply augmenters:

- (1) to take a conventional system like central generating facility and work within individual buildings to augment supply at the individual building level;
- (2) to look at the Metro Center as a whole and set up perhaps a utility generation system, or augmentation system within The Woodlands itself; and
- (3) to go Woodlands-wide with the system, picking up the industrial district, perhaps going into the residential component in a larger scale onsite generation system.

Each of these is almost accumulative. Each of the alternatives and techniques used at the building level in plan one (which is perhaps the least radical in terms of departure from the conventional plan) could also be used at the Metro Center-wide plan and at The Woodlands-wide plan. From the standpoint of looking at utility systems for augmenting supply of power within The Woodlands, onsite generation is perhaps the most attractive theoretically--certainly for utilization of solid waste--however, from a practical standpoint, it may be the most difficult to consider. Looking at the phasing schedule, for example, as things become built up, there is a lead time constraint with respect to establishing an onsite generation system. The phasing program lends itself to perhaps an onsite generation system for the eastern half of the Metro Center, but the western half may have to have elements of plan one, with each individual parcel or building having its own conservation mechanism. What we select may well be some hybrid among the three alternative approaches that we are looking at and analyzing at this time.

Within The Woodlands itself, the Metro Center serves as its town center, with this study area being about 500 acres of the 900-acre downtown area. One

of the first things that the marketing people did was try to determine the basic kinds of land uses that are required to relate to different types of services required for neighborhood centers, village centers, and the town center itself. The Woodlands is actually working with the State right now to put in an interchange on I-45 to deal with the potential traffic demands of the regional mall that will be located in Metro Center. We are sensitive to the turning and moving relationship and how we handle speed and new traffic into the area.

We developed a series of prototypes on each of the parcels in terms of program requirements and came up with the number of buildings, square footages, and basic series of relationships with which Texas A&M can converge into the shade and sun and wind, etc. We are also generating a series of peak relationships and finding out from the traffic point of view when there is more commercial traffic than usual; and we are investigating the need relationship for residential neighborhoods. From marketing, we are starting to understand the relationship among office, retail, parking capabilities, and local-use structures. All land uses that we have here are in single structures; there are no mixed-use structures.

Therefore, by understanding how we integrate these land uses into single local structures, and by understanding the requirements for orientation within the village to work with sun, shade, and wind, we are going to develop what we hope will be a new concept of land use within the Metro Center itself.

Along with concepts of basic distribution, we hope to be able to put a basic grid system on this, although there appears to be some question in line losses. We hope to identify how to determine the options in the future so that we can start with a series of conventional programs, and, over a period of time, move into the conservation program we are talking about. Marketing then can work with the revised program and its economics, possibly bypassing certain parts of the work relationships and structure costs.

One of the major byproducts of the study for The Woodlands Corporation is going to be a very viable plan. For example, we can start to develop a spine system, have major orientations, bring in some plazas, have a sense of place where people will come to and be part of. Through conservation, we can probably achieve a unique opportunity within the United States, particularly in terms of the financing, the market, the location, and the freedom to deal with zoning and planning.

Before we open the presentation to questions, two other individuals will speak on behalf of the members of the team: Dr. Joe Pyle of the Houston/Galveston Area Council, and Mr. Richard Peterman, of Gulf States Utilities Company.

3.5.6 Houston-Galveston Area Council - Dr. Pyle

We are a regional planning agency and the Council of Government for the 13-county area around Houston with a planning jurisdiction of 12,500 square miles. We have a good relationship with The Woodlands, and we have been working with them for a long time. They are involved with most of our programs, all of which tremendously impact The Woodlands, e.g., HUD 701.

We are a designated Metropolitan Planning Organization for transportation planning throughout the 13-county area. Environmentally, we are working in 208 water quality planning; we will be initiating air quality planning and solid waste management. Through the interest of The Woodlands, we will be contracting for a thoroughfare plan for southern Montgomery County later this year under sponsorship of the Montgomery County Board. We are also the designated A-95 agency, and have been commenting on programs being carried out at The Woodlands.

We have just completed an energy study entitled *Weather Induced Energy Shortages*. You may recall several winters ago that we had a severe incident up north where someone felt that energy should be diverted from the south to the north, thereby increasing the dichotomy between the sunbelt/frostbelt relationship. The completed study shows a tremendous energy dependence in the Houston area, particularly on natural gas. Therefore, any federal program that may evolve that tries to divert energy from the south to the north will be met with substantial opposition from our area, because these programs have regional implications.

In summary, I would like to say that, to my knowledge, this is our first direct interface with the Department of Energy. We commend them for encouraging local governmental participation. Thank you very much.

3.5.7 Gulf States Utilities Company - Mr. Peterman

I would like to echo some of the same comments that have already been made. We are very happy to be working on a project where something can be done about energy *before* the project is built. We are dealing with a half million customers and trying to show them ways to conserve now, which is very difficult, so this is the kind of project that we like.

We are enthusiastic about doing anything that can reduce our load growth, which is substantially greater than the national rate. We have projects ourselves that are testing how much energy can be saved; so we welcome the chance to work with The Woodlands and we will do all we can to help in the study.

3.5.8 Synopsis of Discussion

Much of the discussion has revolved around the viability of implementing developments containing substantial multi-use areas. Several of the earlier presentations described difficulties encountered with the developer, the builder, and the local development ordinances when they examined the feasibility and marketability of mixed uses on their sites.

Without knowing the exact grain of activity mix in the Metro Center, there is a range of mixing activities from single buildings with their own parking contained on a salable land parcel, to a very mixed condition of uses in the same structure. A current option under examination is the concept of selling "building pads" rather than the entire site, and retaining parking requirements under a "parking authority." Under this concept, shared parking advantages could be realized very early, and conventional land use mixes could be sited closer together because of the shared parking requirements. As an example, 200 apartments units with nonassigned spaces can be combined with a 2- or 3-story, 75,000 ft² office structure in a logical site plan with parking that could be efficient to both structures.

More small-scale mixtures of activities are already occurring in many areas. In Dallas, one such project, Willow Creek, has been very successful. The Embarcadero Center is another example, although in a decidedly more urban context than The Woodlands presently offers. This kind of mix is unlikely to occur within the next five years, but over the total development period for the Metro Center, particularly as it takes on a more urban character, a framework will be needed where such projects can occur.

The Woodlands has several marketing advantages in this respect. For example, The Woodlands not only undertakes land development, but is an active builder of residential, retail, and office space as well. In terms of mixed use, it is able to finance and undertake certain innovations internally if they will not be undertaken by others. The Woodlands also has the ability to set some of the development rules. Unlike Burke Centre, for example, if there is to be a supermarket in the 20,000-acre community, The Woodlands does have something to say about its design, if only in terms of the development standards and constraints.

These levers probably will become more effective over the longer run as The Woodlands grows, particularly when it begins to absorb an even greater share of the regional market as land in Houston becomes scarce and more expensive.

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4 COMMUNITY ANNUAL STORAGE ENERGY SYSTEMS (CASES) - DR. POWELL

4.1 INTRODUCTION

This presentation describes a novel energy conservation system called Community Annual Storage Energy Systems, or CASES. The fundamental idea behind CASES is the collection of heat during the summer when it's readily available, and storage for use to reduce the energy consumption (up to 80%) for heating in winter. Also fundamental to the concept of CASES, is to preserve the chill of winter so that it can provide the necessary cooling in the community instead of running electrical air conditioners, which saves about 90%. So from an energy conservation point of view, CASES is a very attractive concept. CASES cooperates with nature in using thermal storage on an annual basis rather than trying to overpower nature with fuel consumption.

The aspect of this system considered to be unique is the community scale of annual storage. Community scale is used for two reasons. First, if all buildings of a community are integrated, only the imbalance in the heating and cooling requirements of the community must be provided. This difference is much less than either heating or cooling in a thermally balanced community. The second reason has to do with simple economics of thermal storage. It is more economical to store thermal energy for six months with use in the complementary season, provided it is done on a large scale rather than in individual buildings. Basically, this is just a surface-to-volume effect; i.e., if the linear dimension of a reservoir is doubled, the volume or capacity of thermal storage goes up by a factor of eight; but the surface area, which is most closely related to cost, goes up only by a factor of four. Every time storage scale is doubled, cost per unit served is cut in half. For those two reasons, CASES is a community system. CASES can start with only a few buildings and develop, with proper planning, into a complete community system.

The basic idea behind CASES is to replace fossil energy consumption to the largest extent possible with heat collection in the summer and to replace totally artificial air conditioning with cold that is preserved from winter.

Fig. 4.1 illustrates the typical seasonal variation in heating and cooling demand. Depending on the weather and the mix of buildings, either cooling or heating can be dominant. Conventional air conditioning systems

ACTUAL THERMAL DEMAND WASHINGTON DC

Fig. 4.1 Seasonal Pattern of Heating and Cooling

take up heat from building and throw it away; CASES keeps heat in the system and returns it, providing heating without fossil fuel. Fig. 4.2 is a representation of what's going on in the community. The entire community has access to warm and cold water pipelines, probably uninsulated. Any building, or any portion of a building, that requires cooling at any time during the year simply draws cold water from the cold-water pipeline and warms it up with cooling coils in a very conventional manner as if the coils were driven by chillers, and then returns the warm water to the warm-water pipeline. This is heat recovery within the community.

Likewise, CASES uses warm water from the warm-water pipeline as a source of heat for water-source heat pumps to heat any building requiring heat at any time. Rather than simply discarding the cooling effect of the heat pump as is the case with an air-to-air heat pump, CASES saves the chilled water produced by its heat pumps to provide "energy-free" cooling. Therefore, to the extent that these instantaneous demands balance, no energy is required for the CASES central plant. Only the difference between the demand for warm and cold water is actually presented to the central storage facility.

Fig. 4.2 Energy and Cost Savings Through Synergistic Interactions Between Buildings in CASES Community

4.1.1 Aquifer Storage

Because waste heat recovery and waste cold recovery rarely are exactly in balance, there is a short-term buffer at the central facility to help achieve a more perfect balance on a diurnal basis. Short-term storage facilities cannot handle the seasonal imbalance shown in Fig. 4.1. In the summer, there is continuous demand for cooling and excess warm water. In the winter time, there is more demand for heating and excess cold water. Figs. 4.3 and 4.4 show one of the most attractive ways to store the excess warm and cold water.

If suitable aquifers are available, we simply inject the excess cold water produced in winter into the ground so that it will be available the following summer for cooling. During summer, we inject the excess warm water into a second aquifer or a separate part of the same aquifer. The earth is an excellent insulator. Both heat and "cold" can be stored in the earth for

Fig. 4.3 Aquifer Flow Pattern in Winter

Fig. 4.4 Aquifer Flow Pattern in Summer

long times with little loss. It is also easy to make up any losses or to collect extra warm or cold water if the demand for either is anticipated to exceed the supply produced in the community as a by-product of heating and cooling. We use an Environmental Energy Exchanger to collect cold water in winter and/or warm water in summer with essentially no energy consumption as is illustrated in Figs. 4.3 and 4.4. It is important to note that CASES does not consume groundwater. For every pound of warm water taken up in winter as a source of heat for efficient heat pumps, a pound of cold water from these same heat pumps is injected back into the ground. Thus, CASES uses aquifers as a "heat bank," not as a water source.

CASES is really a solar energy system in disguise. Instead of expensive solar collectors, it uses the buildings themselves to collect solar heat. This gives CASES a tremendous economic advantage over conventional solar energy systems. Solar heat not only is available and free in summer, but people will pay you to take it away when you call it "cooling services."

4.1.2 Ice Storage

Where the geology or other factors do not permit the annual storage component of the CASES to be based on aquifers, it is necessary to provide an artificial method of storing the surplus summer heat and winter cold until they are needed. If suitable aquifers are unavailable, it does not appear economically feasible to store all of the cold water produced in winter as a byproduct of heating with water-source heat pumps. Instead, the cold water flowing back to the central CASES facility is heated and returned to the community in a closed-loop flow pattern. The heat required can be obtained from water with an ice machine.

Great quantities of heat must be removed from liquid water to produce ice. For each cubic foot of cold water converted into ice by an ice machine, more than 10,000 Btu are made available for reheating the water circulating in the community distribution pipelines. Ice machines taking heat out of a cold water pond will deliver more heat to the circulating water than could be obtained directly from the same pond if it were full of boiling water. Ice machines are simply heat pumps that also produce ice.

The ice produced during winter is saved for non-electrical "energy-free" cooling the following summer. It is store under a floating insulated

roof in the same ice/water pond from which the ice machines take heat in winter. As the winter progresses, more and more of the ice/water pond is converted into ice. During summer, this ice is melted while cooling the community. The size of the ice/water pond is chosen to be large enough to store all the ice produced in winter and desired for summer cooling.

4.2 SYSTEM COMPONENTS

4.2.1 Environmental Energy Exchanger (EEE)

Part of the heat used to reheat the water circulating in the community when CASES employs ice machines and an ice/water pond for annual storage instead of aquifers, can be collected "energy-free" directly from the environment with an Environmental Energy Exchanger. This EEE is more economical than most solar heaters because it has no cover glass. It can be used after sunset to collect air heat any time the air temperature is greater than the cold-water temperature (40°F). The EEE can collect more heat than the solar input and thus may be more than 100% efficient if considered to be only a solar collector.

In northern communities, the EEE can collect heat to melt ice in the ice/water pond any time the air temperature is above freezing. By melting excess ice during the winter, it is possible to freeze the water in the ice/water pond several times each winter and obtain as much heat as if the pond were several times larger. Thus, in northern locations, the EEE can be used both to substitute "energy-free" environmental heat for ice-machine heat and to reduce the size and cost of the ice/water pond required.

In southern locations, the heat removed from buildings in summer exceeds the heat required in winter. The EEE can be used to discharge this excess heat in winter without using electrically driven air conditioners if aquifer storage is feasible (see Fig. 4.3). If an ice/water pond is used for annual storage, the EEE can be designed to collect natural ice in winter to supplement the ice produced as a byproduct of winter heating.

Thus, the EEE is used to achieve an annual balance in the heating and cooling loads and to reduce both energy consumption and costs. An EEE used for both ice and heat collection is part of the central CASES facility illustrated in Fig. 4.5 and schematically represented in Fig. 4.6.

Fig. 4.5 Ice/Water Pond Annual Storage System with Ice or Heat Collection via Spray-Type Environmental Energy Exchanger

Fig. 4.6 Heat and Fluid Flow for CASES Central Plant with Ice-Machine Heat Pump

4.2.2 Water Source Heat Pumps - Efficiency

The water source heat pumps used in CASES buildings remain highly efficient even in cold weather because warm water from the pipeline is always available to them as a source of heat. In cold weather, air-to-air heat pumps tend to condense water vapor from the air and freeze up. Periodic defrost cycles are required. Air-to-air heat pumps become less efficient as the weather becomes colder. In subfreezing weather, most air-to-air heat pumps have a coefficient of performance, COP, of 1.0 or less; but the COP of CASES heat pumps typically exceeds five at all times. Although some energy is consumed at the central CASES facilities to keep warm water continuously available, much of the warm water is produced "energy-free" or recovered as excess heat from other buildings with cooling needs.

4.2.3 Costs

The water-source heat pumps used in CASES are similar to air-source heat pumps except their input heat exchanger is smaller, and no outside fan-coil unit is required. They should be more economical than air-source heat pumps when produced in the same volume. The absence of outside fan-coil units reduces installation costs and lessens the chance for fluorocarbon leaks to the environment. Water-source heat pumps can be hermetically sealed at the factory, but air-source heat pumps typically require field connections for fluorocarbon lines between the inside and outside units.

4.2.4 Peak Loads

Air-source heat pumps require less electrical energy than electrical resistance heaters on mild winter days, but often require slightly more on cold winter days. Thus they represent a more variable electric load than electric heaters and worsen electric utility load curves (equipment utilization averages). As is true for conventional solar heating, wind-energy systems, and other "part-time" energy systems with electrical back-up, air-source heat pumps tend to make electric power more expensive. Someone must pay for idle electrical generation equipment held in reserve as back-up for part-time energy systems.

The water-source heat pumps used in CASES also require more electric power on cold days to supply more heat, but the peak electric demand is

typically five times smaller than with an air-source heat pump. CASES can further improve electric utility equipment utilization rates by actions taken at the central CASES facility as discussed below.

4.2.5 Short-Term Storage Facilities

Even when aquifers are available, short-term storage facilities on the surface may be desirable to buffer the flow of warm and cold water into the aquifers. The well pumps and well-field, bore-hole expense can be reduced if part of the peak flow is into and out of water storage basins on the surface. An ice-collecting EEE may be useful, even with aquifer storage, if coupled to these short-term storage facilities. On the coldest winter nights, ice can be rapidly collected and then converted into cold water for injection into the aquifer at lower flow rates. Excessive flow rates can damage the aquifer and result in greater pumping power requirements.

The savings in peak power or "demand" charges possible with short-term storage facilities are most important when aquifers are not available. It is possible to operate the ice machines at night (or other times when electric power is cheap) with considerable economic advantage if short-term storage facilities are included in CASES.

Many electric utility companies have recognized that the cost of thermal storage can be less than the cost of expanding peak generation and transmission facilities which would be required in the absence of storage facilities. With central energy storage as used in CASES, the cost of the storage facilities can be reduced because the large scale results in a more economical surface-to-volume ratio. The cost of separate electric meters for off-peak electric power is also reduced with centralized storage. Only one meter for each rate period is required for the entire community. It is economically feasible to provide a separate meter and rate scale for each hour of the day to more accurately reflect electric utility cost of production. Conventional "time-of-day" prices are limited to a few different rates to avoid excessive costs for the meters installed in each building.

The short-term storage facilities, available at the central CASES plant, could be operated directly by the local electric utility to produce a more cost-effective form of load control. Prearranged electric rate schedules, regardless of how detailed, cannot accurately reflect demand variability and

unforeseen events that affect generation capacity. The ability to take all ice-machine heat pumps "off-the-line" for a few hours in power emergencies could prevent a "black-out" in the community. During this period, all central plant thermal output would be drawn from short-term storage facilities.

4.2.6 Water Distribution Pipelines

The primary disadvantage of CASES is the need for water distribution lines. Because the warm and cold water circulating in these lines is only a few degrees different from ground temperatures, it does not appear cost effective to insulate these pipelines. They would be essentially identical in construction with potable water lines. The cost of thermal water distribution should add less to the heating and cooling bill than does the water bill because the water used in CASES pipelines is not consumed; neither is it processed to potable water standards. In many communities, the cost of the sewer lines and sewerage treatment plants is also included in the water bill. For these communities, the cost associated with distribution pipelines for CASES should be much less than their current "water" bills.

4.2.7 Long-Term Storage Facilities

Electric utility companies usually have a seasonable imbalance in the demand for electric power as well as diurnal peaks in the electric demand curves. For a utility company with a growing summer peak load, the provision of non-electric air conditioning, either by cold water from an aquifer or by melting ice stored from winter, can reduce the chance of blackouts and need for expansion to service peak loads. The fact that CASES may replace present gas and oil furnaces with electrically powered heat pumps also is attractive because this adds electric demand in winter. Thus, this shift of electric demand from summer to winter is a direct result of the annual storage feature inherent in CASES.

For an electric utility with a wintertime peak demand, the surplus heat collected in summer is the attractive long-term storage feature. This, together with proper use of short-term storage facilities for diurnal load management, permits the peak electric heating demand to be about five times less than if air-source heat pumps were employed.

4.2.8 Ice Machines

Ice machines used in CASES produce flake ice as heat transport. (Thick ice would make the machines less efficient.) Flake ice also is convenient because it can be pumped in an ice/water slurry to the bottom of the ice/water storage pond. These ice machines are not needed for heating in summer and can be used to manufacture ice for sale to defray part of their costs with a corresponding reduction in the cost of heating and cooling services.

4.3 ANALYSIS

4.3.1 Method

Evaluation of any annual storage energy system requires data for a full year. The cost and performance characteristics of CASES have been determined using a simulation model which consists of 8760 hours (one year) of sequential steady states. The simulation model assumes that an ice/water pond is used for annual storage instead of aquifers. Thus it sets an upper limit on costs and a lower limit on efficiency because ice machines are both more expensive and less efficient than pumping warm and cold water into the ground. In other ways, the model is conservative in its estimates and assumptions so that future refinements that make it more complete and detailed should not lead to any significantly less attractive result. Everything assumed in the model is commercially available today.

4.3.2 CASES Model

HCLOAD

The first of four computer program modules contained in the CASES simulation is called HCLOAD. It is a simplified version of NBSLD. Each building is described by only 30 physical parameters, which is much simpler than the original. In addition to the characteristics of NBSLD, we have also developed what we call a thermostat model. We specify the temperature every hour of the year, but instead of calculating the heating the cooling required to maintain the specified thermostat level, we also have a dead band that allows the system to float within it. HCLOAD produces a file of hourly heating and cooling loads (Btu/hr) for each of the nine building types and two core zones. In addition to this hourly output data, certain monthly and

annual peak and total loads are recorded. These auxiliary data are used in subsequent program modules to determine efficiently both the size of heating and cooling equipment required in each building and the size of various energy storage facilities needed at the central CASES plant.

CDIST

The second module of the simulation code, CDIST, requires the distribution water temperatures in addition to the files written by HCLoad as input data. CDIST calculates the size and cost of user heating the cooling equipment needed for each building. It produces an hourly record of the electric power required for operating the heating and cooling equipment. It also converts the load data into a demand (lb water/hr) data file. This conversion depends on the water temperatures and on the efficiency of the equipment selected for each building.

Next, CDIST uses the water-demand file and data on the pipeline route to each terminal building to determine the size and capital cost of all pipes and trenches in the distribution system. More refined editions of CDIST also calculate pumping and thermal losses and the associated costs. The current simulation model doubles costs of the pipe and trench to form a conservative estimate of pipeline and other cost details omitted from the distribution system. Finally, CDIST condenses all the demand data down to a net demand or "virtual user" hourly demand file.

CAPS

The third simulation module, CAPS, simulates hourly operation of the central CASES plant as it services this user under an assumed set of operating rules. CAPS has to make certain decisions; e.g., if the ice machine is turned on to satisfy people in the winter, it will use more energy than if it draws heat from short-term storage. Those decisions are made, based in part, on the current cost of electricity; i.e. - It may be more economical to draw heat from storage during the peak heat demand period and recharge at night, etc. The ability to use the ice next summer also is considered. If large amounts of ice are already being stored at the ice facility, then the incremental value of ice is not as great as when the system appears not to have enough ice to get through the system's annual cooling requirements. So numerous decisions must be made, and the system produces 8,760 hours worth of

heating, cooling, and electrical use data. CAPS also determines the size and cost of the various energy storage facilities and ice machines required at the central plant.

COST

The final module, COST (in progress), will process the various cost and energy consumption files written by CDIST and CAPS. Various financial rates and Btu prices will be used in COST along with the processed CASES data to determine the total cost of CASES and the expected rate of return on invested capital. To evaluate the efficiency and annual energy savings, COST also will total all energy consumption and compare it to the heating and cooling services supplied. Presently, hand calculations have been used to combine the results of CDIST and CAPS. In lieu of detailed economic analysis, it is assumed that 15% of the capital is recovered annually.

4.3.3 Reference Community

Our model community has a much lower population density than those discussed previously at the workshop. It consists of three neighborhoods similar to Wilde Lake Village in Columbia, MD. There are 8000 residents (2500 households) and 866 buildings in three neighborhoods that share a common village center, all on 1500 acres of land. Each neighborhood has its own elementary school and civic-commercial center. The community's middle school, high school, office buildings, factory, shops, and CASES facility are located in the village center. These buildings and clusters of residential units comprise the 43 zones (local load centers) shown in Fig. 4.7 which also illustrates the route of major distribution lines, but not the connections to individual buildings in each zone.

Fig. 4.7 Layout of 866 Buildings and Pipeline Route in Standard Reference Community

The composition and demography of the reference community are further described in Tables 4.1 and 4.2. Hourly weather records for 1967 were used.

Table 4.1 Community Buildings

400	Two-story, Four-bedroom Frame Houses
800	One-story, Three-bedroom Brick Houses
100	Two-story, Four-unit Townhouses
53	Three-story, 24-unit Apartments
1	14-story, 140-unit Apartment Building
5	One-story Schools (different sizes)
2	12-story, 1000-worker Office Buildings
4	One-story, Civic-commercial Buildings
1	One-story, two-shift, 40,000 sq ft Factory

Table 4.2 Community Demography

2500	Residential Households
4625	Adult Residents
2890	Full-time Jobs and Workers
330	Part-time Jobs and Workers
933	Preschool Children
1320	Primary School Students
561	Middle School Students
561	High School Students
8000	Total Resident Population

4.4 RESULTS

The results predicted by the simulation model for the standard reference community are given in Table 4.3.

Table 4.3 Monthly Summary for Standard Community

SERVICES PROVIDED			EFFICIENCY
(1967)	Heating (MBtu)	Cooling (MBtu)	Combined COP
Jan	59,460	15,150	4.509
Feb	69,430	13,130	4.001
Mar	43,240	16,190	5.279
Apr	25,780	17,410	6.707
May	38,170	16,100	5.414
June	8,285	21,110	12.142
July	4,809	22,220	17.216
Aug	7,000	20,210	13.411
Sept	11,120	19,500	10.515
Oct	30,230	17,310	5.783
Nov	49,760	14,880	4.972
Dec	60,580	14,870	4.586
Annual	407,864	208,290	5.524

Capital Cost at Central Plant	\$ 5,097,449
Capital Cost for Pipelines	1,435,000
Capital Cost in Buildings	8,758,400
Total Capital Invested	\$15,291,000
(Electrical utility capital excluded)	
Total Electric Cost	\$1,047,000
15% of Capital Total as Annual Cost	\$2,294,000
Total Revenue Required Annually	\$3,341,000

Thus, \$3.69/MBtu of Heat if cooling
is sold at 4 times heating price.

The capital breakdown includes \$5 million in the central plant, \$1.5 million in the pipeline distribution network, and almost \$9 million for heat pumps and coils in various buildings. The overall (yearly) average coefficient of performance for CASES in the standard reference community exceeds 5.5. Thus, CASES provides efficient heating and cooling services to all the buildings of community including offices, etc., with a capital investment of less than \$6,200/resident household. The typical solar home-heating system costs more than this and requires more electrical energy for back-up on heating on cloudy days. CASES can provide both heating and cooling services to more buildings with less capital investment and lower energy consumption than most solar energy systems.

Neither the standard reference community nor the design parameters and control strategy assumed have been selected to optimize the cost and performance characteristics of CASES. Work in this area has only recently begun. Table 4.4 provides some preliminary results that indicate that other communities and other designs for CASES may be more efficient and economical. In the standard reference community it was assumed in the model that temperature of cold water, TCW, was 40°F; however, in view of Table 4.4 results, 45°F cold water may be more attractive.*

Table 4.4 Summary of Results

CASES CONDITIONS	ANNUAL COP	HEAT PRICE (\$/MBtu)	CAPITAL REQUIRED (\$ per Capita)
REFERENCE CASE	5.24	2.69	1,911
TCW = 45°F	5.83	2.64	1,908
HAT = 110°F	5.58	2.56	1,784
+2 OFFICE BLDG.	5.99	2.44	2,040
+4°F WARMER	6.23	2.59	1,894
DOUBLE SIZE	5.24	2.55	1,759
DOUBLE DENSITY	5.24	2.48	1,708

The highest air temperature, HAT, used in the building during peak winter heating demand is 120°F in the standard simulation. A larger flow of less warm air can also deliver the same heat and permit the water-source heat

* The temperature of both the cold and warm water pipelines should vary with the weather for optimum results, but only portions of the computer code required to simulate this variation are currently functional.

pumps to operate more efficiently as illustrated in Table 4.4 with a HAT = 110°F, but the economy of HAT = 110°F, predicted by the simulation model, is suspect because the cost increment for larger ducts and/or air fans is not included in the current model.

Increasing the total community cooling load relative to the total heating load either by adding office buildings to the community or by assuming warmer weather produces a community more nearly in thermal balance on an annual basis. Such a community is more efficient and provides more economical services as indicated in Table 4.4.

The effect of doubling both the population and number of buildings served is also included in Table 4.4. In one case, the density is held constant and the size is increased. In the other case, the area of the community is held constant and the population and building density are increased. In both cases, there is little change in system efficiency. Large, dense communities are most economical to heat and cool; however, the primary reason for the economy of CASES heating and cooling is large scale, not high density. The standard reference community is economical with residential density of only two household/acre, which is not "high-density" housing. The economy of CASES heating and cooling arises from large-scale cooperation with nature and the synergistic interaction among diverse buildings in the community. CASES is a heating and cooling system hundreds of times larger than that used in an individual residence and enjoys many benefits of scale--even in a low-density community.

4.5 SUMMARY

4.5.1 Electric Utility Viewpoint

One of the first observations a utility should make about CASES is that it is not a monopoly. Anyone can provide his own heating and cooling equipment, independent of CASES. Thus, CASES services must be priced to ensure that most building owners find participation attractive.

CASES provides the possibility of air conditioning without electric energy. It makes use of the chilling output of heat pumps (which currently is discarded) by saving it and then using it six months later to prevent increase of electric demand associated with conventional air-conditioning of the com-

munity. Presently, anybody can buy an air conditioner and plug it in even if it results in blacking out New York City simply because there is no way to control the demand for air conditioners. CASES can have a very favorable effect on utilities with a summertime peak demand. It can actually lead to lower electric power rates through improved load factors.

CASES also offers many benefits to a winter peaking utility because of its thermal storage. For example, the ice machines at the central plant can be operated at night when electric demand is low. Even the building heat pumps which might be operating at time of electrical peak demand would require less electric power. One of the nasty characteristics of air-to-air heat pumps is that, when they are needed most, they are less efficient. In fact, many of the heat pumps that are on the market today do not even try to be heat pumps when it gets under 20°; they just shut off and they run as resistance heating. They can present the same peak demand that electrical heaters would present to the electric grid. But CASES heat pumps remain efficient because they always have warm water available to them. CASES heat pumps have a coefficient of performance (with 60°F water available) of about 5.0. The heating power demand peak thus can be reduced by a factor of 5 compared to either electric heaters or conventional air-source heat pumps. CASES should be able to provide the same peak heating rate in subfreezing weather with less than half the electric power demand of even the most efficient (and very expensive) air-source heat pumps now available.

From a load-control point of view, air-source heat pumps are worse than electrical heaters. Although they may use less electric power on mild days, they can use as much as room heaters (because of duct work losses and cycling losses) on cold days. They can worsen electric demand curves and drive up the cost of electrical energy. CASES provides a way of filling the electric demand curve valleys and shaving off the peaks. It can lower the cost of electrical energy.

One of the main obstacles to implementing time-of-day rates is the cost of a two-way control system for resetting the clocks after power failures. These costs range from \$100 to \$300 for metering, depending on the sophistication of the system. With CASES, there is only one large time-of-day customer. The utility can get the benefits of time-of-day rates without the liabilities of time-of-day metering costs. Moreover, time-of-day rates are only a crude

attempt to predict what the cost of producing electric power will be and can never be fully accurate. For example, if a low-cost generation plant must be taken out of service when the utility expected to have cheap power available but does not, then time-of-day rates can make the problem worse. It would be a much more cost effective form of load control to have this CASES system actually owned and operated by the electric utility and used for load control rather than trying to influence the customer who, perhaps after four days of heat, says "the hell with expensive rates, I want my air conditioner to work again," and he opts out of the system, possibly crashing it. Actual hands-on control by an electric utility company gives it the ability to adjust CASES central plant electrical demands and to use it for very fine scale load management -- not just two or three time-of-day rate levels that depend on voluntary compliance for any effect at all.

Also of interest to utility companies is the increase in the net consumption of electrical energy. This is achieved by the displacement of oil or natural gas consumption in the community, which is very important from a national point of view.

4.5.2 National Viewpoint

From the government view, the fundamental advantage of CASES is that the system runs on electrical power -- be it solar, coal, or nuclear; it can have a dramatic savings in the amount of fossil fuel that is in short supply. Therefore, this system not only saves energy and is cost effective, it also conserves critical fuels. Also, eliminating conventional fossil fuel furnaces could be a very significant step in the centralization of the energy pollution problems.

The analysis done so far shows that you can save capital as well as energy capital costs. For example, the standard community capital investment was more than \$15 million. Installing electrical generation equipment for that same community at \$700 kWh would cause an incremental power plant capitalization cost of \$20 million. Thus, the whole CASES system can actually be put in a new community for less than the expansion cost of the electric power plant to keep up with the greater peak power demand from the same community if conventional "all electric" heating and cooling is used. Air-source heat pumps and solar heating systems also require more capital when the capital invested by the electric utility part of the system is included in the analysis.

4.5.3 Building Owner's Viewpoint

From the home owner's point of view, and also very important to the commercialization effort, is the fact that about \$2,000 can be cut off the cost of the house. CASES is an economical form of solar energy, although it does not have any solar collectors that one can point out as being a "dedicated" solar collector. Instead, we use the buildings themselves to collect solar heat and also by-product heat from lights and other processes. So it is like a solar energy system with the major cost element left out, and because it is a 100% system, no back-up heating system is required. Moreover, we do not have any air conditioners. We do not have to provide furnaces or flue pipes, and we do not have installation costs for these items. Addition of these savings shows that, unlike conventional solar energy systems which might add \$5,000-\$10,000 to the cost of the house, about \$2,000 can be saved on the cost of the house. From a developer's perspective, they might be able to offer the same model house for a couple of thousand of dollar less than the competition.

Another point is that home owners tend to procrastinate. The typical home owner who has an air conditioner that starts to lose freon and deteriorate will only call the service man when it eventually becomes so inefficient it has to stay on continually and still can not keep his house cool. In the CASES system, the equipment would be centrally owned. CASES is a thermal utility, and would have meter readers. Equipment would be inspected and maintained at an economically viable, or more optimum, intervals.

The CASES system also will provide a higher quality of service than is currently available, because interior temperatures will be kept within a 2° dead-band. For example, on a cool fall or spring day, a person normally would be less apt to turn his furnace back on if it were off. By maintaining internal temperature within the dead-band, CASES may, in fact, provide cooling in the afternoon and heating the next night, which would be prohibitive in a normal system. For CASES, this amounts to basically removing heat during the day and returning it at night, producing a very small net thermal demand.

In summation, CASES is a system that can continuously provide superior heating and cooling economically to every building in a community with greatly reduced energy demands. Heating and cooling are controlled solely by each building owner.

4.6 SYNOPSIS OF DISCUSSION

An Environmental Energy Exchanger (EEE), for example, a cooling tower, is very broadly defined, for the purposes of this discussion, as anything that allows an energy transfer with the environment. Environment is also very broadly defined. For example, the use of Lake Michigan as a thermal source/sink for such transfers is included. Air-heat and geothermal energy are also possible. If, on an annual basis, a net input of heat is required by the system, as in the case in Minnesota, then air-heat collection can take place any time the temperature is greater than 32° by recirculating the chilled water to melt excess ice.

One of the distinguishing features of CASES is that it permits a synergistic interaction among various building demands that is unavailable on a single-building system. However, from a user perspective, CASES has a single-building delivery capability and control feature.

To date, there has not been much analysis on the way in which economic benefits would be divided. The ongoing assumption is that, from a total system perspective, CASES requires less total capital and less total energy than a conventional system, so that all participants can presumably be net beneficiaries under the system as compared to alternative choices. We postulate a flow metering based on time of year, where differential rates are applied to cooling versus heating. In mid-winter, a cooling-demand customer is very valuable to the system because he would accept the cold water provided by the heat pumps. This could lead to a monthly basis for rate schedules based on usage from a Btu meter, although the details of the service economies have not yet been established.

The most natural operator of a CASES system would be the electric utility company. Public expectations anticipate that the utility will be perpetually available, and will be able to provide back-up services for repair, replacement, etc. Utilities are also very familiar with operating capital-intensive enterprises; the load management potential of CASES is so great, that it appears as a natural benefit to internalized control within the utility, especially in lieu of generation expansion, or coupled with a reduced rate of expansion. However, this subject has not yet been formally broached with utility representatives because development research is under contract to DOE.

Climatically, the CASES concept appears to be applicable as far north as central Canada; however, the further south, the less cost-effective the system becomes in an annual storage mode. At some point in the "deep south," the system would become more of an off-peak air-conditioning system, where cold water would be produced during the night at a large central plant using cheap electric power and then circulated during the day. The economics point to this variant because, as one moves south, the heating load will not be large enough to make the necessary amount of ice or cold water as a by-product of winter heating, nor will there be enough hours of freezing temperatures to utilize an Environmental Energy Exchanger to collect the annual supply of cold water or ice "energy-free." There is, therefore, a threshold, south of which enough chilling effect cannot be reliably produced in winter to meet summer cooling demands.

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5 OPEN DISCUSSION

Following the technical presentations, the floor was opened for a general discussion and comparison of the findings to date. The following documentation summarizes many and varied viewpoints that were advanced during the discussion.

5.1 DOE REMARKS

5.1.1 Mr. J. Kaminsky

Looking at the five case studies, and the problems of implementing energy-conservation design for a site or a neighborhood, the following six agents, or actors, can be identified that influence the acceptability of any options: (1) the designers and design teams that came up with the solutions and evaluated them; (2) the developer; (3) the builder; (4) the financiers, either as a separate group, or associated with the builder; (5) the utility company; and (6) the local regulatory agency. From the point of assembling a team of professionals to try to incorporate energy conservation into a development, each of these groups makes decisions and has its own role in the process.

In the five case studies, two teams were organized around the designers as the prime movers: Radisson and Burke Centre. In the other three, this role was basically assumed by the developer, who was also the contractor and who defined his role. Although the five case studies started at different times, and are not yet complete, there was a marked range in the degree of comprehensiveness exhibited by each presentation.

5.1.2 Mr. I. Sewell

A major concern is the degree of emphasis that has been placed on buildings and HVAC systems. Building consumption and space-conditioning requirements constitute only a small proportion of total community energy requirements. As much as 80% of the energy requirements is not directly impacted by space conditioning, especially by weather or siting. To make a major impact in conservation, this portion must be addressed. It is a difficult area, being less well quantified than the buildings level, and it will require a more generalized look at systems rather than on specifics.

A flow-through methodology of tracing out energy paths is desirable to define system resource energy savings as they relate to end-use energy service requirements. Unless this kind of transfer is made, we will not be able to determine the important impact of options beyond the small fraction of end-use demand accounted for by space conditioning.

In the remaining portions of work, the case studies should expand their focus from end-use service demand to include the resource energy requirements.

5.2 GENERAL DISCUSSION - ALL PARTICIPANTS

A major reason for the reduced emphasis on total energy system consideration was the understanding at the outset of the contract awards, that feasible energy-conserving options should be able to be included in the development schedule of the study sites -- usually between one to three years. This short time frame precludes extremely large innovations in energy supply systems if they are to be implemented in phase with most of the study sites.

Many of the passive and siting design options can be immediately implemented into the framework of the development process of the study sites that were selected. The ability of the study teams to control or affect this particular set of options was a factor in their selection; whereas, inclusion of utility considerations may tax the capabilities of this framework to implement other kinds of options at this time. Much is not yet known in the area of community-level options, and it is not yet clear that any team has all the prerequisite abilities to deal with all these institutional problems. What can be accomplished along these lines is a careful documentation of what was attempted and considered, and why particular options were not brought forward for implementation.

These five case studies have not yet developed the experience of how to look at community energy usage as a totality, from a total energy point of view. Various perceptions have emerged in dealing with energy at a particular site, tailored to the site characteristics, and not necessarily applicable on a national basis. The case studies include various climates, different kinds of marketing programs, etc. This is why there is a range of case studies, and why there will probably be even more before methods can be identified for achieving energy conservation at the site level that would provide appropriate models for nation-wide dissemination. As such, it must be recognized that each

of the case studies is exploratory and is breaking new ground in areas that have not had previous design involvement. It will be important to identify what has been learned to date, and what must still be achieved under the existing organizational framework.

5.2.1 Developer-Builder Relationships

An issue that was addressed during the technical presentations was the nature of the relationship between the developer and the builder. Generally, the developer hopes to induce builders to build in his development. The builder recognizes the necessity of dealing with the developer to secure his raw product -- land. The degree to which the developer can exert further influence is an individual matter. Nevertheless, given setback requirements and other regulations, the developer can determine fairly well in advance the orientation of structures by affecting the street layout and lot pattern. In this manner, Greenbrier was able to achieve desirable solar orientation in 80% of the structures. Had a different, less definitive lotting pattern been used, it is likely that the builders would have ignored any voluntary guidelines on exposure and would have oriented their buildings more randomly.

In general, if the advice or recommendation of the developer makes good business sense, or if it demonstrates increased sales potential or greater profit, it will be heeded. Otherwise, there is not much that the normal developer is willing to do as far as trying to force anything on builders.

In many cases, the prior experience of the builder is a major factor. The builder in the Burke Centre village center simply had no previous involvement in the area of energy-efficient buildings. At the same time, a major home builder on a nearby site is working in an organization that has well established the fact that they can sell various types of energy packages. Although these packages are not very exotic, they have established a proven track record for the organization. As a further contrast, the retail food industry is very aware of energy conservation and is actively transferring this information within the industry itself and sharing technological data. Obviously, the degree of builder sophistication directly influences what the designer will be able to achieve.

Where builders have already moved to increased insulation, tighter construction, etc., it will be difficult to improve further the end-use performance. There is also a builder reluctance to try to integrate too many new devices in at any given time. To do so, increases the number of new subcontractors on site which creates some confusion. Many builders choose to try one new technique at a time, thereby giving the subcontractors time to adjust to having the new subcontractors on the job and leading to increased productivity.

The Woodlands, through its internal builder activities, development codes, building inspectors, and development standards review committee, is in a position to determine more closely the development character -- although it still cannot afford to be oblivious to market conditions. At Radisson, the developer was concerned that any design critique or review of builder spec plans by the study design team be done very sensitively, because the UDC did not wish to antagonize any of its active builders, who, in their opinion, were providing good quality, attractive, salable units.

As a general observation, drawing the experience of the three developer-led teams and the two designer-led teams together, the ability of the study team to influence the developer appeared to be highly related to the personal commitment of the developer to energy conservation. By comparing the processes described to date, there is an extra series of discussions involved if the developer himself must be first approached by the design team, followed by the decisions of that meeting being communicated to the builders.

Under either scenario, however, it is the final series of discussions with the builder, be it under the auspices of the developer himself or his designers, where the greatest reluctance to questionably marketable innovations will be encountered. At this level, the bottom line is *marketing*; absolutely nothing is achieved if the units will not sell.

Without building up some prior experience to serve as examples for other builders and developers, the marketing question will remain. If, on the other hand, one or more of the case studies can accept the posture that it will be an energy-efficient development and market this concept, convincing their builders to follow it and supporting them with advertising, the case studies will begin to provide a vehicle for creating a track record for energy conservation. The challenge is to take energy conservation as far as possible without impacting builder marketability.

5.2.2 Local Government's Role

In addition to the relationship among the developer, the design team, and the builder, local government also plays a part in the decision process, as was indicated earlier at many points within the technical presentations. An important question along these lines is whether there is a local governmental role in energy conservation, and if so, what it would be.

A range of lateral diversity is embodied within each of the five case study teams. Radisson and Burke Centre exhibit the least diversification; they are basically design teams working with the developer, with the builders, and with the local government. At the other extreme, The Woodlands is design team, developer, local government, and, to a large degree, even the builder, which creates a totally different organizational situation. It is important to extract out of these case studies potential useful roles for local governments in realizing energy-conserving design, and to identify particular activities currently being carried out internally to some of the case studies (The Woodlands, for example, and, to a lesser degree, in Shenandoah and Greenbrier, respectively) where the developer has assumed a large role of government activities -- density control, development standards, sewer and water, building inspectors, etc. All of these activities would probably have been viewed as local governmental functions as little as 15 or 20 years ago.

A major concern of developers with governmental involvement centers on delay and red tape in the processes necessary to secure all required approvals and review. This aspect alone has been a major impetus toward incorporating many of these functions into the large developer's operations.

None of the five case studies have provided specific recommendations to date as to what aspects, if any, of their local regulatory environment might need to be altered to allow particular options. Thus, it appears somewhat premature to attempt to formulate any recommendations in this area, because the results, to date, are inconclusive. Although it is also unclear whether it would be appropriate for a local government to take a lead role in promoting energy-efficient developments, there is clearly a facilitative and coordinative posture that is desirable.

Because the kinds of developments represented in the case studies comprise such a small amount of total development activity, e.g., in Fairfax County there are only two such projects, it will be imperative to identify how

to affect the much larger, overall amount of development that is occurring on sites of less than 50 acres if there is going to be any significant penetration at all.

In many of the case studies, the realization that most, if not all, of the systems-level options were already fixed as constraints has led to the emphasis on end-use situations and other options that were not constrained or fixed. This may necessitate dealing with developments that are not yet as far down the road as the case studies. It may be necessary to work in situations four or five years ahead of marketing, or in zoning and comprehensive planning stages with local governments.

5.3 SUMMATION - MR. J. KAMINSKY

Through the involvement of the five case studies, we have already generated a range of experiences, techniques, and different approaches to energy conservation in various site and climatic conditions. These different approaches depend on factors, such as the nature and mix of land uses, the size of the development, and on team capabilities. Each study has different issues to confront.

From the participation that has taken place, and from the interaction and interest that has been generated, this workshop has been successful.

We anticipate another workshop to be held in January, hopefully involving additional developers on HUD-sponsored projects. Because some of the case studies will be completed or nearing completion by then, we expect to have enough information at that time to make the products of these case studies beneficial to others outside this process. We see this forum as an integral part of our dissemination activities in making information available to others in a usable form.

Although we have not decided exactly how it will be organized, the January Workshop probably will be another two-day session on a schedule and format similar to today's, with ample time for detailed presentation and discussion.

In the interim, we will continue to keep in touch with you, and discuss what has been achieved and where each case study needs to go. I appreciate your attendance and participation, and I hope to see you all again here in January. Thank you!

APPENDIX A

SITE AND NEIGHBORHOOD DESIGN CASE STUDY REVIEW AND WORKSHOP

September 14-15, 1978

4222C Conference Room
 U.S. Department of Energy
 20 Massachusetts Avenue, N.W.
 Washington, D.C. 20540

A G E N D AThursday, September 148:15 Welcome

Introduction of Participants

Mr. Kaminsky

8:30 Executive Session

Project Highlights and Overview of Progress to Date

8:30 - Burke Centre

Mr. Hall

8:50 - Greenbrier

Mr. McClurkin

9:10 - Shenandoah

Mr. Birchfield

9:30 - The Woodlands

Mr. Browne

9:50 - Radisson

Mr. Crandall

10:10 Break

Technical Presentations

10:30 Burke Centre Case Study

Mr. Hall, et al.

12:00 Lunch

1:00 Radisson Case Study

Mr. Crandall, et al.

2:40 Break

2:50 Greenbrier Case Study

Mr. McClurkin, et al.

4:30 Adjournment

Friday, September 15

8:30 Shenandoah Case Study

Mr. Moore, et al.

10:10 Break

10:20 The Woodlands Case Study

Mr. Swanson, et al.

12:00 Lunch

Guest Presentation

1:00 Community Annual Storage Energy Systems (CASES)

Dr. Powell

2:30 Open Discussion

Mr. Kaminsky,
Moderator

4:00 Adjournment

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