CENTRAL ENERGY SYSTEMS -- APPLICATIONS TO ECONOMIC DEVELOPMENT

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ABSTRACT

The City of San Antonio's Office of Public Utilities has developed an innovative process to assess predesign energy conservation strategies for new buildings. This assessment also provides direction for the community's overall economic development objectives. The process utilizes two computer-aided programs to evalute quickly and cost effectively the energy efficiency of new buildings. The City uses the Predesign Energy Program (PREP) to analyze efficiency in new individual buildings during the conceptual stage of design. The second program, Central Energy Systems Analysis Program (CESAP) analyzes energy efficiency for a group of buildings and determines if a new district heating and cooling (DHC) system would be a cost effective application to serve the development project's energy requirements. The combination of these programs have given the City of San Antonio the ability to: (1) help builders, owners and architects to reduce energy and construction costs; and (2) evaluate the feasibility of new district heating and cooling systems as a means to promote economic development wihin the City of San Antonio.

PROJECT PURPOSE

The primary purpose of this project was to define and evaluate potential benefits of central energy systems (specifically, district heating and cooling) for private development in one or more specifically targeted areas within the City of San Antonio. A secondary purpose was to integrate energy conserving features into public and private development, thus, controlling San Antonio's energy growth.

INTRODUCTION -- CENTRAL ENERGY SYSTEMS

District heating and cooling (DHC) facilities are types of central energy systems that are receiving renewed attention in cities and counties throughout the United States. Developed as a prominent energy supply and distribution technology in the late 19th century, DHC in the U.S. declined as an energy supply option when natural gas, petroleum and electricity became widely available during the first half of the 20th century. With today's higher energy prices and single fuel dependency, DHC systems are an excellent choice, providing flexibility, efficiency and cost effectiveness.

Benefits

District heating and cooling systems promise a continuing supply of thermal energy at a price that is predictably stable and not prone to sudden interruptions. This promise is made, however, at the expense of higher than normal capital costs for the design and construction of the central energy plant and its distribution system. Even with these constraints, DHC can be a significant factor in the enhancement of economic activity through its ability to reduce energy costs for commercial and industrial operations. the successful capture of these benefits for economic development requires rational planning for new DHC facilities that address thermal loads, environmental concerns, regulatory considerations, land use implications and, significantly, a system's overall economics, financing and ownership options.

Definition of DHC System

A central energy system can be generally defined as a facility that produces and distributes energy from a central site for use in a number of other structures, of facilities. A central energy system that supplies thermal energy for the heating and cooling needs of a series of buildings is generally referred to as a district heating and cooling system. A district heating and cooling system (DHC), delivers hot or chilled water or steam from a central source through pipes to customers for space heating, air conditioning and industrial purposes. The center of operations for a DHC system is often called a central energy plant. In this report, the terms central energy and district heating and cooling are used interchangeably.

METHODOLOGY

The City of San Antonio's Office of Public Utilities currently provides developers and owners: (1) an analysis of energy efficiency strategies for individual buildings; (2) an analysis of the combined loads for several individual buildings for use in estimating the benefits of a central energy system; and (3) a cost comparsion of individual energy systems versus a central energy system plant.

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Computer Model

PREP (Predesign Energy Program), a recent winder of the DOE sponsored Energy Innovation Award, is an IBM Personal Computer based, building energy simulation programs. PREP calculates annual heating, cooling, lighting, appliance usage and provides important insight into annual kWh usage and peak KW load. CESAP (Central Energy System Analysis Program), has the capability of combining individual building heating and cooling loads, to determine the costs associated with a central DHC system versus conventional single-building energy plants. The use of PREP and CESAP has proven to be a simple, cost effective and accurate way to provide valuable energy information.

DHC DESIGN CRITERIA

Based on experiences there are certain key "design factors" for a successful and cost effective DHC system:

(1) A building or a complex of buildings served by a DHC system should have a high load factor. This requirement is essential to allow the low operating costs of a DHC system to payback its high initial capital costs. Buildings that have the highest load factors include multi-shift industries, hospitals, hotels and buildings within some multi-use (Commercial/industrial or commercial/residential) developments. Typically, these buildings are often located within centralized industrial districts, medical complexes and in central business districts.

(2) It is important that a proposed DHC system have a balanced thermal demand over the course of the year to offer low cost and chilled water. This will prevent the DHC system from producing thermal energy at a peak demand for only a particular hour, day or season and therefore, be under-utilized during the remaining period of operation. A balanced thermal demand can be achieved by connecting end-users whose peak demand are diversified over a 24 hour period. To achieve this goal, a mixture of building types is often necessary; such as large commercial, hotel and office buildings clustered in central business districts, office parks and mall developments. These buildings typically have thermal demand requirements 365 day a year with a varied 24-hour thermal load demand. This increase of load demand for heat and chilled water in a mixed-use or clustered development also provides the potential to increase the thermal load density, by attracting other customers to the system.

(3) A high thermal load density will reduce the distribution cost. This is significant, since the distribution costs are the largest single component (about 35-50%) of the capital costs for a DHC system. The vital importance of this measure is twofold. First, the DHC system can provide heat and chilled water at a lower cost per-Btu to the customer since capital costs are reduced, and, second, the thermal demand costs can be spread over a greater number of annual Btu's generated.

It is stressed, that a DHC system can exist for many industrial and commercial developments that are not necessarily within the central business district or in an institutional setting. Structures within these developments can have one or more owners. The key to developing a DHC system is the presense of individual and combined heating and cooling loads sufficient to support the central thermal plant. Economic advantages for the development and operation of a centralized DHC system for an industrial district or a multi-use development are essentially the same as for the development of a downtown district system, or an institutional "campus" system.

A DHC EXAMPLE

A DHC system cost feasibility analysis is centered around an energy assessment of each individual building in a proposed development project. The first step is to use PREP to analyze the indivudal buildings and provide insight into annual kWh use and peak load.

The second step is to use CESAP to combine the individual building heating and cooling loads on an hour-by-hour basis to summarize the costs involved in utilizing a DHC system versus the costs for construction of an in-building conventional energy system.

Step 1: Individual Building Loads

The first step in evaluating a central heating/cooling plant is to characterize the loads of the individual buildings it will serve. To accomplish this the PREP program is used to characterize the individual loads for each proposed building. An example case, illustrates the concepts for evaluating the energy requirements for a small DHC system. The three buildings that are considered are a hotel, a shopping center and an office building. The physical characteristics and occupancy patterns of these three buildings are shown in Table 1.

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TABLE 1. BUILDING CHARACTERISTICS

DESCRIPTION	OFFICE	HOTEL	SHOPPING CENTER
Area (SF)	240,000	225,000	90,000
Stores	15	10	1
% Glass Area	45	50	8
Skylight Area	-	-	10,000
Glass Type	REFLECTIVE	CLEAR	CLEAR
Occupancy (SF/person)	250	400	250
Lighting (W/SF)	2.5	1.5	2.75
Appliance	0.25	0.5	-
Cooling COP	2.5	2.5	2.5
Heating Eff. (%)	100	100	100

Each of the three buildings shown in Table 1 were analyzed to determine their individual load characteristics. The typical winter heating loads are shown in Figure 1 while typical summer cooling loads are shown in Figure 2. A key point to note in Figures 1 and 2 is the diversity of the peak loads for the individual buildings. It is important to note that the cooling loads in particular do not all occur simulaneously. This diversity between the loads is critical to the overall economics of the DHC system. If all three buildings were office buildings with identically the same peak, many of the benefits would not accure to the DHC system.

Step 2: Combined Building Loads

The second step in evaluating a DHC plant is to look at how the individual buildings combine to produce a load on a central plant. In concept, the process is simple: just add up the load at each hour. The arithmetic becomes tedious and there are many individual loads that need to be added on an hour-by-hour basis. CESAP, which combines individual buildings loads on an hour-by-hour basis, was developed for that purpose. The data from the PREP program can be automatically loaded into the CESAP program, with the calculations performed automatically to combine the loads for the whole system. A summary of CESAP results are shown in Table 2.

TABLE 2. CESAP SYSTEM SUMMARY

	CENTRAL PLANT	SEPARATE PLANTS
Total Installation Cost	532,800	659,940*
Cooling System Tons	1503.49	1575.43
Heating System MMBTUH	3.08608	4.20884
Annual Cooling Costs	312,901	312,901
Annual Heating Costs	20,825	20,825
Total Energy Costs	333,727	333,727

*The total cost of each building provided their own heating and cooling requirements.

In comparing the individual loads shown in Figures 1 and 2 to the combined loads shown in Figures 3 and 4, notice that if the peak loads were just summed individually the peak cooling load would be 1575 tons, and the peak heating load would be 4.2 MMBTUH; whereas, the diversified or combined load of the three buildings has a system peak of 1503 tons for cooling and only 3.1 MMBTUH for heating. The combined loads are reduced by 4.5% for cooling and 26% for heating as compared to the sum of the individual loads. it is important to note that the diverse building types still have simultaneous peak cooling loads in the late afternoon. Therefore, the cooling savings from a DHC system in this case are small. Heating peak loads occur at various times so the effect of combining loads substantially decreases equipment capacity, from that which would be required for individual systems.

This savings due to the diversity in load is surprisingly small. It is important to note, however, that these three buildings were intentionally selected to have different occupancy schedules and different operating hours. One of the interesting conclusions of this study is that in San Antonio, cooling is such a dominant need that not much diversity occurs. If the building is occupied at all, it has to be cooled, and if the three buildings were occupied simulanously (as they are in the afternoon), then not much diversity is possible. Although this effect was not studied in detail, this probably works to the detriment of DHC systems located in climates which are dominated by cooling requirements (e.g., most of the Sunbelt cities). In contrast, the individual peak heating loads add up to about 4.2 million BTU per hour while the diversified total heating load for the DHC system is only 3.1 million BTU per hour. This represents over a 26% capacity savings. While climatic effects were not studied, the implication is that DHC systems are probably more cost-effective in climates where heating costs are more important than cooling costs.

COMPARISION OF A CENTRAL PLANT VS INDIVIDUAL PLANTS

While there is not much diversity in the peak cooling load, combining the three buildings into a central DHC system does not allow economics of scale in chiller selection. It also can reduce standby reserve margins. To explore this point, Figure 5 compares DHC system costs of about $532,800 versus the sum of the three individual systems of $696,940. If all three buildings and the DHC system were built at the same time, then the savings in the initial capital costs would be about 8 percent. An important point to note, however, is that much of the savings of the DHC system comes from selecting larger chillers which cost less per ton than smaller chillers. If the DHC system was built incrementally (i.e., if all three buildings were not completed simultaneously), then some diseconomies would occur.

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FIGURE 1 THE INDIVIDUAL BUILDING HEATING LOADS

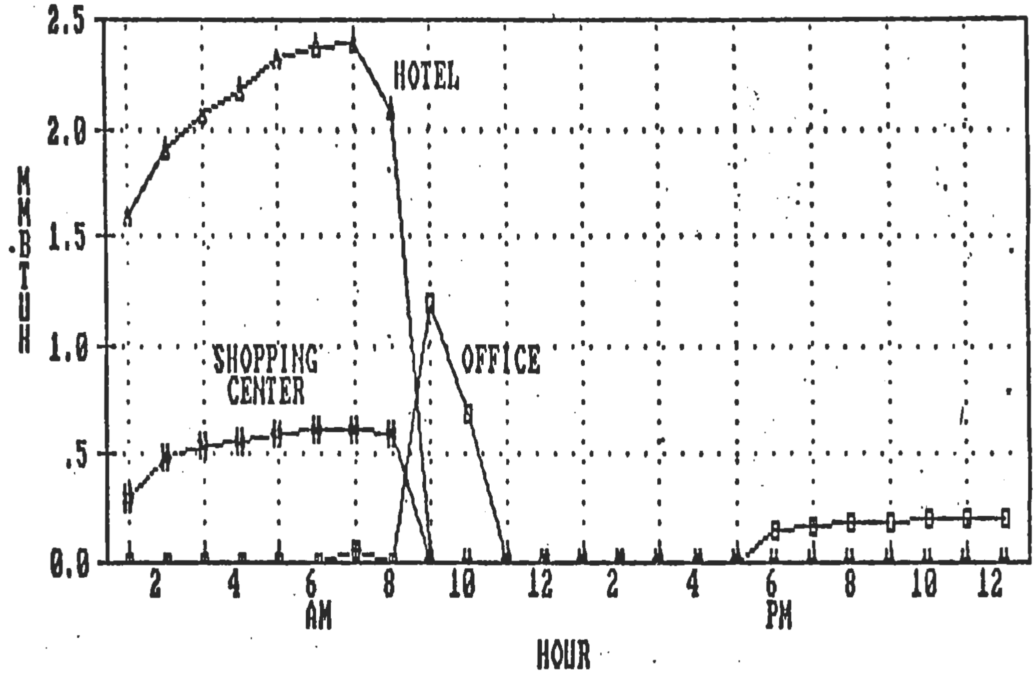


FIGURE 2 THE INDIVIDUAL BUILDING COOLING LOADS

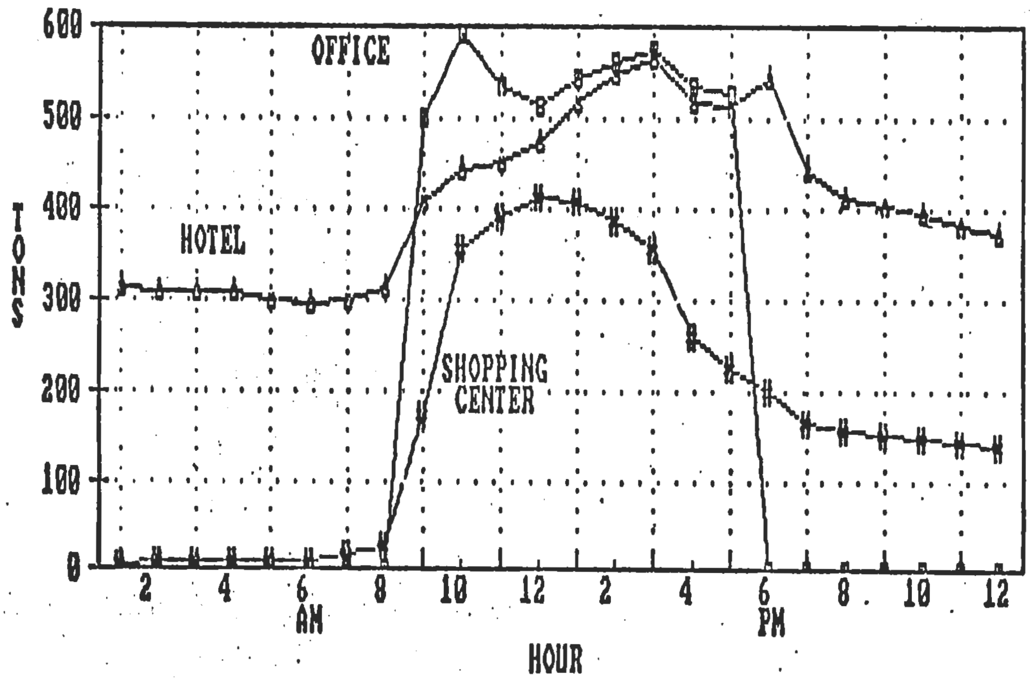


FIGURE 3 THE COMBINED BUILDING COOLING LOAD

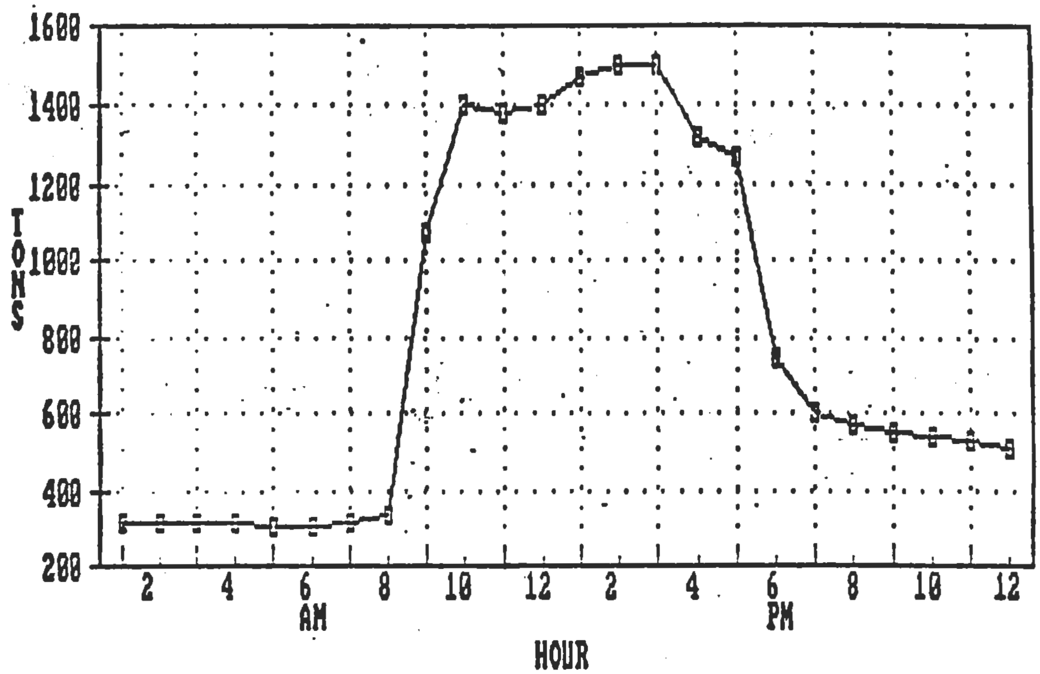
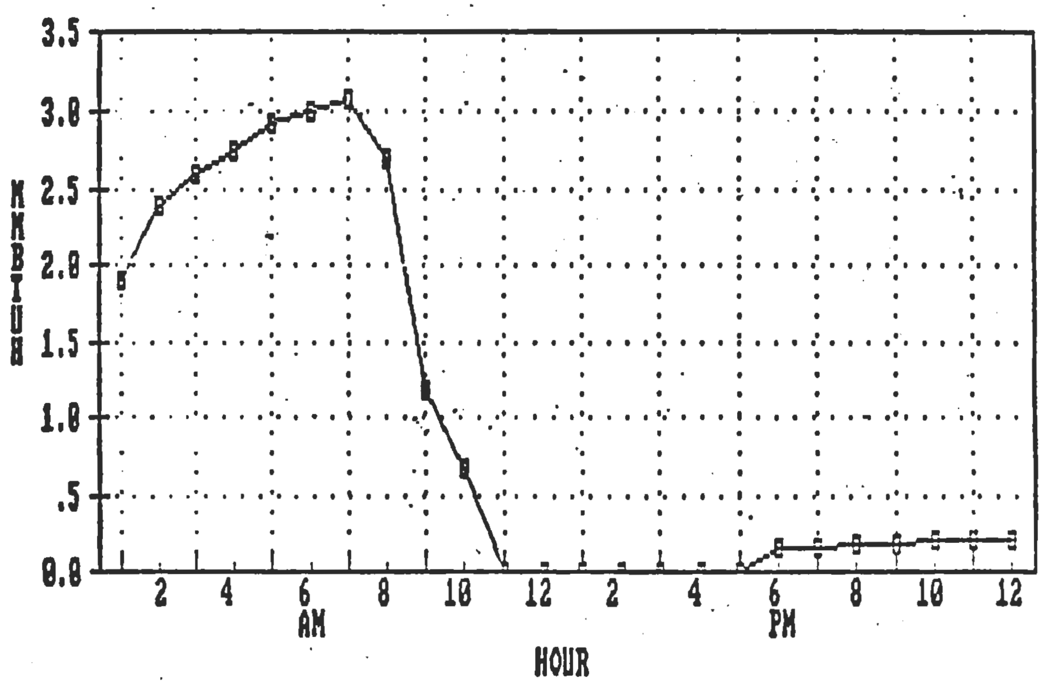


FIGURE 4 THE COMBINED BUILDING HEATING LOAD



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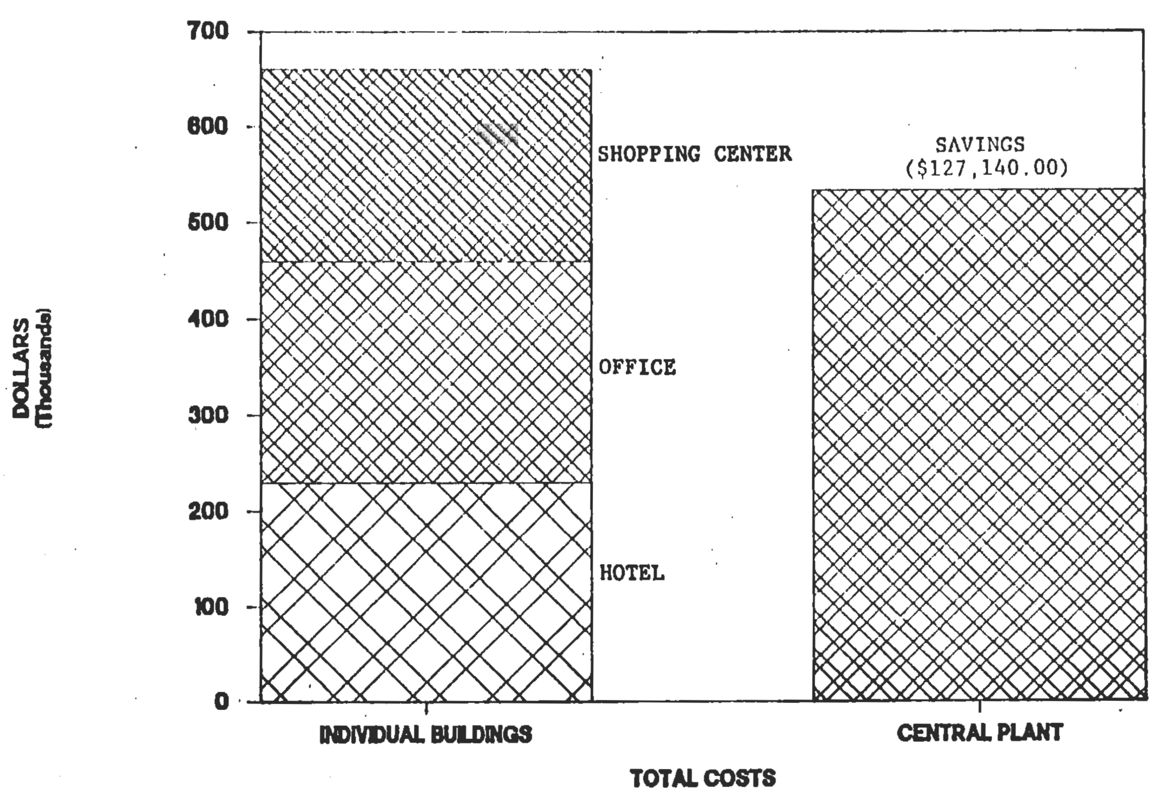
Specifically, if the DHC system owner bought the large chillers and then ran them at part load, they would be less efficient and there would be increased energy costs. Also while the cost per ton is less than for the larger chillers, their absolute cost is higher. Thus a DHC system owner who installed the larger chillers would be paying for the additional capacity even though he could not sell it. This illustrates very clearly and graphically the problem that is faced by a DHC system which goes in first and then expects buildings to be added as additional load. Somebody winds up paying for inefficiency and/or paying for additional capacity until it is actually required. If the DHC system owner tried to build the DHC system with smaller chillers (comparable to the same chillers that would be used in the individual buildings), then no first cost savings are incurred, and in fact the DHC system would cost more because of the piping costs.

POLICY IMPLICATIONS AND CONCLUSION

The combination of analyzing future energy demands, with predesign energy analysis for either residential, commercial or industrial construction projects has the potential to act as an economic growth generator influencing new development, neighborhood revitalization and to create new jobs in the community. In response to the lack of information regarding DHC system in the business community, a coordinated effort was developed among City departments to inform investors and developers about predesign energy conservation assistance and central energy systems during the design stage of a project. The intent of the analysis programs was to provide the City's energy managers with the means to quickly evaluate the cost effectiveness of implementing predesign energy conservation measures in new development projects. If the analysis resulted in a cost savings to the developer, the City would then be prepared to offer technical and financial assistance in developing energy conservation strategies.

FIGURE 5 INDIVIDUAL BUILDINGS vs CENTRAL PLANT COSTS



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