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Final Report: Comparative Ranking of 0.1 - 10 MW_e Solar Thermal Electric Power Systems

Volume II Supporting Data

John P. Thornton
Kenneth C. Brown
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F. Ann Herlevich
Thomas A. Kriz

SERI

Solar Energy Research Institute
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Golden, Colorado 80401

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FINAL REPORT: COMPARATIVE RANKING OF 0.1-10 MW_e SOLAR THERMAL ELECTRIC POWER SYSTEMS

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PREPARED UNDER TASK NO. 3456.10

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PREFACE

This report documents work on SERI Tasks 3509 and 3456.10 by members of the Systems Development Branch of the Utility and Industry Division. The task extended from April 1978 through September 1979 and was supported by Systems Development Division, Office of Solar Applications, U.S. Department of Energy.

Many people within SERI who helped to gather data, conduct site visits, and participate in design reviews are acknowledged in Appendix F.

The authors want to thank Stephen Cronin, Louise Morrison, Doug Madison, and Marshall Buhl for their invaluable assistance in developing BALDR, the system simulation computer code.

John P. Thornton

John Thornton, Task Leader
Small Power Systems Study

Approved for:
SOLAR ENERGY RESEARCH INSTITUTE

Neil H. Woodley, Division Manager
Division of Industry and Utilities

Charles J Bishop

Charles Bishop, Branch Chief
Systems Development

SUMMARY

The Thermal Power Systems Branch, Division of Central Solar Technology of the U.S. Department of Energy (DOE) has initiated the Small Solar Thermal Power Systems Program to explore the technical, economic, and institutional feasibility of providing remote load centers, small communities, rural areas, and industrial users with supplementary energy sources. The objective of the Small Solar Thermal Power Systems Program is to establish the technical readiness of cost-competitive solar thermal power systems. A Small Communities Application project supports the program. The U.S. Department of Energy delegated responsibility for both technical management of the small communities project and for development of experimental systems that achieve the goals of the program to the Jet Propulsion Laboratory in Pasadena, California.

To identify the most likely options for long-term commercialization of small solar thermal electric power systems, DOE requested a comparative analysis of the major generic solar thermal electric systems. The Small Solar Thermal Electric Power Systems Study began in April 1978, at both the Solar Energy Research Institute (SERI) and Battelle Pacific Northwest Laboratories.

The original objective of the Small Solar Thermal Electric Power Systems Study (SPSS) was to project the mid-1990 cost and performance of selected generic solar thermal electric power systems for utility applications and to rank these systems by criteria that reflect their future commercial acceptance. This study considered plants with rated capacities of 1-10 MW_e, operating over a range of capacity factors from the no-storage case to 0.7 and above. Later, the study was extended to include systems with capacities from 0.1-1 MW_e, a range that is attractive to industrial and other nonutility applications.

In the first phase of SPSS, completed in October 1978, generic systems and their variations and a simulation technique for projecting future cost and performance were selected, ground rules were established, and a ranking method was defined. A report summarizing the approach of the study and its selections of generic systems was released in July 1978.*

Systems from 1-10 MW_e rated capacity were examined during the second phase of SPSS, completed in May 1979. A preliminary summary of the ranking of 1-10 MW_e systems was published in September 1979.**

The third and last phase of SPSS, completed in September 1979, ranked systems with rated capacities of 0.1-1 MW_e. Because utilities usually are not interested in systems of this capacity, ground rules were modified and ten systems that have an available backup power source such as a grid or diesel generator were modeled for industrial or small community use. Unlike the 1-10 MW_e systems, these smaller systems do not operate as an integral part of the grid.

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*Thornton, J. et al. 1978 (July). Small Power Systems Study Quarterly Report No.1. SERI-36. Golden, CO: Solar Energy Research Institute.

**Thornton, J. et al. 1979 (September). Comparative Ranking of 1-10 MW_e Solar Thermal Electric Power Systems. SERI/TR-35-238. Golden, CO: Solar Energy Research Institute.

Volume I of this report summarizes the results for both the 1-10 MW_e and 0.1-1 MW_e capacity studies. The second volume presents data on performance, cost, and ranking methodology.

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SECTION 1.0

INTRODUCTION

Volume I presents the conclusions of the Small Solar Thermal Electric Power Systems Study (SPSS). For those who want more information on the performance of the generic systems and on the method and results of the multiattribute decision analysis, this volume offers specific data.

Sections 2.0 and 3.0 provide component, subsystem, and system costs and performance summaries for the 1-10 MW_e and 0.1-1 MW_e systems, respectively. These data are condensed from the detailed computer simulations of each system obtained during the study.

Section 4.0 presents data used in the multiattribute decision analysis that was used to rank systems in both parts of the study.

SECTION 2.0

COST AND PERFORMANCE SUMMARY SHEETS FOR 1-10 MW_e SYSTEMS

The systems studied in the 1-10 MW_e range for utility applications cover a broad spectrum of solar thermal technologies. Eight types of collector technologies were considered ranging from two-axis tracking concentrating collectors to nontracking, nonconcentrating collectors. Figure 2-1 shows the collector types modeled. Each collector was combined with one or more storage and power conversion technologies for a total of eleven systems (see Table 2-1).

Cost and performance data for the 1-10 MW_e systems are presented in Tables 2-2 to 2-45. Data are presented for each system at 1, 5, and 10 MW_e capacities and at capacity factors of 0.4, 0.7, the no storage case, and the optimum case for each capacity, selected on the basis of lowest levelized busbar energy cost (BBEC).

The performance summary section shows system efficiencies together with the capacity factor selected for each case. The capacity factor represents the amount of electrical energy produced for the full year divided by the amount of energy that would be produced had the plant operated at rated capacity for the entire year. The collection subsystem efficiency is a total field efficiency including receiver losses, expressed as an annual average efficiency. Transport Subsystem Efficiency represents the annual average efficiency of the thermal transport subsystem only assuming an ambient temperature of 20° C. For these summary sheets, systems with electrical transport are given a thermal transport efficiency of 1.0. The average thermal power collected by the collector subsystem and delivered to the power conversion subsystem by the transport subsystem in MW_t is helpful in determining overall system efficiency. The storage subsystem efficiency represents annual average efficiency of thermal or electrical storage and takes into account any energy that must be wasted if storage is absent. Conversion subsystem efficiency includes engine and generator efficiencies for an annual average efficiency. For the subsystems with thermal storage, conversion efficiency when operating from storage is also given. Finally, the annual average system efficiency is presented for each case. To determine the system efficiency, a thermal capacity factor is found by dividing the average thermal power collected by the plant rated capacity. Then dividing the electrical capacity factor by this thermal capacity factor, one obtains an overall thermal-to-electrical efficiency that includes engine and generator, auxiliaries, and power-conditioning equipment. This efficiency is multiplied by the field efficiency and the transport efficiency for an overall system efficiency.

The economic summary of each case is presented on the second half of each system's summary sheet. Capital costs for subsystem components are given on a unit basis. The unit costs for concentrator and receiver are given in $\$/m^2$ of collector area except for the troughs, CPC, and shallow solar ponds. In these cases, receiver and concentrator costs are combined. For the central receiver systems, riser and downcomer and tower costs are included in receiver cost. The transport cost represents the cost for thermal or electrical storage as appropriate for each system. The storage cost, however, is broken down separately for systems with thermal or electrical storage. Conversion subsystem cost is divided into engine cost and generator cost. Balance of plant includes cooling towers, pumps, control system, buildings, and any necessary site work and power conditioning equipment. The total capital cost of the system is presented in 1978 dollars. Average operation and maintenance costs are given in mills/kWh. Finally, BBEC is given in mills/kWh.

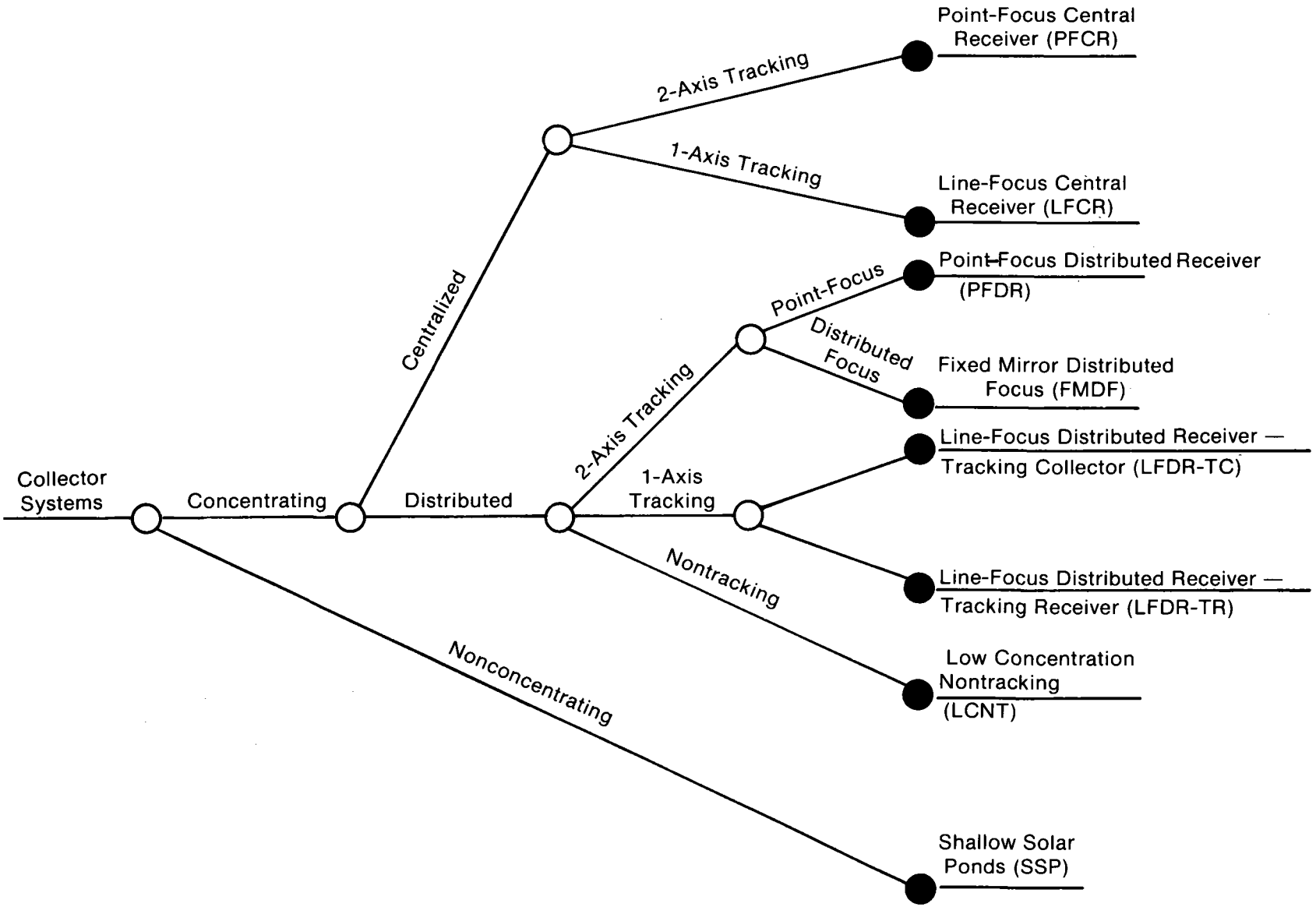

Figure 2-1. Generic Options Considered in the 1-10 MW_e Ranking

Table 2-1. Combination of Technologies Considered in 1-10 MW_e Study

Concentrator Options	System Options												
	Conversion					Transport				Storage			
											Thermal		
	Cent-Rankine	Cent-Brayton	Dist-Rankine	Dist-Brayton	Dist-Stirling	Electrical	Water	Salt	Oil	Electrical	Oil	Salt	Water
Point-Focus Central Receiver	●							●				●	
Point-Focus Central Receiver		●				●				●			
Line-Focus Central Receiver	●							●				●	
Point-Focus Distributed Receiver	●							●				●	
Point-Focus Distributed Receiver				●		●				●			
Point-Focus Distributed Receiver					●	●				●			
Fixed Mirror Distributed Focus	●							●				●	
Line-Focus Distributed Receiver — Tracking Collector	●								●		●		
Line-Focus Distributed Receiver-TrackingReceiver	●								●		●		
Low Concentration Nontracking	●								●		●		
Shallow Solar Ponds			●			●	●						●

TABLE 2-2. Performance and Cost Summary of PFCR/R System, No Storage Case

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		1	5	10
Capacity Factor		0.332	0.315	0.302
Collection Subsystem Efficiency (Annual Average)		0.648	0.555	0.555
Transport Subsystem Efficiency[a]		0.991	0.989	0.989
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	1.87	8.01	14.2
Storage Subsystem Efficiency[a]		1.0	1.0	1.0
Conversion Subsystem Efficiency from Field[a] (@ T_{field}=540°C)		0.283	0.305	0.304
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=540°C)		0.283	0.305	0.304
System Efficiency (Annual Average)		0.121	0.115	0.124

[a] $T_{ambient}$ = 20°C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	75	75	75
	Receiver		30	16	14
Transport Subsystem		$/m² Collector	0.58	0.84	1.1
Electrical Storage Subsystem		$/$kW_e$	---	---	---
		$/$kW_e$h	---	---	---
Thermal Storage Subsystem		$/$kW_t$	---	---	---
		$/$kW_t$h	---	---	---
Conversion Subsystem	Engine	$/kW	480	320	269
	Generator	$/$kW_e$	30	28	24
Balance of Plant		$/$kW_e$	620	411	346
Total Capital Cost		$ × 10^6	2.61	10.2	17.3
O&M Costs (Average)		mills/kW_eh	12.2	12.8	13.3
$\overline{BBEC}$		mills/kW_eh	156	132	119

[b] All costs include installation

TABLE 2-3. Performance and Cost Summary of PFCR/R System, 0.4 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		1	5	10
Capacity Factor		0.408	0.404	0.404
Collection Subsystem Efficiency (Annual Average)		0.648	0.555	0.555
Transport Subsystem Efficiency[a]		0.991	0.989	0.989
Average Thermal Power Collected (8784 h/yr)	$\overline{MW}_t$	1.67	8.01	16.0
Storage Subsystem Efficiency[a]		0.655	0.562	0.561
Conversion Subsystem Efficiency from Field[a] (@ T_{field}= 540°C)		0.284	0.305	0.305
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=540°C)		0.284	0.305	0.305
System Efficiency (Annual Average)		0.167	0.147	0.147

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	75	75	75
	Receiver		30	16	14
Transport Subsystem		$/m² Collector	0.58	0.84	1.1
Electrical Storage Subsystem		$/$kW_e$	---	---	---
		$/$kW_e$h	---	---	---
Thermal Storage Subsystem		$/$kW_t$	93	93	93
		$/$kW_t$h	15	15	15
Conversion Subsystem	Engine	$/kW	480	320	269
	Generator	$/$kW_e$	30	28	24
Balance of Plant		$/$kW_e$	620	411	346
Total Capital Cost		$ × 10^6	2.79	11.5	20.9
O&M Costs (Average)		mills/kW_eh	10.3	10.4	10.4
$\overline{BBEC}$		mills/kW_eh	136	115	106

[b] All costs include installation

TABLE 2-4. Performance and Cost Summary of PFCR/System, 0.7 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		1	5	10
Capacity Factor		0.709	0.715	0.702
Collection Subsystem Efficiency (Annual Average)		0.648	0.555	0.555
Transport Subsystem Efficiency[a]		0.991	0.989	0.989
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	2.91	13.4	28.5
Storage Subsystem Efficiency[a]		0.817	0.861	0.732
Conversion Subsystem Efficiency from Field[a] (@ T_{field}= 540°C)		0.284	0.305	0.305
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=540°C)		0.284	0.305	0.305
System Efficiency (Annual Average)		0.166	0.156	0.144

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	75	75	75
	Receiver		30	16	14
Transport Subsystem		$/m² Collector	0.58	0.84	1.1
Electrical Storage Subsystem		$/$kW_e$	---	---	---
		$/$kW_e$h	---	---	---
Thermal Storage Subsystem		$/$kW_t$	93	93	93
		$/$kW_t$h	15	15	15
Conversion Subsystem	Engine	$/kW	480	320	269
	Generator	$/$kW_e$	30	28	24
Balance of Plant		$/$kW_e$	620	411	346
Total Capital Cost		$ × 10^6	3.97	17.9	33.2
O&M Costs (Average)		mills/kW_eh	6.8	6.8	6.9
$\overline{BBEC}$		mills/kW_eh	109	99	94

[b] All costs include installation

TABLE 2-5. Performance and Cost Summary of PFCR/R System, Optimum Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		1	5	10
Capacity Factor		0.786	0.759	0.739
Collection Subsystem Efficiency (Annual Average)		0.648	0.555	0.555
Transport Subsystem Efficiency[a]		0.991	0.989	0.989
Average Thermal Power Collected (8784 h/yr)	$\overline{MW}_t$	3.33	15.1	28.5
Storage Subsystem Efficiency[a]		0.785	0.767	0.812
Conversion Subsystem Efficiency from Field[a] (@ T_{field}= 540°C)		0.284	0.305	0.305
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=540°C)		0.284	0.305	0.305
System Efficiency (Annual Average)		0.161	0.146	0.150

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	75	75	75
	Receiver		30	16	14
Transport Subsystem		$/m² Collector	0.58	0.84	1.1
Electrical Storage Subsystem		$/$kW_e$	---	---	---
		$/$kW_e$h	---	---	---
Thermal Storage Subsystem		$/$kW_t$	93	93	93
		$/$kW_t$h	15	15	15
Conversion Subsystem	Engine	$/kW	480	320	269
	Generator	$/$kW_e$	30	28	24
Balance of Plant		$/$kW_e$	620	411	346
Total Capital Cost		$ × 10^6	4.31	18.8	34.7
O&M Costs (Average)		mills/kW_eh	6.4	6.5	6.7
$\overline{BBEC}$		mills/kW_eh	107	98	93

[b] All costs include installation

TABLE 2-6. Performance and Cost Summary of PFDR/S, No Storage Case

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		1	5	10
Capacity Factor		0.348	0.348	0.348
Collection Subsystem Efficiency (Annual Average)		0.667	0.667	0.667
Transport Subsystem Efficiency[a]		0.96	0.96	0.96
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	1.2	5.9	11.9
Storage Subsystem Efficiency[a]		1.0	1.0	1.0
Conversion Subsystem Efficiency from Field[a] (@ T_{field}=750°C)		0.353	0.353	0.353
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=)		N/A	N/A	N/A
System Efficiency (Annual Average)		0.201	0.201	0.201

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	100	100	100
	Receiver		12	12	12
Transport Subsystem		$/m² Collector	4.0	5.8	7.0
Electrical Storage Subsystem		$/$kW_e$	---	---	---
		$/$kW_e$h	---	---	---
Thermal Storage Subsystem		$/$kW_t$	---	---	---
		$/$kW_t$h	---	---	---
Conversion Subsystem	Engine	$/kW	125	125	125
	Generator	$/$kW_e$	35	35	35
Balance of Plant		$/$kW_e$	620	411	346
Total Capital Cost		$ × 10^6	1.76	7.60	14.6
O&M Costs (Average)		mills/kW_eh	13.7	13.7	13.7
$\overline{BBEC}$		mills/kW_eh	108	96	93

[b] All costs include installation

TABLE 2-7. Performance and Cost Summary of PFDR/S System, 0.4 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		1	5	10
Capacity Factor		0.417	0.417	0.417
Collection Subsystem Efficiency (Annual Average)		0.667	0.667	0.667
Transport Subsystem Efficiency[a]		0.96	0.96	0.96
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	1.5	7.6	15.3
Storage Subsystem Efficiency[a]		0.933	0.933	0.933
Conversion Subsystem Efficiency from Field[a] (@ T_{field}=750°C)		0.353	0.353	0.353
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=)		N/A	N/A	N/A
System Efficiency (Annual Average)		0.188	0.188	0.188

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	100	100	100
	Receiver		12	12	12
Transport Subsystem		$/m² Collector	4.0	5.8	7.0
Electrical Storage Subsystem		$/$kW_e$	160	160	160
		$/$kW_e$h	16	16	16
Thermal Storage Subsystem		$/$kW_t$	-	-	-
		$/$kW_t$h	-	-	-
Conversion Subsystem	Engine	$/kW	125	125	125
	Generator	$/$kW_e$	35	35	35
Balance of Plant		$/$kW_e$	620	411	346
Total Capital Cost		$ × 10^6	2.24	10.0	19.5
O&M Costs (Average)		mills/kW_eh	12.0	12.0	12.0
$\overline{BBEC}$		mills/kW_eh	111	101	99

[b] All costs include installation

TABLE 2-8. Performance and Cost Summary of PFDR/S System, 0.7 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		1	5	10
Capacity Factor		0.692	0.692	0.692
Collection Subsystem Efficiency (Annual Average)		0.667	0.667	0.667
Transport Subsystem Efficiency[a]		0.96	0.96	0.96
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	3.1	15.3	30.6
Storage Subsystem Efficiency[a]		0.773	0.773	0.773
Conversion Subsystem Efficiency from Field[a] (@ T_{field}= 750°C)		0.353	0.353	0.353
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=)		N/A	N/A	N/A
System Efficiency (Annual Average)		0.156	0.156	0.156

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	100	100	100
	Receiver		12	12	12
Transport Subsystem		$/m² Collector	4.0	5.8	7.0
Electrical Storage Subsystem		$/$kW_e$	160	160	160
		$/$kW_e$h	16	16	16
Thermal Storage Subsystem		$/$kW_t$	-	-	-
		$/$kW_t$h	-	-	-
Conversion Subsystem	Engine	$/kW	125	125	125
	Generator	$/$kW_e$	35	35	35
Balance of Plant		$/$kW_e$	620	411	346
Total Capital Cost		$ × 10^6	3.57	16.7	32.8
O&M Costs (Average)		mills/kW_eh	8.57	8.57	8.57
$\overline{BBEC}$		mills/kW_eh	104	98	96

[b] All costs include installation

TABLE 2-9. Performance and Cost Summary of PFDR/S System, Optimum Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		1	5	10
Capacity Factor		0.727	0.727	0.348
Collection Subsystem Efficiency (Annual Average)		0.667	0.667	0.667
Transport Subsystem Efficiency[a]		0.96	0.96	0.96
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	3.1	15.3	11.9
Storage Subsystem Efficiency[a]		0.812	0.812	1.0
Conversion Subsystem Efficiency from Field[a] (@ T_{field}=750°C)		0.353	0.353	0.353
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=)		N/A	N/A	N/A
System Efficiency (Annual Average)		0.164	0.164	0.200

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	100	100	100
	Receiver		12	12	12
Transport Subsystem		$/m² Collector	4.0	5.8	7.0
Electrical Storage Subsystem		$/$kW_e$	160	160	-
		$/$kW_e$h	16	16	-
Thermal Storage Subsystem		$/$kW_t$	-	-	-
		$/$kW_t$h	-	-	-
Conversion Subsystem	Engine	$/kW	125	125	125
	Generator	$/$kW_e$	35	35	35
Balance of Plant		$/$kW_e$	620	411	346
Total Capital Cost		$ × 10^6	3.66	17.2	14.6
O&M Costs (Average)		mills/kW_eh	8.3	8.3	13.7
$\overline{BBEC}$		mills/kW_eh	101	95	93

[b] All costs include installation

TABLE 2-10. Performance and Cost Summary of PFDR/CR System, No Storage Case

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		1	5	10
Capacity Factor		0.361	0.354	0.352
Collection Subsystem Efficiency (Annual Average)		0.627	0.627	0.627
Transport Subsystem Efficiency[a]		0.95	0.91	0.89
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	1.93	8.3	16.3
Storage Subsystem Efficiency[a]		1.0	1.0	1.0
Conversion Subsystem Efficiency from Field[a] (@ T_{field}= 455°C)		0.274	0.297	0.297
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}= 455°C)		0.274	0.297	0.297
System Efficiency (Annual Average)		0.118	0.129	0.128

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	100	100	100
	Receiver		9	9	9
Transport Subsystem		$/m² Collector	24	38	46
Electrical Storage Subsystem		$/$kW_e$	-	-	-
		$/$kW_e$h	-	-	-
Thermal Storage Subsystem		$/$kW_t$	0	0	0
		$/$kW_t$h	0	0	0
Conversion Subsystem	Engine	$/kW	480	320	269
	Generator	$/$kW_e$	30	28	24
Balance of Plant		$/$kW_e$	616	411	346
Total Capital Cost		$ × 10^6	2.6	11.2	21.7
O&M Costs (Average)		mills/kW_eh	14.3	14.5	14.6
$\overline{BBEC}$		mills/kW_eh	147	131	129

[b] All costs include installation

TABLE 2-11. Performance and Cost Summary of PFDR/CR System 0.4 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		1	5	10
Capacity Factor		0.404	0.408	0.406
Collection Subsystem Efficiency (Annual Average)		0.627	0.627	0.627
Transport Subsystem Efficiency[a]		0.95	0.91	0.89
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	1.74	8.32	16.3
Storage Subsystem Efficiency[a]		0.473	0.411	0.446
Conversion Subsystem Efficiency from Field[a] (@ T_{field}= 455°C)		0.275	0.298	0.298
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=455°C)		0.275	0.298	0.298
System Efficiency (Annual Average)		0.147	0.149	0.148

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	100	100	100
	Receiver		9	9	9
Transport Subsystem		$/m² Collector	24	38	46
Electrical Storage Subsystem		$/$kW_e$	-	-	-
		$/$kW_e$h	-	-	-
Thermal Storage Subsystem		$/$kW_t$	93	93	93
		$/$kW_t$h	15	15	15
Conversion Subsystem	Engine	$/kW	480	320	269
	Generator	$/$kW_e$	30	28	24
Balance of Plant		$/$kW_e$	616	411	346
Total Capital Cost		$ × 10^6	2.7	12.1	23.7
O&M Costs (Average)		mills/kW_eh	13.4	13.2	13.3
$\overline{BBEC}$		mills/kW_eh	137	123	121

[b] All costs include installation

TABLE 2-12. Performance and Cost Summary of PFDR/CR System, 0.7 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		1	5	10
Capacity Factor		0.679	0.697	0.681
Collection Subsystem Efficiency (Annual Average)		0.627	0.627	0.627
Transport Subsystem Efficiency[a]		0.95	0.91	0.89
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	3.09	12.9	28.9
Storage Subsystem Efficiency[a]		0.687	0.900	0.671
Conversion Subsystem Efficiency from Field[a] (@ T_{field}=455°C)		0.275	0.298	0.298
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=455°C)		0.275	0.298	0.298
System Efficiency (Annual Average)		0.139	0.163	0.140

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	100	100	100
	Receiver		9	9	9
Transport Subsystem		$/m² Collector	24	38	46
Electrical Storage Subsystem		$/$kW_e$	-	-	-
		$/$kW_eh$	-	-	-
Thermal Storage Subsystem		$/$kW_t$	93	93	93
		$/$kW_th$	15	15	15
Conversion Subsystem	Engine	$/kW	480	320	269
	Generator	$/$kW_e$	30	28	24
Balance of Plant		$/$kW_e$	616	411	346
Total Capital Cost		$ × 10^6	3.9	17.6	34.9
O&M Costs (Average)		mills/kW_eh	10.0	9.9	9.9
$\overline{BBEC}$		mills/kW_eh	115	103	104

[b] All costs include installation

TABLE 2-13. Performance and Cost Summary of PFDR/CR System, Optimum Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		1	5	10
Capacity Factor		0.815	0.803	0.799
Collection Subsystem Efficiency (Annual Average)		0.627	0.627	0.627
Transport Subsystem Efficiency[a]		0.95	0.91	0.89
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	3.47	16.6	32.6
Storage Subsystem Efficiency[a]		0.817	0.741	0.763
Conversion Subsystem Efficiency from Field[a] (@ T_{field}=455°C)		0.275	0.298	0.298
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=455°C)		0.275	0.298	0.298
System Efficiency (Annual Average)		0.148	0.146	0.146

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	100	100	100
	Receiver		9	9	9
Transport Subsystem		$/m² Collector	24	38	46
Electrical Storage Subsystem		$/$kW_e$	-	-	-
		$/$kW_e$h	-	-	-
Thermal Storage Subsystem		$/$kW_t$	93	93	93
		$/$kW_t$h	15	15	15
Conversion Subsystem	Engine	$/kW	480	320	269
	Generator	$/$kW_e$	30	28	24
Balance of Plant		$/$kW_e$	616	411	346
Total Capital Cost		$ × 10^6	4.3	20.0	39.5
O&M Costs (Average)		mills/kW_eh	9.6	9.2	9.3
$\overline{BBEC}$		mills/kW_eh	106	101	101

[b] All costs include installation

TABLE 2-14. Performance and Cost Summary of PFDR/B System, No Storage Case

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		1	5	10
Capacity Factor		0.339	0.328	0.337
Collection Subsystem Efficiency (Annual Average)		0.659	0.659	0.659
Transport Subsystem Efficiency[a]		0.96	0.96	0.95
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	1.34	6.30	13.4
Storage Subsystem Efficiency[a]		1.0	1.0	1.0
Conversion Subsystem Efficiency from Field[a] (@ T_{field}=815°C)		0.281	0.281	0.278
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=		N/A	N /A	N/A
System Efficiency (Annual Average)		0.171	0.177	0.179

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	100	100	100
	Receiver		12	12	12
Transport Subsystem		$/m² Collector	4.0	5.8	7.0
Electrical Storage Subsystem		$/$kW_e$	-	-	-
		$/$kW_e$h	-	-	-
Thermal Storage Subsystem		$/$kW_t$	-	-	-
		$/$kW_t$h	-	-	-
Conversion Subsystem	Engine	$/kW	239	239	239
	Generator	$/$kW_e$	35	35	35
Balance of Plant		$/$kW_e$	616	411	346
Total Capital Cost		$ × 10^6	2.04	8.54	17.0
O&M Costs (Average)		mills/kW_eh	12.0	12.4	12.1
$\overline{BBEC}$		mills/kW_eh	123	111	108

[b] All costs include installation

TABLE 2-15. Performance and Cost Summary of PFDR/B System, 0.4 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		1	5	10
Capacity Factor		0.410	0.399	0.408
Collection Subsystem Efficiency (Annual Average)		0.659	0.659	0.659
Transport Subsystem Efficiency[a]		0.96	0.96	0.95
Average Thermal Power Collected (8784 h/yr)	$\overline{MW}_t$	1.68	7.98	16.8
Storage Subsystem Efficiency[a]		0.920	0.943	0.926
Conversion Subsystem Efficiency from Field[a] (@ T_{field}= 815°C)		0.281	0.281	0.281
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=)		N/A	N/A	N/A
System Efficiency (Annual Average)		0.166	0.170	0.174

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	100	100	100
	Receiver		12	12	12
Transport Subsystem		$/m² Collector	4.0	5.8	7.0
Electrical Storage Subsystem		$/$kW_e$	160	160	160
		$/$kW_e$h	16	16	16
Thermal Storage Subsystem		$/$kW_t$	-	-	-
		$/$kW_t$h	-	-	-
Conversion Subsystem	Engine	$/kW	239	239	239
	Generator	$/$kW_e$	35	35	35
Balance of Plant		$/$kW_e$	616	411	346
Total Capital Cost		$\$ \times 10^6$	2.56	11.3	22.7
O&M Costs (Average)		mills/kW_eh	10.3	10.5	10.3
$\overline{BBEC}$		mills/kW_eh	125	115	113

[b] All costs include installation

TABLE 2-16. Performance and Cost Summary of PFDR/B System, 0.7 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		1	5	10
Capacity Factor		0.698	0.698	0.695
Collection Subsystem Efficiency (Annual Average)		0.659	0.659	0.659
Transport Subsystem Efficiency[a]		0.96	0.96	0.95
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	3.36	16.8	33.6
Storage Subsystem Efficiency[a]		0.784	0.784	0.789
Conversion Subsystem Efficiency from Field[a] (@ T_{field}= 815°C)		0.281	0.281	0.281
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=)		N/A	N/A	N/A
System Efficiency (Annual Average)		0.141	0.141	0.148

[a] $T_{ambient}$ = 20°C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	100	100	100
	Receiver		12	12	12
Transport Subsystem		$/m² Collector	4.0	5.8	7.0
Electrical Storage Subsystem		$/$kW_e$	160	160	160
		$/$kW_e$h	16	16	16
Thermal Storage Subsystem		$/$kW_t$	-	-	-
		$/$kW_t$h	-	-	-
Conversion Subsystem	Engine	$/kW	239	239	239
	Generator	$/$kW_e$	35	35	35
Balance of Plant		$/$kW_e$	616	411	346
Total Capital Cost		$ × 10^6	4.26	20.1	39.6
O&M Costs (Average)		mills/kW_eh	6.9	6.9	6.9
$\overline{BBEC}$		mills/kW_eh	118	112	111

[b] All costs include installation

TABLE 2-17. Performance and Cost Summary of PFDR/B System, Optimum Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		1	5	10
Capacity Factor		0.720	0.328	0.337
Collection Subsystem Efficiency (Annual Average)		0.659	0.659	0.659
Transport Subsystem Efficiency[a]		0.96	0.96	0.95
Average Thermal Power Collected (8784 h/yr)	$\overline{MW}_t$	3.36	6.30	13.4
Storage Subsystem Efficiency[a]		0.809	0.982	0.956
Conversion Subsystem Efficiency from Field[a] (@ T_{field}=815° C)		0.281	0.281	0.278
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=)		N/A	N/A	N/A
System Efficiency (Annual Average)		0.146	0.177	0.179

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	100	100	100
	Receiver		12	12	12
Transport Subsystem		$/m² Collector	4.0	5.8	7.0
Electrical Storage Subsystem		$/$kW_e$	160	160	160
		$/$kW_e$h	16	16	16
Thermal Storage Subsystem		$/$kW_t$	-	-	-
		$/$kW_t$h	-	-	-
Conversion Subsystem	Engine	$/kW	239	239	239
	Generator	$/$kW_e$	35	35	35
Balance of Plant		$/$kW_e$	616	411	346
Total Capital Cost		$ × 10^6	4.34	8.71	17.5
O&M Costs (Average)		mills/kW_eh	6.8	12.4	12.1
$\overline{BBEC}$		mills/kW_eh	117	111	108

[b] All costs include installation

TABLE 2-18. Performance and Cost Summary of PFCR/B System, No Storage Case

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		1	5	10
Capacity Factor		0.312	0.287	0.287
Collection Subsystem Efficiency (Annual Average)		0.500	0.411	0.411
Transport Subsystem Efficiency[a]		0.990	0.981	0.981
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	1.28	5.23	10.4
Storage Subsystem Efficiency[a]		1.0	1.0	1.0
Conversion Subsystem Efficiency from Field[a] (@ T_{field}=815°C)		0.315	0.345	0.343
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=)		N/A	N/A	N/A
System Efficiency (Annual Average)		0.128	0.118	0.118

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	75	75	75
	Receiver		26	18	14
Transport Subsystem		$/m² Collector	13	6.8	1.0
Electrical Storage Subsystem		$/$kW_e$	-	-	-
		$/$kW_e$h	-	-	-
Thermal Storage Subsystem		$/$kW_t$	-	-	-
		$/$kW_t$h	-	-	-
Conversion Subsystem	Engine	$/kW	187	126	106
	Generator	$/$kW_e$	30	28	24
Balance of Plant		$/$kW_e$	620	411	346
Total Capital Cost		$ × 10^6	2.28	8.98	15.4
O&M Costs (Average)		mills/kW_eh	12.9	13.8	13.8
$\overline{BBEC}$		mills/kW_eh	147	130	114

[b] All costs include installation

TABLE 2-19. Performance and Cost Summary of PFCR/B System, 0.4 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		1	5	10
Capacity Factor		0.392	0.402	0.402
Collection Subsystem Efficiency (Annual Average)		0.500	0.411	0.411
Transport Subsystem Efficiency[a]		0.990	0.981	0.981
Average Thermal Power Collected (8784 h/yr)	$\overline{MW}_t$	1.93	7.84	15.7
Storage Subsystem Efficiency[a]		0.937	0.909	0.908
Conversion Subsystem Efficiency from Field[a] (@ T_{field}=815°C)		0.314	0.343	0.343
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=)		N/A	N/A	N/A
System Efficiency (Annual Average)		0.107	0.110	0.110

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	75	75	75
	Receiver		26	18	14
Transport Subsystem		$/m² Collector	13	6.8	1.0
Electrical Storage Subsystem		$/$kW_e$	160	160	160
		$/$kW_e$h	16	16	16
Thermal Storage Subsystem		$/$kW_t$	-	-	-
		$/$kW_t$h	-	-	-
Conversion Subsystem	Engine	$/kW	187	126	106
	Generator	$/$kW_e$	30	28	24
Balance of Plant		$/$kW_e$	620	411	346
Total Capital Cost		$ × 10^6	2.99	12.7	23.0
O&M Costs (Average)		mills/kW_eh	10.7	10.5	10.5
$\overline{BBEC}$		mills/kW_eh	151	126	116

[b] All costs include installation

TABLE 2-20. Performance and Cost Summary of PFCR/B System, 0.7 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		1	5	10
Capacity Factor		0.703	0.709	0.705
Collection Subsystem Efficiency (Annual Average)		0.500	0.411	0.411
Transport Subsystem Efficiency[a]		0.990	0.981	0.981
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	3.21	15.7	30.0
Storage Subsystem Efficiency[a]		0.804	0.753	0.759
Conversion Subsystem Efficiency from Field[a] (@ T_{field}=815°C)		0.316	0.345	0.346
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=)		N/A	N/A	N/A
System Efficiency (Annual Average)		0.115	0.097	0.101

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	75	75	75
	Receiver		26	18	14
Transport Subsystem		$/m² Collector	13	6.8	1.0
Electrical Storage Subsystem		$/$kW_e$	160	160	160
		$/$kW_e$h	16	16	16
Thermal Storage Subsystem		$/$kW_t$	-	-	-
		$/$kW_t$h	-	-	-
Conversion Subsystem	Engine	$/kW	187	126	106
	Generator	$/$kW_e$	30	28	24
Balance of Plant		$/$kW_e$	620	411	346
Total Capital Cost		$ × 10^6	4.54	21.4	39.2
O&M Costs (Average)		mills/kW_eh	6.9	6.8	6.9
$\overline{BBEC}$		mills/kW_eh	124	117	109

[b] All costs include installation

TABLE 2-21. Performance and Cost Summary of PFCR/B System, Optimum Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		1	5	10
Capacity Factor		0.734	0.689	0.665
Collection Subsystem Efficiency (Annual Average)		0.500	0.411	0.411
Transport Subsystem Efficiency[a]		0.990	0.981	0.981
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	3.21	14.4	26.3
Storage Subsystem Efficiency[a]		0.767	0.767	0.791
Conversion Subsystem Efficiency from Field[a] (@ T_{field}=815°C)		0.320	0.347	0.350
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=)		N/A	N/A	N/A
System Efficiency (Annual Average)		0.120	0.103	0.109

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	75	75	75
	Receiver		26	18	14
Transport Subsystem		$/m² Collector	13	6.8	1.0
Electrical Storage Subsystem		$/$kW_e$	160	160	160
		$/$kW_e$h	16	16	16
Thermal Storage Subsystem		$/$kW_t$	-	-	-
		$/$kW_t$h	-	-	-
Conversion Subsystem	Engine	$/kW	187	126	106
	Generator	$/$kW_e$	30	28	24
Balance of Plant		$/$kW_e$	620	411	346
Total Capital Cost		$ × 10^6	4.66	20.5	36.4
O&M Costs (Average)		mills/kW_eh	6.7	7.0	7.2
$\overline{BBEC}$		mills/kW_eh	123	116	108

[b] All costs include installation

TABLE 2-22. Performance and Cost Summary of LFDR-TC System, No Storage Case

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		1	5	10
Capacity Factor		0.342	0.340	0.340
Collection Subsystem Efficiency (Annual Average)		0.597	0.597	0.597
Transport Subsystem Efficiency[a]		0.980	0.970	0.970
Average Thermal Power Collected (8784 h/yr)	$\overline{MW}_t$	2.28	10.3	20.7
Storage Subsystem Efficiency[a]		1.0	1.0	1.0
Conversion Subsystem Efficiency from Field[a] (@ T_{field}=285°C)		0.205	0.222	0.222
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=285°C)		0.205	0.222	0.222
System Efficiency (Annual Average)		0.093	0.101	0.101

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

			85+	85+	85+
Collector Subsystem	Concentrator	$/m² Collector	-	-	-
	Receiver				
Transport Subsystem		$/m² Collector	4.0	7.0	8.2
Electrical Storage Subsystem		$/$kW_e$	-	-	-
		$/$kW_e$h	-	-	-
Thermal Storage Subsystem		$/$kW_t$	-	-	-
		$/$kW_t$h	-	-	-
Conversion Subsystem	Engine	$/kW	480	320	269
	Generator	$/$kW_e$	30	28	24
Balance of Plant		$/$kW_e$	466	311	262
Total Capital Cost		$ × 10^6	2.54	10.5	19.9
O&M Costs (Average)		mills/kW_eh	11.9	12.0	12.0
$\overline{BBEC}$		mills/kW_eh	149	126	120

[b] All costs include installation

+Includes receiver cost

TABLE 2-23. Performance and Cost Summary of LFDR-TC System, 0.4 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		1	5	10
Capacity Factor		0.405	0.402	0.402
Collection Subsystem Efficiency (Annual Average)		0.597	0.597	0.597
Transport Subsystem Efficiency[a]		0.980	0.970	0.970
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	2.28	10.3	20.7
Storage Subsystem Efficiency[a]		0.599	0.617	0.617
Conversion Subsystem Efficiency from Field[a] (@ T_{field}= 285°C)		0.205	0.223	0.223
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=285°C)		0.205	0.223	0.223
System Efficiency (Annual Average)		0.111	0.120	0.118

[a] $T_{ambient}$ = 20°C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	85	85	85
	Receiver		-	-	-
Transport Subsystem		$/m² Collector	4.0	7.0	8.2
Electrical Storage Subsystem		$/$kW_e$	-	-	-
		$/$kW_e$h	-	-	-
Thermal Storage Subsystem		$/$kW_t$	200	200	200
		$/$kW_t$h	12	12	12
Conversion Subsystem	Engine	$/kW	480	320	269
	Generator	$/$kW_e$	30	28	24
Balance of Plant		$/$kW_e$	466	311	262
Total Capital Cost		$ × 10^6	2.98	12.6	24.1
O&M Costs (Average)		mills/kW_eh	10.4	10.5	10.5
$\overline{BBEC}$		mills/kW_eh	143	126	121

[b] All costs include installation

TABLE 2-24. Performance and Cost Summary of LFDR-TC System, 0.7 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		1	5	10
Capacity Factor		0.692	0.707	0.700
Collection Subsystem Efficiency (Annual Average)		0.597	0.597	0.597
Transport Subsystem Efficiency[a]		0.980	0.970	0.970
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	4.17	18.8	39.4
Storage Subsystem Efficiency[a]		0.709	0.725	0.690
Conversion Subsystem Efficiency from Field[a] (@ T_{field}=285°C)		0.206	0.223	0.223
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=285°C)		0.206	0.223	0.223
System Efficiency (Annual Average)		0.103	0.112	0.109

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	85	85	85
	Receiver		-	-	-
Transport Subsystem		$/m² Collector	4.0	7.0	8.2
Electrical Storage Subsystem		$/$kW_e$	-	-	-
		$/$kW_e$h	-	-	-
Thermal Storage Subsystem		$/$kW_t$	200	200	200
		$/$kW_t$h	12	12	12
Conversion Subsystem	Engine	$/kW	480	320	269
	Generator	$/$kW_e$	30	28	24
Balance of Plant		$/$kW_e$	466	311	262
Total Capital Cost		$ × 10^6	4.71	21.3	40.9
O&M Costs (Average)		mills/kW_eh	6.96	6.86	6.91
$\overline{BBEC}$		mills/kW_eh	131	117	114

[b] All costs include installation

TABLE 2-25. Performance and Cost Summary of LFDR-TC System, Optimum Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		1	5	10
Capacity Factor		0.678	0.685	0.669
Collection Subsystem Efficiency (Annual Average)		0.597	0.597	0.597
Transport Subsystem Efficiency[a]		0.980	0.970	0.970
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	4.55	18.8	35.7
Storage Subsystem Efficiency[a]		0.717	0.780	0.763
Conversion Subsystem Efficiency from Field[a] (@ T_{field}= 285°C)		0.206	0.224	0.223
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}= 285°C)		0.206	0.224	0.223
System Efficiency (Annual Average)		0.102	0.116	0.115

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	85	85	85
	Receiver		-	-	-
Transport Subsystem		$/m² Collector	4.0	7.0	8.2
Electrical Storage Subsystem		$/$kW_e$	-	-	-
		$/$kW_e$h	-	-	-
Thermal Storage Subsystem		$/$kW_t$	200	200	200
		$/$kW_t$h	12	12	12
Conversion Subsystem	Engine	$/kW	480	320	269
	Generator	$/$kW_e$	30	28	24
Balance of Plant		$/$kW_e$	466	311	262
Total Capital Cost		$ × 10^6	4.61	20.4	38.9
O&M Costs (Average)		mills/kW_eh	7.06	7.01	7.13
$\overline{BBEC}$		mills/kW_eh	131	116	113

[b] All costs include installation

TABLE 2-26. Performance and Cost Summary of LCNT System, No Storage Case

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		1	5	10
Capacity Factor		0.231	0.237	0.228
Collection Subsystem Efficiency (Annual Average)		0.357	0.357	0.357
Transport Subsystem Efficiency[a]		0.969	0.952	0.930
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	1.57	7.70	14.0
Storage Subsystem Efficiency[a]		1.0	1.0	1.0
Conversion Subsystem Efficiency from Field[a] (@ T_{field}= 285°C)		0.209	0.227	0.227
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=285°C)		0.209	0.227	0.227
System Efficiency (Annual Average)		0.054	0.055	0.062

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

			55+	55+	55+
Collector Subsystem	Concentrator	$/m² Collector			
	Receiver		-	-	-
Transport Subsystem		$/m² Collector	4.0	7.0	8.2
Electrical Storage Subsystem		$/$kW_e$	-	-	-
		$/$kW_e$h	-	-	-
Thermal Storage Subsystem		$/$kW_t$	-	-	-
		$/$kW_t$h	-	-	-
Conversion Subsystem	Engine	$/kW	480	320	269
	Generator	$/$kW_e$	30	28	24
Balance of Plant		$/$kW_e$	392	261	219
Total Capital Cost		$ × 10^6	2.14	9.15	16.7
O&M Costs (Average)		mills/kW_eh	16.7	16.8	16.9
$\overline{BBEC}$		mills/kW_eh	187	159	153

[b] All costs include installation

+Includes receiver cost

TABLE 2-27. Performance and Cost Summary of LCNT System, 0.4 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		1	5	10
Capacity Factor		0.399	0.393	0.405
Collection Subsystem Efficiency (Annual Average)		0.357	0.357	0.357
Transport Subsystem Efficiency[a]		0.969	0.952	0.930
Average Thermal Power Collected (8784 h/yr)	$\overline{MW}_t$	2.25	9.89	21.5
Storage Subsystem Efficiency[a]		0.745	0.800	0.696
Conversion Subsystem Efficiency from Field[a] (@ T_{field}=285°C)		0.209	0.228	0.228
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}= 285°C)		0.209	0.228	0.228
System Efficiency (Annual Average)		0.065	0.072	0.071

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	55	55	55
	Receiver		-	-	-
Transport Subsystem		$/m² Collector	4.0	7.0	8.2
Electrical Storage Subsystem		$/$kW_e$	-	-	-
		$/$kW_e$h	-	-	-
Thermal Storage Subsystem		$/$kW_t$	200	200	200
		$/$kW_t$h	12	12	12
Conversion Subsystem	Engine	$/kW	480	320	269
	Generator	$/$kW_e$	30	28	24
Balance of Plant		$/$kW_e$	392	261	219
Total Capital Cost		$ × 10^6	3.14	13.3	27.1
O&M Costs (Average)		mills/kW_eh	10.5	10.6	10.4
$\overline{BBEC}$		mills/kW_eh	155	135	133

[b] All costs include installation

TABLE 2-28. Performance and Cost Summary of LCNT System, 0.7 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		1	5	10
Capacity Factor		0.693	0.714	0.703
Collection Subsystem Efficiency (Annual Average)		0.357	0.357	0.357
Transport Subsystem Efficiency[a]		0.969	0.952	0.930
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	4.04	17.6	34.5
Storage Subsystem Efficiency[a]		0.786	0.905	0.911
Conversion Subsystem Efficiency from Field[a] (@ T_{field}=285°C)		0.210	0.228	0.228
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=285°C)		0.210	0.228	0.228
System Efficiency (Annual Average)		0.063	0.073	0.077

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	55	55	55
	Receiver		-	-	-
Transport Subsystem		$/m² Collector	4.0	7.0	8.2
Electrical Storage Subsystem		$/$kW_e$	-	-	-
		$/$kW_e$h	-	-	-
Thermal Storage Subsystem		$/$kW_t$	200	200	200
		$/$kW_t$h	12	12	12
Conversion Subsystem	Engine	$/kW	480	320	269
	Generator	$/$kW_e$	30	28	24
Balance of Plant		$/$kW_e$	392	261	219
Total Capital Cost		$ × 10^6	4.89	22.0	43.0
O&M Costs (Average)		mills/kW_eh	6.95	6.80	6.89
$\overline{BBEC}$		mills/kW_eh	136	119	119

[b] All costs include installation

TABLE 2-29. Performance and Cost Summary of LCNT System, Optimum Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		1	5	10
Capacity Factor		0.808	0.792	0.782
Collection Subsystem Efficiency (Annual Average)		0.357	0.357	0.357
Transport Subsystem Efficiency[a]		0.969	0.952	0.930
Average Thermal Power Collected (8784 h/yr)	$\overline{MW}_t$	4.49	19.8	38.8
Storage Subsystem Efficiency[a]		0.859	0.889	0.899
Conversion Subsystem Efficiency from Field[a] (@ T_{field}=285°C)		0.210	0.228	0.228
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=285°C)		0.210	0.228	0.228
System Efficiency (Annual Average)		0.066	0.072	0.077

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	55	55	55
	Receiver		-	-	-
Transport Subsystem		$/m² Collector	4.0	7.0	8.2
Electrical Storage Subsystem		$/$kW_e$	-	-	-
		$/$kW_e$h	-	-	-
Thermal Storage Subsystem		$/$kW_t$	200	200	200
		$/$kW_t$h	12	12	12
Conversion Subsystem	Engine	$/kW	480	320	269
	Generator	$/$kW_e$	30	28	24
Balance of Plant		$/$kW_e$	392	261	219
Total Capital Cost		$ × 10^6	5.50	24.0	47.2
O&M Costs (Average)		mills/kW_eh	6.26	6.40	6.40
$\overline{BBEC}$		mills/kW_eh	131	117	117

[b] All costs include installation

TABLE 2-30. Performance and Cost Summary of LFCR System, No Storage Case

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		1	5	10
Capacity Factor		0.289	0.297	0.302
Collection Subsystem Efficiency (Annual Average)		0.286	0.437	0.454
Transport Subsystem Efficiency[a]		0.969	0.959	0.960
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	1.44	7.48	15.6
Storage Subsystem Efficiency[a]		1.0	1.0	1.0
Conversion Subsystem Efficiency from Field[a] (@ T_{field}=510°C)		0.274	0.297	0.297
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=510°C)		0.274	0.297	0.297
System Efficiency (Annual Average)		0.058	0.089	0.090

[a] $T_{ambient}$ = 20°C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	75	75	75
	Receiver		34	51	51
Transport Subsystem		$/m² Collector	0.50	1.23	1.47
Electrical Storage Subsystem		$/$kW_e$	-	-	-
		$/$kW_e$h	-	-	-
Thermal Storage Subsystem		$/$kW_t$	-	-	-
		$/$kW_t$h	-	-	-
Conversion Subsystem	Engine	$/kW	480	320	269
	Generator	$/$kW_e$	30	28	24
Balance of Plant		$/$kW_e$	542	361	304
Total Capital Cost		$ × 10^6	3.67	14.0	26.6
O&M Costs (Average)		mills/kW_eh	13.9	13.4	13.2
$\overline{BBEC}$		mills/kW_eh	250	186	175

[b] All costs include installation

TABLE 2-31. Performance and Cost Summary of LFCR System, 0.4 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		1	5	10
Capacity Factor		0.409	0.403	0.412
Collection Subsystem Efficiency (Annual Average)		0.286	0.437	0.454
Transport Subsystem Efficiency[a]		0.969	0.959	0.960
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	1.62	7.48	15.6
Storage Subsystem Efficiency[a]		0.906	0.837	0.788
Conversion Subsystem Efficiency from Field[a] (@ T_{field}= 510°C)		0.275	0.298	0.298
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=510°C)		0.275	0.298	0.298
System Efficiency (Annual Average)		0.079	0.120	0.123

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	75	75	75
	Receiver		34	51	51
Transport Subsystem		$/m² Collector	0.50	1.23	1.47
Electrical Storage Subsystem		$/$kW_e$	-	-	-
		$/$kW_eh$	-	-	-
Thermal Storage Subsystem		$/$kW_t$	93	93	93
		$/$kW_th$	15	15	15
Conversion Subsystem	Engine	$/kW	480	320	269
	Generator	$/$kW_e$	30	28	24
Balance of Plant		$/$kW_e$	542	361	304
Total Capital Cost		$ × 10^6	4.30	15.7	30.0
O&M Costs (Average)		mills/kW_eh	10.3	10.4	10.3
$\overline{BBEC}$		mills/kW_eh	202	153	144

[b] All costs include installation

TABLE 2-32. Performance and Cost Summary of LFCR System, 0.7 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		1	5	10
Capacity Factor		0.709	0.702	0.693
Collection Subsystem Efficiency (Annual Average)		0.286	0.437	0.454
Transport Subsystem Efficiency[a]		0.969	0.959	0.960
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	2.88	12.9	28.3
Storage Subsystem Efficiency[a]		0.902	0.929	0.765
Conversion Subsystem Efficiency from Field[a] (@ T_{field}=510°C)		0.275	0.298	0.298
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=510°C)		0.275	0.298	0.298
System Efficiency (Annual Average)		0.073	0.121	0.114

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	75	75	75
	Receiver		34	51	51
Transport Subsystem		$/m² Collector	0.50	1.23	1.47
Electrical Storage Subsystem		$/$kW_e$	-	-	-
		$/$kW_e$h	-	-	-
Thermal Storage Subsystem		$/$kW_t$	93	93	93
		$/$kW_t$h	15	15	15
Conversion Subsystem	Engine	$/kW	480	320	269
	Generator	$/$kW_e$	30	28	24
Balance of Plant		$/$kW_e$	542	361	304
Total Capital Cost		$ × 10^6	6.22	22.7	44.4
O&M Costs (Average)		mills/kW_eh	6.85	6.0	6.95
$\overline{BBEC}$		mills/kW_eh	167	125	122

[b] All costs include installation

TABLE 2-33. Performance and Cost Summary of LFCR System, Optimum Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		1	5	10
Capacity Factor		0.782	0.788	0.801
Collection Subsystem Efficiency (Annual Average)		0.286	0.437	0.454
Transport Subsystem Efficiency[a]		0.969	0.959	0.960
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	3.24	15.0	31.1
Storage Subsystem Efficiency[a]		0.877	0.885	0.850
Conversion Subsystem Efficiency from Field[a] (@ T_{field}=510°C)		0.275	0.298	0.298
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=510°C)		0.275	0.298	0.298
System Efficiency (Annual Average)		0.071	0.117	0.120

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	75	75	75
	Receiver		34	51	51
Transport Subsystem		$/m² Collector	0.50	1.23	1.47
Electrical Storage Subsystem		$/$kW_e$	-	-	-
		$/$kW_e$h	-	-	-
Thermal Storage Subsystem		$/$kW_t$	93	93	93
		$/$kW_t$h	15	15	15
Conversion Subsystem	Engine	$/kW	480	320	269
	Generator	$/$kW_e$	30	28	24
Balance of Plant		$/$kW_e$	542	361	304
Total Capital Cost		$ × 10^6	6.74	24.8	48.3
O&M Costs (Average)		mills/kW_eh	6.40	6.40	6.30
$\overline{BBEC}$		mills/kW_eh	163	121	116

[b] All costs include installation

TABLE 2-34. Performance and Cost Summary of FMDF System, No Storage Case

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		1	5	10
Capacity Factor		0.275	0.261	0.266
Collection Subsystem Efficiency (Annual Average)		0.438	0.438	0.438
Transport Subsystem Efficiency[a]		0.982	0.982	0.970
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	1.67	6.97	13.8
Storage Subsystem Efficiency[a]		1.0	1.0	1.0
Conversion Subsystem Efficiency from Field[a] (@ T_{field}=455°C)		0.265	0.282	0.297
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=455°C)		0.265	0.282	0.297
System Efficiency (Annual Average)		0.075	0.086	0.090

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	100	100	100
	Receiver		17	17	17
Transport Subsystem		$/m² Collector	0.98	1.8	2.2
Electrical Storage Subsystem		$/$kW_e$	-	-	-
		$/$kW_e$h	-	-	-
Thermal Storage Subsystem		$/$kW_t$	-	-	-
		$/$kW_t$h	-	-	-
Conversion Subsystem	Engine	$/kW	480	320	304
	Generator	$/$kW_e$	30	28	24
Balance of Plant		$/$kW_e$	542	361	304
Total Capital Cost		$ × 10^6	3.00	11.7	22.1
O&M Costs (Average)		mills/kW_eh	14.3	15.0	14.7
$\overline{BBEC}$		mills/kW_eh	214	180	168

[b] All costs include installation

TABLE 2-35. Performance and Cost Summary of FMDF System, 0.4 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		1	5	10
Capacity Factor		0.400	0.397	0.378
Collection Subsystem Efficiency (Annual Average)		0.438	0.438	0.438
Transport Subsystem Efficiency[a]		0.982	0.982	0.970
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	1.67	8.36	16.6
Storage Subsystem Efficiency[a]		0.850	0.660	0.463
Conversion Subsystem Efficiency from Field[a] (@ T_{field}= 455°C)		0.266	0.283	0.298
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=455°C)		0.266	0.283	0.298
System Efficiency (Annual Average)		0.109	0.108	0.106

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	100	100	100
	Receiver		17	17	17
Transport Subsystem		$/m² Collector	0.98	1.8	2.2
Electrical Storage Subsystem		$/$kW_e$	-	-	-
		$/$kW_e$h	-	-	-
Thermal Storage Subsystem		$/$kW_t$	93	93	93
		$/$kW_t$h	15	15	15
Conversion Subsystem	Engine	$/kW	480	320	304
	Generator	$/$kW_e$	30	28	24
Balance of Plant		$/$kW_e$	542	361	304
Total Capital Cost		$ × 10^6	3.46	14.7	27.2
O&M Costs (Average)		mills/kW_eh	10.5	10.6	11.0
$\overline{BBEC}$		mills/kW_eh	169	146	143

[b] All costs include installation

TABLE 2-36. Performance and Cost Summary of FMDF System, 0.7 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		1	5	10
Capacity Factor		0.695	0.704	0.698
Collection Subsystem Efficiency (Annual Average)		0.438	0.438	0.438
Transport Subsystem Efficiency[a]		0.982	0.982	0.970
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	3.08	13.9	27.6
Storage Subsystem Efficiency[a]		0.823	0.897	0.817
Conversion Subsystem Efficiency from Field[a] (@ T_{field}= 455°C)		0.266	0.284	0.298
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=455°C)		0.266	0.284	0.298
System Efficiency (Annual Average)		0.104	0.116	0.118

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	100	100	100
	Receiver		17	17	17
Transport Subsystem		$/m² Collector	0.98	1.8	2.2
Electrical Storage Subsystem		$/$kW_e$	-	-	-
		$/$kW_e h$	-	-	-
Thermal Storage Subsystem		$/$kW_t$	93	93	93
		$/$kW_t h$	15	15	15
Conversion Subsystem	Engine	$/kW	480	320	304
	Generator	$/$kW_e$	30	28	24
Balance of Plant		$/$kW_e$	542	361	304
Total Capital Cost		$ × 10^6	5.32	23.8	44.2
O&M Costs (Average)		mills/$kW_e h$	6.94	6.92	6.92
$\overline{BBEC}$		mills/$kW_e h$	147	130	123

[b] All costs include installation

TABLE 2-37. Performance and Cost Summary of FMDF System, Optimum Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		1	5	10
Capacity Factor		0.752	0.774	0.757
Collection Subsystem Efficiency (Annual Average)		0.438	0.438	0.438
Transport Subsystem Efficiency[a]		0.982	0.982	0.970
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	3.34	16.7	30.3
Storage Subsystem Efficiency[a]		0.816	0.772	0.805
Conversion Subsystem Efficiency from Field[a] (@ T_{field}=455°C)		0.266	0.284	0.298
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=455°C)		0.266	0.284	0.298
System Efficiency (Annual Average)		0.103	0.106	0.116

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	100	100	100
	Receiver		17	17	17
Transport Subsystem		$/m² Collector	0.98	1.8	2.2
Electrical Storage Subsystem		$/$kW_e$	-	-	-
		$/$kW_e h$	-	-	-
Thermal Storage Subsystem		$/$kW_t$	93	93	93
		$/$kW_t h$	15	15	15
Conversion Subsystem	Engine	$/kW	480	320	304
	Generator	$/$kW_e$	30	28	24
Balance of Plant		$/$kW_e$	542	361	304
Total Capital Cost		$ × 10^6	5.73	26.1	48.1
O&M Costs (Average)		mills/$kW_e h$	6.58	6.45	6.54
$\overline{BBEC}$		mills/$kW_e h$	147	130	123

[b] All costs include installation

TABLE 2-38. Performance and Cost Summary of LFDR-TR System, No Storage Case

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		1	5	10
Capacity Factor		0.239	0.237	0.239
Collection Subsystem Efficiency (Annual Average)		0.340	0.347	0.350
Transport Subsystem Efficiency[a]		0.982	0.971	0.971
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	1.73	7.65	15.4
Storage Subsystem Efficiency[a]		1.0	1.0	1.0
Conversion Subsystem Efficiency from Field[a] (@ T_{field}=285°C)		0.206	0.224	0.224
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=285°C)		0.206	0.224	0.224
System Efficiency (Annual Average)		0.049	0.056	0.056

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	85+	85+	85+
	Receiver		-	-	-
Transport Subsystem		$/m² Collector	4.0	7.0	8.2
Electrical Storage Subsystem		$/$kW_e$	-	-	-
		$/$kW_eh$	-	-	-
Thermal Storage Subsystem		$/$kW_t$	-	-	-
		$/$kW_th$	-	-	-
Conversion Subsystem	Engine	$/kW	480	320	269
	Generator	$/$kW_e$	30	28	24
Balance of Plant		$/$kW_e$	466	311	262
Total Capital Cost		$ × 10^6	2.95	12.0	23.0
O&M Costs (Average)		mills/kW_eh	16.2	16.2	16.2
$\overline{BBEC}$		mills/kW_eh	242	202	193

[b] All costs include installation

+Includes receiver cost

TABLE 2-39. Performance and Cost Summary of LFDR-TR System, 0.4 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		1	5	10
Capacity Factor		0.402	0.403	0.405
Collection Subsystem Efficiency (Annual Average)		0.340	0.347	0.350
Transport Subsystem Efficiency[a]		0.982	0.971	0.971
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	2.16	9.84	19.8
Storage Subsystem Efficiency[a]		0.858	0.886	0.881
Conversion Subsystem Efficiency from Field[a] (@ T_{field}= 285°C)		0.207	0.225	0.225
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}= 285°C)		0.207	0.225	0.225
System Efficiency (Annual Average)		0.066	0.073	0.074

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	85	85	85
	Receiver		-	-	-
Transport Subsystem		$/m² Collector	4.0	7.0	8.2
Electrical Storage Subsystem		$/$kW_e$	-	-	-
		$/$kW_e$h	-	-	-
Thermal Storage Subsystem		$/$kW_t$	200	200	200
		$/$kW_t$h	12	12	12
Conversion Subsystem	Engine	$/kW	480	320	269
	Generator	$/$kW_e$	30	28	24
Balance of Plant		$/$kW_e$	466	311	262
Total Capital Cost		$\$ \times 10^6$	3.96	16.9	32.8
O&M Costs (Average)		mills/kW_eh	10.5	10.4	10.4
$\overline{BBEC}$		mills/kW_eh	190	164	159

[b] All costs include installation

TABLE 2-40. Performance and Cost Summary of LFDR-TR System, 0.7 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		1	5	10
Capacity Factor		0.703	0.696	0.699
Collection Subsystem Efficiency (Annual Average)		0.340	0.347	0.350
Transport Subsystem Efficiency[a]		0.982	0.971	0.971
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	3.89	17.5	35.9
Storage Subsystem Efficiency[a]		0.863	0.883	0.865
Conversion Subsystem Efficiency from Field[a] (@ $T_{field}=285^{o}C$)		0.208	0.226	0.226
Conversion Subsystem Efficiency from Storage[a] (@ $T_{stor}=285^{o}C$)		0.208	0.226	0.226
System Efficiency (Annual Average)		0.064	0.071	0.068

[a] $T_{ambient} = 20°C$

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	85	85	85
	Receiver		-	-	-
Transport Subsystem		$/m² Collector	4.0	7.0	8.2
Electrical Storage Subsystem		$/$kW_e$	-	-	-
		$/$kW_e$h	-	-	-
Thermal Storage Subsystem		$/$kW_t$	200	200	200
		$/$kW_t$h	12	12	12
Conversion Subsystem	Engine	$/kW	480	320	269
	Generator	$/$kW_e$	30	28	24
Balance of Plant		$/$kW_e$	466	311	262
Total Capital Cost		$ × 10^6	6.30	27.3	55.7
O&M Costs (Average)		mills/kW_eh	6.89	6.0	6.0
$\overline{BBEC}$		mills/kW_eh	170	150	147

[b] All costs include installation

TABLE 2-41. Performance and Cost Summary of LFDR-TR System, Optimum Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		1	5	10
Capacity Factor		0.755	0.773	0.759
Collection Subsystem Efficiency (Annual Average)		0.340	0.347	0.350
Transport Subsystem Efficiency[a]		0.982	0.971	0.971
Average Thermal Power Collected (8784 h/yr)	$\overline{MW}_t$	4.11	19.7	38.0
Storage Subsystem Efficiency[a]		0.893	0.870	0.893
Conversion Subsystem Efficiency from Field[a] (@ T_{field}= 285°C)		0.208	0.226	0.226
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=285°C)		0.208	0.226	0.226
System Efficiency (Annual Average)		0.065	0.070	0.069

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	85	85	85
	Receiver		-	-	-
Transport Subsystem		$/m² Collector	4.0	7.0	8.2
Electrical Storage Subsystem		$/$kW_e$	-	-	-
		$/$kW_e$h	-	-	-
Thermal Storage Subsystem		$/$kW_t$	200	200	200
		$/$kW_t$h	12	12	12
Conversion Subsystem	Engine	$/kW	480	320	269
	Generator	$/$kW_e$	30	28	24
Balance of Plant		$/$kW_e$	466	311	262
Total Capital Cost		$ × 10^6	6.68	30.2	59.3
O&M Costs (Average)		mills/kW_eh	6.56	6.40	6.54
$\overline{BBEC}$		mills/kW_eh	167	149	146

[b] All costs include installation

TABLE 2-42. Performance and Cost Summary of SSP System, No Storage Case

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		1	5	10
Capacity Factor		0.116	0.116	0.116
Collection Subsystem Efficiency (Annual Average)		0.232	0.232	0.232
Transport Subsystem Efficiency[a]		0.978	0.978	0.978
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	3.69	18.4	36.9
Storage Subsystem Efficiency[a]		1.0	1.0	1.0
Conversion Subsystem Efficiency from Field[a] (@ T_{field}= 71°C)		0.057	0.057	0.057
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}= 71°C)		0.057	0.057	0.057
System Efficiency (Annual Average)		0.008	0.008	0.008

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	22	22	22
	Receiver		-	-	-
Transport Subsystem		$/m² Collector	1.5	2.4	2.9
Electrical Storage Subsystem		$/$kW_e$	-	-	-
		$/$kW_e h$	-	-	-
Thermal Storage Subsystem		$/$kW_t$	-	-	-
		$/$kW_t h$	-	-	-
Conversion Subsystem	Engine	$/kW	480	282	237
	Generator	$/$kW_e$	32	32	32
Balance of Plant		$/$kW_e$	392	261	219
Total Capital Cost		$ × 10^6	2.67	11.7	22.8
O&M Costs (Average)		mills/$kW_e h$	31.0	31.0	31.0
$\overline{BBEC}$		mills/$kW_e h$	452	401	392

[b] All costs include installation

TABLE 2-43. Performance and Cost Summary of SSP System, 0.4 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		1	5	10
Capacity Factor		0.392	0.392	0.392
Collection Subsystem Efficiency (Annual Average)		0.232	0.232	0.232
Transport Subsystem Efficiency[a]		0.978	0.978	0.978
Average Thermal Power Collected (8784 h/yr)	$\overline{MW}_t$	18.4	92.2	184
Storage Subsystem Efficiency[a]		0.250	0.134	0.250
Conversion Subsystem Efficiency from Field[a] (@ T_{field}=71°C)		0.057	0.057	0.057
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}= 71°C)		0.057	0.057	0.057
System Efficiency (Annual Average)		0.005	0.004	0.005

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	22	22	22
	Receiver		-	-	-
Transport Subsystem		$/m² Collector	1.5	2.4	2.9
Electrical Storage Subsystem		$/$kW_e$	-	-	-
		$/$kW_e$h	-	-	-
Thermal Storage Subsystem		$/$kW_t$	500	500	500
		$/$kW_t$h	139	139	139
Conversion Subsystem	Engine	$/kW	480	282	237
	Generator	$/$kW_e$	32	32	32
Balance of Plant		$/$kW_e$	392	261	219
Total Capital Cost		$ × 10^6	38.4	19.0	38.0
O&M Costs (Average)		mills/kW_eh	10.7	10.9	10.7
$\overline{BBEC}$		mills/kW_eh	1781	1766	1763

[b] All costs include installation

TABLE 2-44. Performance and Cost Summary of SSP System, 0.7 Capacity Factor

No Systems Applicable

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e) 1	5	10
Capacity Factor				
Collection Subsystem Efficiency (Annual Average)				
Transport Subsystem Efficiency[a]				
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$			
Storage Subsystem Efficiency[a]				
Conversion Subsystem Efficiency from Field[a] (@ T_{field}=)				
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=)				
System Efficiency (Annual Average)				

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector			
	Receiver				
Transport Subsystem		$/m² Collector			
Electrical Storage Subsystem		$/$kW_e$			
		$/$kW_e$h			
Thermal Storage Subsystem		$/$kW_t$			
		$/$kW_t$h			
Conversion Subsystem	Engine	$/kW			
	Generator	$/$kW_e$			
Balance of Plant		$/$kW_e$			
Total Capital Cost		$\$ \times 10^6$			
O&M Costs (Average)		mills/kW_eh			
$\overline{BBEC}$		mills/kW_eh			

[b] All costs include installation

TABLE 2-45. Performance and Cost Summary of SSP System, Optimum Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		1	5	10
Capacity Factor		0.116	0.116	0.116
Collection Subsystem Efficiency (Annual Average)		0.232	0.232	0.232
Transport Subsystem Efficiency[a]		0.978	0.978	0.978
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	3.69	18.4	36.9
Storage Subsystem Efficiency[a]		1.0	1.0	1.0
Conversion Subsystem Efficiency from Field[a] (@ T_{field}= 71°C)		0.057	0.057	0.057
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=71°C)		0.057	0.057	0.057
System Efficiency (Annual Average)		0.008	0.008	0.008

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	22	22	22
	Receiver		-	-	-
Transport Subsystem		$/m² Collector	1.5	2.4	2.9
Electrical Storage Subsystem		$/$kW_e$	-	-	-
		$/$kW_e$h	-	-	-
Thermal Storage Subsystem		$/$kW_t$	-	-	-
		$/$kW_t$h	-	-	-
Conversion Subsystem	Engine	$/kW	480	282	237
	Generator	$/$kW_e$	32	32	32
Balance of Plant		$/$kW_e$	392	261	219
Total Capital Cost		$ × 10^6	2.67	11.7	22.8
O&M Costs (Average)		mills/kW_eh	31.0	31.0	31.0
$\overline{BBEC}$		mills/kW_eh	452	401	392

[b] All costs include installation

SECTION 3.0

COST AND PERFORMANCE SUMMARY SHEETS FOR 0.1-1 MW_e INDUSTRIAL SYSTEMS

The study of 0.1-1 MW_e systems for industrial applications, like the 1-10 MW_e study, examined a broad range of collector technologies. In this study five collector types were modeled (see Fig. 3-1). The collectors were combined with various storage and power conversion technologies for a total of ten systems shown in Table 3-1.

Cost and performance data for the 0.1-1 MW_e systems are given in Tables 3-2 to 3-61. Data are presented for each system at 0.1, 0.3, and 1 MW_e capacities and at capacity factors of 0.3, 0.4, 0.5, 0.6, 0.7, and 0.8.

The data are presented in the same format as the 1-10 MW_e systems. However, an additional entry of the simple payback period appears in the economic summary. This attribute was found to be a key factor in decisions made by potential users of the 0.1-1 MW_e systems. The payback calculation most used by the decision makers, the simple payback, ignores the effects of inflation and income tax and is calculated by the following formula:

$$PYBCK = \frac{1 - TXCDT}{\frac{PRICE \times OUTPUT \times 1000}{STC} - OMPC} \qquad (1)$$

where

PYBCK = payback (years),

TXCDT = tax credit,

PRICE = cost of displaced fuel (mills/kWh),

OUTPUT = annual output of plant (kWh/yr),

STC = system total capital cost ($), and

OMPC = annual O&M cost (percentage of STC).

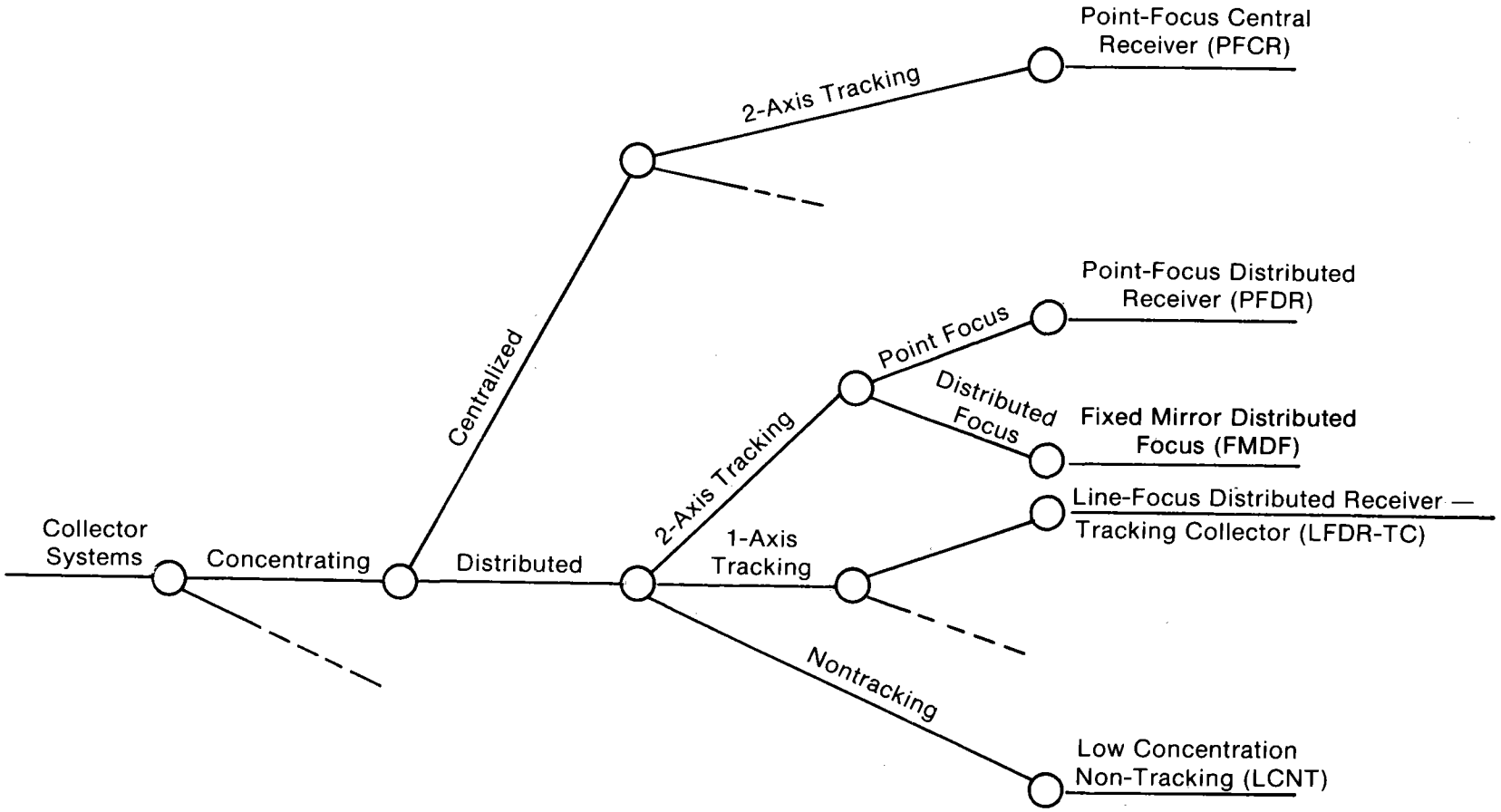

Figure 3-1. Generic Options Considered in the 0.1-1 MW_e Ranking

Concentrator Options	Systems Options											
	Conversion					Transport				Storage		
											Thermal	
	Cent-Rankine	Cent-Brayton	Cent-Stirling	Dist-Brayton	Dist-Rankine	Dist-Stirling	Electrical	Salt	Oil	Electrical	Oil	Salt
Point-Focus Central Receiver	●							●				●
Point-Focus Central Receiver		●					●			●		
Point-Focus Central Receiver			●				●			●		
Point-Focus Distributed Receiver	●							●				●
Point-Focus Distributed Receiver					●		●			●		
Point-Focus Distributed Receiver				●			●			●		
Point-Focus Distributed Receiver						●	●			●		
Fixed Mirror Distributed Focus	●							●				●
Line-Focus Distributed Receiver — Tracking Collector	●								●		●	
Low Concentration Nontracking	●								●		●	

Table 3-1. Combination of Technologies Considered in 0.1 - 1 MW_e Study

TABLE 3-2. Performance and Cost Summary of PFDR/S System, 0.3 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		0.1	0.3	1.0
Capacity Factor		0.337	0.322	0.302
Collection Subsystem Efficiency (Annual Average)		0.667	0.667	0.667
Transport Subsystem Efficiency[a]		1.00	1.00	1.00
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	0.114	0.310	0.919
Storage Subsystem Efficiency[a]		0.872	0.942	0.989
Conversion Subsystem Efficiency from Field[a] (@ T_{field}= 750°C)		0.359	0.356	0.354
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=)		N/A	N/A	N/A
System Efficiency (Annual Average)		0.202	0.217	0.226

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	105	105	105
	Receiver		12	12	12
Transport Subsystem		$/m² Collector	2.3	2.8	3.2
Electrical Storage Subsystem		$/$kW_e$	160	160	160
		$/$kW_e$h	16	16	16
Thermal Storage Subsystem		$/$kW_t$	-	-	-
		$/$kW_t$h	-	-	-
Conversion Subsystem	Engine	$/kW	100	100	100
	Generator	$/$kW_e$	34	34	34
Balance of Plant		$/$kW_e$	383	268	152
Total Capital Cost		$ × 10^6	0.145	0.326	0.979
O&M Costs (Average)		mills/kW_eh	14.1	14.6	16.3
$\overline{BBEC}$		mills/kW_eh	94	84	76
Simple Payback		years	6.7	5.8	5.1

[b] All costs include installation

TABLE 3-3. Performance and Cost Summary of PFDR/S System, 0.4 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		0.1	0.3	1.0
Capacity Factor		0.466	0.404	0.411
Collection Subsystem Efficiency (Annual Average)		0.667	0.667	0.667
Transport Subsystem Efficiency[a]		1.00	1.00	1.00
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	0.153	0.383	1.30
Storage Subsystem Efficiency[a]		0.892	0.936	0.932
Conversion Subsystem Efficiency from Field[a] (@ T_{field}= 750°C)		0.363	0.360	0.361
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=)		N/A	N/A	N/A
System Efficiency (Annual Average)		0.209	0.218	0.217

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	105	105	105
	Receiver		12	12	12
Transport Subsystem		$/m² Collector	2.3	2.8	3.2
Electrical Storage Subsystem		$/$kW_e$	160	160	160
		$/$kW_e$h	16	16	16
Thermal Storage Subsystem		$/$kW_t$	-	-	-
		$/$kW_t$h	-	-	-
Conversion Subsystem	Engine	$/kW	100	100	100
	Generator	$/$kW_e$	34	34	34
Balance of Plant		$/$kW_e$	383	268	152
Total Capital Cost		$ × 10^6	0.209	0.513	1.60
O&M Costs (Average)		mills/kW_eh	11.1	12.3	12.1
$\overline{BBEC}$		mills/kW_eh	93	90	84
Simple Payback		years	6.8	6.5	6.0

[b] All costs include installation

TABLE 3-4. Performance and Cost Summary of PFDR/S System, 0.5 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		0.1	0.3	1.0
Capacity Factor		0.531	0.501	0.509
Collection Subsystem Efficiency (Annual Average)		0.667	0.667	0.667
Transport Subsystem Efficiency[a]		1.00	1.00	1.00
Average Thermal Power Collected (8784 h/yr)	$\overline{MW}_t$	0.191	0.498	1.76
Storage Subsystem Efficiency[a]		0.808	0.884	0.842
Conversion Subsystem Efficiency from Field[a] (@ T_{field}=750°C)		0.366	0.364	0.365
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=)		N/A	N/A	N/A
System Efficiency (Annual Average)		0.191	0.208	0.199

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	105	105	105
	Receiver		12	12	12
Transport Subsystem		$/m² Collector	2.3	2.8	3.2
Electrical Storage Subsystem		$/$kW_e$	160	160	160
		$/$kW_e$h	16	16	16
Thermal Storage Subsystem		$/$kW_t$	-	-	-
		$/$kW_t$h	-	-	-
Conversion Subsystem	Engine	$/kW	100	100	100
	Generator	$/$kW_e$	34	34	34
Balance of Plant		$/$kW_e$	383	268	152
Total Capital Cost		$ × 10^6	0.245	0.660	2.03
O&M Costs (Average)		mills/kW_eh	10.1	10.5	10.4
$\overline{BBEC}$		mills/kW_eh	94	91	84
Simple Payback		years	7.0	6.7	6.1

[b] All costs include installation

TABLE 3-5. Performance and Cost Summary of PFDR/S System, 0.6 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		0.1	0.3	1.0
Capacity Factor		0.580	0.596	0.602
Collection Subsystem Efficiency (Annual Average)		0.667	0.667	0.667
Transport Subsystem Efficiency[a]		1.00	1.00	1.00
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	0.230	0.612	2.07
Storage Subsystem Efficiency[a]		0.731	0.847	0.846
Conversion Subsystem Efficiency from Field[a] (@ T_{field}= 750°C)		0.367	0.366	0.367
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=)		N/A	N/A	N/A
System Efficiency (Annual Average)		0.173	0.201	0.200

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	105	105	105
	Receiver		12	12	12
Transport Subsystem		$/m² Collector	2.3	2.8	3.2
Electrical Storage Subsystem		$/$kW_e$	160	160	160
		$/$kW_e$h	16	16	16
Thermal Storage Subsystem		$/$kW_t$	-	-	-
		$/$kW_t$h	-	-	-
Conversion Subsystem	Engine	$/kW	100	100	100
	Generator	$/$kW_e$	34	34	34
Balance of Plant		$/$kW_e$	383	268	152
Total Capital Cost		$ × 10^6	0.281	0.777	2.48
O&M Costs (Average)		mills/kW_eh	9.6	9.4	9.3
$\overline{BBEC}$		mills/kW_eh	98	89	85
Simple Payback		years	7.3	6.6	6.2

[b] All costs include installation

TABLE 3-6 Performance and Cost Summary of PFDR/S System, 0.7 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		0.1	0.3	1.0
Capacity Factor		0.734	0.711	0.706
Collection Subsystem Efficiency (Annual Average)		0.667	0.667	0.667
Transport Subsystem Efficiency[a]		1.00	1.00	1.00
Average Thermal Power Collected (8784 h/yr)	$\overline{MW}_t$	0.268	0.766	2.53
Storage Subsystem Efficiency[a]		0.791	0.805	0.785
Conversion Subsystem Efficiency from Field[a] (@ T_{field}=750°C)		0.369	0.368	0.368
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=)		N/A	N/A	N/A
System Efficiency (Annual Average)		0.188	0.192	0.187

[a] $T_{ambient}$ = 20°C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	105	105	105
	Receiver		12	12	12
Transport Subsystem		$/m² Collector	2.3	2.8	3.2
Electrical Storage Subsystem		$/$kW_e$	160	160	160
		$/$kW_e$h	16	16	16
Thermal Storage Subsystem		$/$kW_t$	-	-	-
		$/$kW_t$h	-	-	-
Conversion Subsystem	Engine	$/kW	100	100	100
	Generator	$/$kW_e$	34	34	34
Balance of Plant		$/$kW_e$	383	268	152
Total Capital Cost		$ × 10^6	0.338	0.934	2.95
O&M Costs (Average)		mills/kW_eh	8.3	8.4	8.5
$\overline{BBEC}$		mills/kW_eh	92	88	85
Simple Payback		years	6.9	6.6	6.3

[b] All costs include installation

TABLE 3-7. Performance and Cost Summary of PFDR/S System, 0.8 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		0.1	0.3	1.0
Capacity Factor		0.804	0.806	0.808
Collection Subsystem Efficiency (Annual Average)		0.667	0.667	0.667
Transport Subsystem Efficiency[a]		1.00	1.00	1.00
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	0.306	0.957	3.14
Storage Subsystem Efficiency[a]		0.756	0.726	0.714
Conversion Subsystem Efficiency from Field[a] (@ T_{field}= 750°C)		0.370	0.370	0.370
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=)		N/A	N/A	N/A
System Efficiency (Annual Average)		0.181	0.174	0.171

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	105	105	105
	Receiver		12	12	12
Transport Subsystem		$/m² Collector	2.3	2.8	3.2
Electrical Storage Subsystem		$/$kW_e$	160	160	160
		$/$kW_e$h	16	16	16
Thermal Storage Subsystem		$/$kW_t$	-	-	-
		$/$kW_t$h	-	-	-
Conversion Subsystem	Engine	$/kW	100	100	100
	Generator	$/$kW_e$	34	34	34
Balance of Plant		$/$kW_e$	383	268	152
Total Capital Cost		$ × 10^6	0.423	1.13	3.81
O&M Costs (Average)		mills/kW_eh	7.8	7.8	7.8
$\overline{BBEC}$		mills/kW_eh	103	93	94
Simple Payback		years	7.9	7.0	7.0

[b] All costs include installation

TABLE 3-8. Performance and Cost Summary of PFDR/B System, 0.3 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		0.1	0.3	1.0
Capacity Factor		0.301	0.327	0.319
Collection Subsystem Efficiency (Annual Average)		0.659	0.659	0.659
Transport Subsystem Efficiency[a]		1.0	1.0	1.0
Average Thermal Power Collected (8784 h/yr)	$\overline{MW}_t$	0.114	0.379	1.21
Storage Subsystem Efficiency[a]		0.999	0.969	0.985
Conversion Subsystem Efficiency from Field[a] (@ T_{field}=815°C)		0.279	0.281	0.281
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=)		N/A	N/A	N/A
System Efficiency (Annual Average)		0.180	0.176	0.179

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	105	105	105
	Receiver		12	12	12
Transport Subsystem		$/m² Collector	2.3	2.8	3.2
Electrical Storage Subsystem		$/$kW_e$	160	160	160
		$/$kW_e$h	16	16	16
Thermal Storage Subsystem		$/$kW_t$	-	-	-
		$/$kW_t$h	-	-	-
Conversion Subsystem	Engine	$/kW	204	204	204
	Generator	$/$kW_e$	35	35	35
Balance of Plant		$/$kW_e$	396	279	166
Total Capital Cost		$ × 10^6	0.154	0.459	1.35
O&M Costs (Average)		mills/kW_eh	13.3	12.3	12.6
$\overline{BBEC}$		mills/kW_eh	107	98	91
Simple Payback		years	7.9	7.2	6.5

[b] All costs include installation

TABLE 3-9. Performance and Cost Summary of PFDR/B System, 0.4 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		0.1	0.3	1.0
Capacity Factor		0.467	0.443	0.391
Collection Subsystem Efficiency (Annual Average)		0.659	0.659	0.659
Transport Subsystem Efficiency[a]		1.0	1.0	1.0
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	0.189	0.530	1.51
Storage Subsystem Efficiency[a]		0.905	0.922	0.955
Conversion Subsystem Efficiency from Field[a] (@ T_{field}= 815°C)		0.287	0.286	0.284
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=)		N/A	N/A	N/A
System Efficiency (Annual Average)		0.168	0.170	0.175

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	105	105	105
	Receiver		12	12	12
Transport Subsystem		$/m² Collector	2.3	2.8	3.2
Electrical Storage Subsystem		$/$kW_e$	160	160	160
		$/$kW_e$h	16	16	16
Thermal Storage Subsystem		$/$kW_t$	-	-	-
		$/$kW_t$h	-	-	-
Conversion Subsystem	Engine	$/kW	204	204	204
	Generator	$/$kW_e$	35	35	35
Balance of Plant		$/$kW_e$	396	279	166
Total Capital Cost		$ × 10^6	0.256	0.690	1.91
O&M Costs (Average)		mills/kW_eh	9.3	9.7	10.7
$\overline{BBEC}$		mills/kW_eh	109	104	100
Simple Payback		years	8.3	7.8	7.4

[b] All costs include installation

TABLE 3-10. Performance and Cost Summary of PFDR/B System, 0.5 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		0.1	0.3	1.0
Capacity Factor		0.525	0.525	0.484
Collection Subsystem Efficiency (Annual Average)		0.659	0.659	0.659
Transport Subsystem Efficiency[a]		1.0	1.0	1.0
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	0.227	0.681	1.97
Storage Subsystem Efficiency[a]		0.842	0.842	0.900
Conversion Subsystem Efficiency from Field[a] (@ $T_{field}=815^0C$)		0.289	0.288	0.287
Conversion Subsystem Efficiency from Storage[a] (@ $T_{stor}=$)		N/A	N/A	N/A
System Efficiency (Annual Average)		0.157	0.157	0.167

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	105	105	105
	Receiver		12	12	12
Transport Subsystem		$/m² Collector	2.3	2.8	3.2
Electrical Storage Subsystem		$/$kW_e$	160	160	160
		$/$kW_eh$	16	16	16
Thermal Storage Subsystem		$/$kW_t$	-	-	-
		$/$kW_th$	-	-	-
Conversion Subsystem	Engine	$/kW	204	204	204
	Generator	$/$kW_e$	35	35	35
Balance of Plant		$/$kW_e$	396	279	166
Total Capital Cost		$ × 10^6	0.295	0.844	2.49
O&M Costs (Average)		mills/kW_eh	8.5	8.5	9.0
$\overline{BBEC}$		mills/kW_eh	110	106	103
Simple Payback		years	8.4	8.0	7.7

[b] All costs include installation

TABLE 3-11. Performance and Cost Summary of PFDR/B System, 0.6 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)	Plant Rating (MW_e)		
	0.1	0.3	1.0
Capacity Factor	0.619	0.594	0.604
Collection Subsystem Efficiency (Annual Average)	0.659	0.659	0.659
Transport Subsystem Efficiency[a]	1.0	1.0	1.0
Average Thermal Power Collected (8784 h/yr) $\overline{MW_t}$	0.265	0.756	2.57
Storage Subsystem Efficiency[a]	0.847	0.855	0.851
Conversion Subsystem Efficiency from Field[a] (@ T_{field}= 815°C)	0.290	0.289	0.290
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=)	N/A	N/A	N/A
System Efficiency (Annual Average)	0.159	0.160	0.160

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	105	105	105
	Receiver		12	12	12
Transport Subsystem		$/m² Collector	2.3	2.8	3.2
Electrical Storage Subsystem		$/$kW_e$	160	160	160
		$/$kW_e$h	16	16	16
Thermal Storage Subsystem		$/$kW_t$	-	-	-
		$/$kW_t$h	-	-	-
Conversion Subsystem	Engine	$/kW	204	204	204
	Generator	$/$kW_e$	35	35	35
Balance of Plant		$/$kW_e$	396	279	166
Total Capital Cost		$\$ \times 10^6$	0.349	0.965	3.14
O&M Costs (Average)		mills/kW_eh	7.5	7.8	7.7
$\overline{BBEC}$		mills/kW_eh	110	106	102
Simple Payback		years	8.4	8.1	7.7

[b] All costs include installation

TABLE 3-12. Performance and Cost Summary of PFDR/B System, 0.7 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		0.1	0.3	1.0
Capacity Factor		0.748	0.690	0.692
Collection Subsystem Efficiency (Annual Average)		0.659	0.659	0.659
Transport Subsystem Efficiency[a]		1.0	1.0	1.0
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	0.341	1.14	3.03
Storage Subsystem Efficiency[a]		0.791	0.823	0.825
Conversion Subsystem Efficiency from Field[a] (@ T_{field}= 815°C)		0.292	0.291	0.291
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=)		N/A	N/A	N/A
System Efficiency (Annual Average)		0.149	0.155	0.155

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	105	105	105
	Receiver		12	12	12
Transport Subsystem		$/m² Collector	2.3	2.8	3.2
Electrical Storage Subsystem		$/$kW_e$	160	160	160
		$/$kW_eh$	16	16	16
Thermal Storage Subsystem		$/$kW_t$	-	-	-
		$/$kW_th$	-	-	-
Conversion Subsystem	Engine	$/kW	204	204	204
	Generator	$/$kW_e$	35	35	35
Balance of Plant		$/$kW_e$	396	279	166
Total Capital Cost		$ × 10^6	0.430	1.13	3.80
O&M Costs (Average)		mills/kW_eh	6.6	7.0	7.0
$\overline{BBEC}$		mills/kW_eh	110	106	107
Simple Payback		years	8.5	8.1	8.2

[b] All costs include installation

TABLE 3-13. Performance and Cost Summary of PFDR/B System, 0.8 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)	Plant Rating (MW_e)		
	0.1	0.3	1.0
Capacity Factor	0.800	0.800	0.808
Collection Subsystem Efficiency (Annual Average)	0.659	0.659	0.659
Transport Subsystem Efficiency[a]	1.0	1.0	1.0
Average Thermal Power Collected (8784 h/yr) $\overline{MW_t}$	0.378	1.13	3.94
Storage Subsystem Efficiency[a]	0.760	0.760	0.720
Conversion Subsystem Efficiency from Field[a] (@ T_{field}=815°C)	0.292	0.292	0.292
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=)	N/A	N/A	N/A
System Efficiency (Annual Average)	0.144	0.144	0.136

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	105	105	105
	Receiver		12	12	12
Transport Subsystem		$/m² Collector	2.3	2.8	3.2
Electrical Storage Subsystem		$/$kW_e$	160	160	160
		$/$kW_e$h	16	16	16
Thermal Storage Subsystem		$/$kW_t$	-	-	-
		$/$kW_t$h	-	-	-
Conversion Subsystem	Engine	$/kW	204	204	204
	Generator	$/$kW_e$	35	35	35
Balance of Plant		$/$kW_e$	396	279	166
Total Capital Cost		$ × 10^6	0.493	1.44	4.60
O&M Costs (Average)		mills/kW_eh	6.3	6.3	6.3
$\overline{BBEC}$		mills/kW_eh	117	114	109
Simple Payback		years	9.1	8.8	8.4

[b] All costs include installation

TABLE 3-14. Performance and Cost Summary of PFCR/S System, 0.3 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		0.1	0.3	1.0
Capacity Factor		0.303	0.308	0.324
Collection Subsystem Efficiency (Annual Average)		0.481	0.520	0.568
Transport Subsystem Efficiency[a]		1.0	1.0	1.0
Average Thermal Power Collected (8784 h/yr)	$\overline{MW}_t$	0.140	0.422	1.47
Storage Subsystem Efficiency[a]		0.973	0.973	0.973
Conversion Subsystem Efficiency from Field[a] (@ T_{field}= 650°C)		0.349	0.343	0.357
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=)		N/A	N/A	N/A
System Efficiency (Annual Average)		0.111	0.121	0.133

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	75	75	75
	Receiver		18	22	26
Transport Subsystem		$/m² Collector	0.1	0.2	0.3
Electrical Storage Subsystem		$/$kW_e$	160	160	160
		$/$kW_e$h	16	16	16
Thermal Storage Subsystem		$/$kW_t$	-	-	-
		$/$kW_t$h	-	-	-
Conversion Subsystem	Engine	$/kW	90	110	125
	Generator	$/$kW_e$	33	32	30
Balance of Plant		$/$kW_e$	505	325	181
Total Capital Cost		$ × 10^6	0.197	0.499	1.44
O&M Costs (Average)		mills/kW_eh	13.2	13.0	12.5
$\overline{BBEC}$		mills/kW_eh	132	112	94
Simple Payback		years	10.0	8.3	6.9

[b] All costs include installation

TABLE 3-15. Performance and Cost Summary of PFCR/S System, 0.4 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		0.1	0.3	1.0
Capacity Factor		0.400	0.421	0.412
Collection Subsystem Efficiency (Annual Average)		0.481	0.520	0.568
Transport Subsystem Efficiency[a]		1.0	1.0	1.0
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	0.156	0.506	1.84
Storage Subsystem Efficiency[a]		0.876	0.857	0.915
Conversion Subsystem Efficiency from Field[a] (@ T_{field}= 650°C)		0.353	0.359	0.363
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=)		N/A	N/A	N/A
System Efficiency (Annual Average)		0.131	0.138	0.135

[a] $T_{ambient}$ = 20°C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	75	75	75
	Receiver		18	22	26
Transport Subsystem		$/m² Collector	0.1	0.2	0.3
Electrical Storage Subsystem		$/$kW_e$	160	160	160
		$/$kW_e$h	16	16	16
Thermal Storage Subsystem		$/$kW_t$	-	-	-
		$/$kW_t$h	-	-	-
Conversion Subsystem	Engine	$/kW	90	110	125
	Generator	$/$kW_e$	33	32	30
Balance of Plant		$/$kW_e$	505	325	181
Total Capital Cost		$ × 10^6	0.270	0.705	2.04
O&M Costs (Average)		mills/kW_eh	10.5	10.1	10.3
$\overline{BBEC}$		mills/kW_eh	133	112	101
Simple Payback		years	10.2	8.4	7.5

[b] All costs include installation

TABLE 3-16. Performance and Cost Summary of PFCR/S System, 0.5 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		0.1	0.3	1.0
Capacity Factor		0.520	0.485	0.503
Collection Subsystem Efficiency (Annual Average)		0.481	0.520	0.568
Transport Subsystem Efficiency[a]		1.0	1.0	1.0
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	0.218	0.675	2.21
Storage Subsystem Efficiency[a]		0.830	0.751	0.859
Conversion Subsystem Efficiency from Field[a] (@ $T_{field}=650^0C$)		0.359	0.363	0.367
Conversion Subsystem Efficiency from Storage[a] (@ $T_{stor}=$)		N/A	N/A	N/A
System Efficiency (Annual Average)		0.122	0.119	0.137

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	75	75	75
	Receiver		18	22	26
Transport Subsystem		$/m² Collector	0.1	0.2	0.3
Electrical Storage Subsystem		$/$kW_e$	160	160	160
		$/$kW_eh$	16	16	16
Thermal Storage Subsystem		$/$kW_t$	-	-	-
		$/$kW_th$	-	-	-
Conversion Subsystem	Engine	$/kW	90	110	125
	Generator	$/$kW_e$	33	32	30
Balance of Plant		$/$kW_e$	505	325	181
Total Capital Cost		$ × 10^6	0.332	0.860	2.53
O&M Costs (Average)		mills/kW_eh	8.6	9.0	8.8
$\overline{BBEC}$		mills/kW_eh	124	116	100
Simple Payback		years	9.6	8.9	7.6

[b] All costs include installation

TABLE 3-17. Performance and Cost Summary of PFCR/S System, 0.6 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		0.1	0.3	1.0
Capacity Factor		0.600	0.602	0.625
Collection Subsystem Efficiency (Annual Average)		0.481	0.520	0.568
Transport Subsystem Efficiency[a]		1.0	1.0	1.0
Average Thermal Power Collected (8784 h/yr)	$\overline{MW}_t$	0.312	0.759	2.58
Storage Subsystem Efficiency[a]		0.820	0.805	0.806
Conversion Subsystem Efficiency from Field[a] (@ T_{field}= 650°C)		0.363	0.364	0.368
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=)		N/A	N/A	N/A
System Efficiency (Annual Average)		0.098	0.132	0.146

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	75	75	75
	Receiver		18	22	26
Transport Subsystem		$/m² Collector	0.1	0.2	0.3
Electrical Storage Subsystem		$/$kW_e$	160	160	160
		$/$kW_e$h	16	16	16
Thermal Storage Subsystem		$/$kW_t$	-	-	-
		$/$kW_t$h	-	-	-
Conversion Subsystem	Engine	$/kW	90	110	125
	Generator	$/$kW_e$	33	32	30
Balance of Plant		$/$kW_e$	505	325	181
Total Capital Cost		$ × 10^6	0.401	1.01	3.09
O&M Costs (Average)		mills/kW_eh	7.7	7.7	7.5
$\overline{BBEC}$		mills/kW_eh	128	109	97
Simple Payback		years	10.0	8.4	7.4

[b] All costs include installation

TABLE 3-18. Performance and Cost Summary of PFCR/S System, 0.7 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		0.1	0.3	1.0
Capacity Factor		0.713	0.702	0.706
Collection Subsystem Efficiency (Annual Average)		0.487	0.520	0.568
Transport Subsystem Efficiency[a]		1.0	1.0	1.0
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	0.312	0.928	3.32
Storage Subsystem Efficiency[a]		0.763	0.776	0.794
Conversion Subsystem Efficiency from Field[a] (@ T_{field}= 650 °C)		0.361	0.367	0.372
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=)		N/A	N/A	N/A
System Efficiency (Annual Average)		0.117	0.125	0.129

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	75	75	75
	Receiver		18	22	26
Transport Subsystem		$/m² Collector	0.1	0.2	0.3
Electrical Storage Subsystem		$/$kW_e$	160	160	160
		$/$kW_e$h	16	16	16
Thermal Storage Subsystem		$/$kW_t$	-	-	-
		$/$kW_t$h	-	-	-
Conversion Subsystem	Engine	$/kW	90	110	125
	Generator	$/$kW_e$	33	32	30
Balance of Plant		$/$kW_e$	505	325	181
Total Capital Cost		$ × 10^6	0.447	1.18	3.56
O&M Costs (Average)		mills/kW_eh	6.8	6.9	6.9
$\overline{BBEC}$		mills/kW_eh	120	108	98
Simple Payback		years	9.3	8.3	7.5

[b] All costs include installation

TABLE 3-19. Performance and Cost Summary of PFCR/S System, 0.8 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		0.1	0.3	1.0
Capacity Factor		0.807	0.799	0.803
Collection Subsystem Efficiency (Annual Average)		0.481	0.520	0.568
Transport Subsystem Efficiency[a]		1.0	1.0	1.0
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	0.436	1.18	4.42
Storage Subsystem Efficiency[a]		0.714	0.689	0.736
Conversion Subsystem Efficiency from Field[a] (@ T_{field}=650°C)		0.367	0.368	0.374
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=)		N/A	N/A	N/A
System Efficiency (Annual Average)		0.095	0.112	0.110

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	75	75	75
	Receiver		18	22	26
Transport Subsystem		$/m² Collector	0.1	0.2	0.3
Electrical Storage Subsystem		$/$kW_e$	160	160	160
		$/$kW_e$h	16	16	16
Thermal Storage Subsystem		$/$kW_t$	-	-	-
		$/$kW_t$h	-	-	-
Conversion Subsystem	Engine	$/kW	90	110	125
	Generator	$/$kW_e$	33	32	30
Balance of Plant		$/$kW_e$	505	325	181
Total Capital Cost		$ × 10^6	0.564	1.45	4.64
O&M Costs (Average)		mills/kW_eh	6.3	6.3	6.3
$\overline{BBEC}$		mills/kW_eh	132	115	111
Simple Payback		years	10.3	8.9	8.0

[b] All costs include installation

TABLE 3-20. Performance and Cost Summary of PFCR/B System, 0.3 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		0.1	0.3	1.0
Capacity Factor		0.306	0.310	0.316
Collection Subsystem Efficiency (Annual Average)		0.466	0.509	0.559
Transport Subsystem Efficiency[a]		1.0	1.0	1.0
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	0.181	0.495	1.45
Storage Subsystem Efficiency[a]		0.977	0.978	0.979
Conversion Subsystem Efficiency from Field[a] (@ T_{field}= 650°C)		0.228	0.248	0.269
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=)		N/A	N/A	N/A
System Efficiency (Annual Average)		0.084	0.103	0.129

[a] $T_{ambient}$ = 20°C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	75	75	75
	Receiver		14	20	26
Transport Subsystem		$/m² Collector	0.1	0.2	0.3
Electrical Storage Subsystem		$/$kW_e$	160	160	160
		$/$kW_e$h	16	16	16
Thermal Storage Subsystem		$/$kW_t$	-	-	-
		$/$kW_t$h	-	-	-
Conversion Subsystem	Engine	$/kW	130	150	170
	Generator	$/$kW_e$	33	32	30
Balance of Plant		$/$kW_e$	527	337	186
Total Capital Cost		$ × 10^6	0.237	0.572	1.50
O&M Costs (Average)		mills/kW_eh	13.1	13.0	12.7
$\overline{BBEC}$		mills/kW_eh	154	125	100
Simple Payback		years	12.0	9.5	7.3

[b] All costs include installation

TABLE 3-21. Performance and Cost Summary of PFCR/B System, 0.4 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		0.1	0.3	1.0
Capacity Factor		0.422	0.422	0.402
Collection Subsystem Efficiency (Annual Average)		0.466	0.509	0.559
Transport Subsystem Efficiency[a]		1.0	1.0	1.0
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	0.211	0.578	1.81
Storage Subsystem Efficiency[a]		0.894	0.899	0.928
Conversion Subsystem Efficiency from Field[a] (@ T_{field}=650°C)		0.240	0.262	0.276
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=)		N/A	N/A	N/A
System Efficiency (Annual Average)		0.099	0.118	0.132

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	75	75	75
	Receiver	$/m² Collector	14	20	26
Transport Subsystem		$/m² Collector	0.1	0.2	0.3
Electrical Storage Subsystem		$/$kW_e$	160	160	160
		$/$kW_e$h	16	16	16
Thermal Storage Subsystem		$/$kW_t$	-	-	-
		$/$kW_t$h	-	-	-
Conversion Subsystem	Engine	$/kW	130	150	170
	Generator	$/$kW_e$	33	32	30
Balance of Plant		$/$kW_e$	527	337	186
Total Capital Cost		$ × 10^6	0.314	0.792	2.11
O&M Costs (Average)		mills/kW_eh	10.1	10.1	10.5
$\overline{BBEC}$		mills/kW_eh	145	124	106
Simple Payback		years	11.3	9.5	8.0

[b] All costs include installation

TABLE 3-22. Performance and Cost Summary of PFCR/B System, 0.5 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		0.1	0.3	1.0
Capacity Factor		0.499	0.503	0.501
Collection Subsystem Efficiency (Annual Average)		0.466	0.509	0.559
Transport Subsystem Efficiency[a]		1.0	1.0	1.0
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	0.272	0.743	2.17
Storage Subsystem Efficiency[a]		0.818	0.827	0.858
Conversion Subsystem Efficiency from Field[a] (@ T_{field}=650°C)		0.242	0.264	0.288
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=)		N/A	N/A	N/A
System Efficiency (Annual Average)		0.091	0.110	0.137

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	75	75	75
	Receiver		14	20	26
Transport Subsystem		$/m² Collector	0.1	0.2	0.3
Electrical Storage Subsystem		$/$kW_e$	160	160	160
		$/$kW_e$h	16	16	16
Thermal Storage Subsystem		$/$kW_t$	-	-	-
		$/$kW_t$h	-	-	-
Conversion Subsystem	Engine	$/kW	130	150	170
	Generator	$/$kW_e$	33	32	30
Balance of Plant		$/$kW_e$	527	337	186
Total Capital Cost		$ × 10^6	0.375	0.954	2.67
O&M Costs (Average)		mills/kW_eh	8.8	8.8	8.8
$\overline{BBEC}$		mills/kW_eh	145	123	106
Simple Payback		years	11.3	9.5	8.0

[b] All costs include installation

TABLE 3-23. Performance and Cost Summary of PFCR/B System, 0.6 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		0.1	0.3	1.0
Capacity Factor		0.617	0.617	0.610
Collection Subsystem Efficiency (Annual Average)		0.466	0.509	0.559
Transport Subsystem Efficiency[a]		1.0	1.0	1.0
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	0.332	0.908	2.90
Storage Subsystem Efficiency[a]		0.824	0.827	0.839
Conversion Subsystem Efficiency from Field[a] (@ T_{field}=650°C)		0.243	0.265	0.283
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=)		N/A	N/A	N/A
System Efficiency (Annual Average)		0.092	0.110	0.125

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	75	75	75
	Receiver		14	20	26
Transport Subsystem		$/m² Collector	0.1	0.2	0.3
Electrical Storage Subsystem		$/$kW_e$	160	160	160
		$/$kW_e$h	16	16	16
Thermal Storage Subsystem		$/$kW_t$	-	-	-
		$/$kW_t$h	-	-	-
Conversion Subsystem	Engine	$/kW	130	150	170
	Generator	$/$kW_e$	33	32	30
Balance of Plant		$/$kW_e$	527	337	186
Total Capital Cost		$ × 10^6	0.464	1.20	3.28
O&M Costs (Average)		mills/kW_eh	7.6	7.5	7.6
$\overline{BBEC}$		mills/kW_eh	143	125	105
Simple Payback		years	11.2	9.6	8.0

[b] All costs include installation

TABLE 3-24. Performance and Cost Summary of PFCR/B System, 0.7 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		0.1	0.3	1.0
Capacity Factor		0.709	0.710	0.692
Collection Subsystem Efficiency (Annual Average)		0.466	0.509	0.559
Transport Subsystem Efficiency[a]		1.0	1.0	1.0
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	0.393	1.07	3.26
Storage Subsystem Efficiency[a]		0.800	0.802	0.816
Conversion Subsystem Efficiency from Field[a] (@ T_{field}=650°C)		0.244	0.266	0.286
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=)		N/A	N/A	N/A
System Efficiency (Annual Average)		0.089	0.107	0.126

[a] $T_{ambient}$ = 20°C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	75	75	75
	Receiver		14	20	26
Transport Subsystem		$/m² Collector	0.1	0.2	0.3
Electrical Storage Subsystem		$/$kW_e$	160	160	160
		$/$kW_e$h	16	16	16
Thermal Storage Subsystem		$/$kW_t$	-	-	-
		$/$kW_t$h	-	-	-
Conversion Subsystem	Engine	$/kW	130	150	170
	Generator	$/$kW_e$	33	32	30
Balance of Plant		$/$kW_e$	527	337	186
Total Capital Cost		$ × 10^6	0.530	1.37	3.70
O&M Costs (Average)		mills/kW_eh	6.8	6.8	7.0
$\overline{BBEC}$		mills/kW_eh	142	123	104
Simple Payback		years	11.1	9.6	7.9

[b] All costs include installation

TABLE 3-25. Performance and Cost Summary of PFCR/B System, 0.8 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		0.1	0.3	1.0
Capacity Factor		0.807	0.810	0.791
Collection Subsystem Efficiency (Annual Average)		0.466	0.509	0.558
Transport Subsystem Efficiency[a]		1.0	1.0	1.0
Average Thermal Power Collected (8784 h/yr)	$\overline{MW}_t$	0.514	1.40	3.99
Storage Subsystem Efficiency[a]		0.732	0.731	0.738
Conversion Subsystem Efficiency from Field[a] (@ T_{field}= 650°C)		0.244	0.265	0.290
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=)		N/A	N/A	N/A
System Efficiency (Annual Average)		0.078	0.094	0.118

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	75	75	75
	Receiver		14	20	26
Transport Subsystem		$/m² Collector	0.1	0.2	0.3
Electrical Storage Subsystem		$/$kW_e$	160	160	160
		$/$kW_e$h	16	16	16
Thermal Storage Subsystem		$/$kW_t$	-	-	-
		$/$kW_t$h	-	-	-
Conversion Subsystem	Engine	$/kW	130	150	170
	Generator	$/$kW_e$	33	32	30
Balance of Plant		$/$kW_e$	527	337	186
Total Capital Cost		$ × 10^6	0.641	1.66	4.55
O&M Costs (Average)		mills/kW_eh	6.3	6.3	6.4
$\overline{BBEC}$		mills/kW_eh	149	130	110
Simple Payback		years	11.7	10.1	8.5

[b] All costs include installation

TABLE 3-26. Performance and Cost Summary of PFCR/R System, 0.3 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		0.1	0.3	1.0
Capacity Factor		0.324	0.307	0.305
Collection Subsystem Efficiency (Annual Average)		0.538	0.570	0.586
Transport Subsystem Efficiency[a]		1.00	1.00	1.00
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	0.139	0.561	1.52
Storage Subsystem Efficiency[a]		0.944	1.00	1.00
Conversion Subsystem Efficiency from Field[a] (@ $T_{field}=425^oC$)[c]		0.248	0.251	0.279
Conversion Subsystem Efficiency from Storage[a] (@ $T_{stor}=425^oC$)[c]		0.248	0.251	0.279
System Efficiency (Annual Average)		0.133	0.100	0.125

[a] $T_{ambient} = 20°C$

[c] $T_{1.0MWe} = 540^oC$

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	75	75	75
	Receiver		24	22	20
Transport Subsystem		$/m² Collector	-	-	-
Electrical Storage Subsystem		$/$kW_e$	-	-	-
		$/$kW_eh$	-	-	-
Thermal Storage Subsystem		$/$kW_t$	93	-	-
		$/$kW_th$	15	-	-
Conversion Subsystem	Engine	$/kW	380	430	480
	Generator	$/$kW_e$	33	32	30
Balance of Plant		$/$kW_e$	530	343	192
Total Capital Cost		$\$ \times 10^6$	0.251	0.667	1.86
O&M Costs (Average)		mills/kW_eh	12.5	13.1	13.1
$\overline{BBEC}$		mills/kW_eh	153	145	125
Simple Payback		years	11.9	11.2	9.4

[b] All costs include installation

TABLE 3-27. Performance and Cost Summary of PFCR/R System, 0.4 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		0.1	0.3	1.0
Capacity Factor		0.405	0.413	0.409
Collection Subsystem Efficiency (Annual Average)		0.538	0.570	0.586
Transport Subsystem Efficiency[a]		1.00	1.00	1.00
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	0.174	0.641	1.71
Storage Subsystem Efficiency[a]		0.945	0.430	0.620
Conversion Subsystem Efficiency from Field[a] (@ T_{field}= 425°C)[c]		0.249	0.252	0.281
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=425°C)[c]		0.249	0.252	0.281
System Efficiency (Annual Average)		0.133	0.116	0.149

[a] $T_{ambient}$ = 20°C

[c] $T_{1.0MWe}$ = 540°C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	75	75	75
	Receiver		24	22	20
Transport Subsystem		$/m² Collector	-	-	-
Electrical Storage Subsystem		$/$kW_e$	-	-	-
		$/$kW_e$h	-	-	-
Thermal Storage Subsystem		$/$kW_t$	93	93	93
		$/$kW_t$h	15	15	15
Conversion Subsystem	Engine	$/kW	380	430	480
	Generator	$/$kW_e$	33	32	30
Balance of Plant		$/$kW_e$	530	343	192
Total Capital Cost		$ × 10^6	0.308	0.809	2.26
O&M Costs (Average)		mills/kW_eh	10.4	10.2	10.3
$\overline{BBEC}$		mills/kW_eh	140	129	111
Simple Payback		years	10.9	9.9	8.5

[b] All costs include installation

TABLE 3-28. Performance and Cost Summary of PFCR/R System, 0.5 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		0.1	0.3	1.0
Capacity Factor		0.536	0.501	0.506
Collection Subsystem Efficiency (Annual Average)		0.538	0.570	0.586
Transport Subsystem Efficiency[a]		1.00	1.00	1.00
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	0.244	0.641	2.28
Storage Subsystem Efficiency[a]		0.932	0.929	0.587
Conversion Subsystem Efficiency from Field[a] (@ T_{field}= 425°C)[c]		0.250	0.252	0.282
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=425°C)[c]		0.250	0.252	0.282
System Efficiency (Annual Average)		0.131	0.141	0.138

[a] $T_{ambient}$ = 20° C

[c] $T_{1.0MWe}$ = 540°C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	75	75	75
	Receiver		24	22	20
Transport Subsystem		$/m² Collector	-	-	-
Electrical Storage Subsystem		$/$kW_e$	-	-	-
		$/$kW_e$h	-	-	-
Thermal Storage Subsystem		$/$kW_t$	93	93	93
		$/$kW_t$h	15	15	15
Conversion Subsystem	Engine	$/kW	380	430	480
	Generator	$/$kW_e$	33	32	30
Balance of Plant		$/$kW_e$	530	343	192
Total Capital Cost		$ × 10^6	0.350	0.916	2.73
O&M Costs (Average)		mills/kW_eh	8.4	8.8	8.7
$\overline{BBEC}$		mills/kW_eh	127	119	107
Simple Payback		years	9.8	9.1	8.1

[b] All costs include installation

TABLE 3-29. Performance and Cost Summary of PFCR/R System, 0.6 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		0.1	0.3	1.0
Capacity Factor		0.609	0.612	0.586
Collection Subsystem Efficiency (Annual Average)		0.538	0.570	0.586
Transport Subsystem Efficiency[a]		1.00	1.00	1.00
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	0.279	0.831	2.66
Storage Subsystem Efficiency[a]		0.834	0.837	0.632
Conversion Subsystem Efficiency from Field[a] (@ T_{field}= 425°C)[c]		0.250	0.253	0.281
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}= 425°C)[c]		0.250	0.253	0.281
System Efficiency (Annual Average)		0.125	0.134	0.137

[a] $T_{ambient}$ = 20° C

[c] $T_{1.0MWe}$ = 540°C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	75	75	75
	Receiver		24	22	20
Transport Subsystem		$/m² Collector	-	-	-
Electrical Storage Subsystem		$/$kW_e$	-	-	-
		$/$kW_e$h	-	-	-
Thermal Storage Subsystem		$/$kW_t$	93	93	93
		$/$kW_t$h	15	15	15
Conversion Subsystem	Engine	$/kW	380	430	480
	Generator	$/$kW_e$	33	32	30
Balance of Plant		$/$kW_e$	530	343	192
Total Capital Cost		$ × 10^6	0.389	1.08	3.10
O&M Costs (Average)		mills/kW_eh	7.4	7.6	7.8
$\overline{BBEC}$		mills/kW_eh	123	114	104
Simple Payback		years	9.5	8.7	7.9

[b] All costs include installation

TABLE 3-30. Performance and Cost Summary of PFCR/R System, 0.7 Capacity Factory

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e) 0.1	0.3	1.0
Capacity Factor		0.709	0.706	0.717
Collection Subsystem Efficiency (Annual Average)		0.538	0.570	0.586
Transport Subsystem Efficiency[a]		1.00	1.00	1.00
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	0.314	0.923	3.04
Storage Subsystem Efficiency[a]		0.912	0.921	0.781
Conversion Subsystem Efficiency from Field[a] (@ T_{field}= 425°C)[c]		0.250	0.253	0.282
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=425°C)[c]		0.250	0.253	0.282
System Efficiency (Annual Average)		0.129	0.139	0.147

[a] $T_{ambient}$ = 20° C

[c] $T_{1.0MWe}$ = 540°C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	75	75	75
	Receiver		24	22	20
Transport Subsystem		$/m² Collector	-	-	-
Electrical Storage Subsystem		$/$kW_e$	-	-	-
		$/$kW_e$h	-	-	-
Thermal Storage Subsystem		$/$kW_t$	93	93	93
		$/$kW_t$h	15	15	15
Conversion Subsystem	Engine	$/kW	380	430	480
	Generator	$/$kW_e$	33	32	30
Balance of Plant		$/$kW_e$	530	343	192
Total Capital Cost		$ × 10^6	0.446	1.23	3.63
O&M Costs (Average)		mills/kW_eh	6.8	6.9	6.8
$\overline{BBEC}$		mills/kW_eh	121	112	99
Simple Payback		years	9.3	8.6	7.5

[b] All costs include installation

TABLE 3-31. Performance and Cost Summary of PFCR/R System, 0.8 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)	Plant Rating (MW_e)		
	0.1	0.3	1.0
Capacity Factor	0.806	0.798	0.791
Collection Subsystem Efficiency (Annual Average)	0.538	0.570	0.586
Transport Subsystem Efficiency[a]	1.00	1.00	1.00
Average Thermal Power Collected (8784 h/yr) $\overline{MW_t}$	0.384	1.11	3.42
Storage Subsystem Efficiency[a]	0.807	0.829	0.767
Conversion Subsystem Efficiency from Field[a] (@ $T_{field}=425^{0}C$)[c]	0.251	0.253	0.282
Conversion Subsystem Efficiency from Storage[a] (@ $T_{stor}=425^{0}C$)[c]	0.251	0.253	0.282
System Efficiency (Annual Average)	0.120	0.131	0.144

[a] $T_{ambient}$ = 20° C

[c] $T_{1.0MWe} = 540^{0}C$

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	75	75	75
	Receiver		24	22	20
Transport Subsystem		$/m² Collector	-	-	-
Electrical Storage Subsystem		$/$kW_e$	-	-	-
		$/$kW_eh$	-	-	-
Thermal Storage Subsystem		$/$kW_t$	93	93	93
		$/$kW_th$	15	15	15
Conversion Subsystem	Engine	$/kW	380	430	480
	Generator	$/$kW_e$	33	32	30
Balance of Plant		$/$kW_e$	530	343	192
Total Capital Cost		$\$ \times 10^{6}$	0.507	1.39	4.01
O&M Costs (Average)		mills/kW_eh	6.3	6.3	6.4
$\overline{BBEC}$		mills/kW_eh	120	112	98
Simple Payback		years	9.3	8.6	7.5

[b] All costs include installation

TABLE 3-32. Performance and Cost Summary of PFDR/R System, 0.3 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		0.1	0.3	1.0
Capacity Factor		0.317	0.317	0.305
Collection Subsystem Efficiency (Annual Average)		0.766	0.766	0.766
Transport Subsystem Efficiency[a]		1.0	1.0	1.0
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	0.176	0.528	1.54
Storage Subsystem Efficiency[a]		0.864	0.863	0.954
Conversion Subsystem Efficiency from Field[a] (@ T_{field}= 425°C)		0.249	0.249	0.248
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=)		N/A	N/A	N/A
System Efficiency (Annual Average)		0.142	0.142	0.156

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	97	97	97
	Receiver		9	9	9
Transport Subsystem		$/m² Collector	2.3	2.8	3.2
Electrical Storage Subsystem		$/$kW_e$	160	160	160
		$/$kW_e$h	16	16	16
Thermal Storage Subsystem		$/$kW_t$	-	-	-
		$/$kW_t$h	-	-	-
Conversion Subsystem	Engine	$/kW	417	417	417
	Generator	$/$kW_e$	33	33	33
Balance of Plant		$/$kW_e$	389	272	160
Total Capital Cost		$ × 10^6	0.213	0.598	1.67
O&M Costs (Average)		mills/kW_eh	12.7	12.7	13.1
$\overline{BBEC}$		mills/kW_eh	135	127	113
Simple Payback		years	10.3	9.7	8.4

[b] All costs include installation

TABLE 3-33. Performance and Cost Summary of PFDR/R System, 0.4 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		0.1	0.3	1.0
Capacity Factor		0.418	0.397	0.418
Collection Subsystem Efficiency (Annual Average)		0.766	0.766	0.766
Transport Subsystem Efficiency[a]		1.0	1.0	1.0
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	0.220	0.616	2.20
Storage Subsystem Efficiency[a]		0.903	0.920	0.902
Conversion Subsystem Efficiency from Field[a] (@ T_{field}= 425°C)		0.252	0.251	0.252
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=)		N/A	N/A	N/A
System Efficiency (Annual Average)		0.150	0.153	0.150

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	97	97	97
	Receiver		9	9	9
Transport Subsystem		$/m² Collector	2.3	2.8	3.2
Electrical Storage Subsystem		$/$kW_e$	160	160	160
		$/$kW_e$h	16	16	16
Thermal Storage Subsystem		$/$kW_t$	-	-	-
		$/$kW_t$h	-	-	-
Conversion Subsystem	Engine	$/kW	417	417	417
	Generator	$/$kW_e$	33	33	33
Balance of Plant		$/$kW_e$	389	272	160
Total Capital Cost		$ × 10^6	0.283	0.766	2.57
O&M Costs (Average)		mills/kW_eh	10.1	10.6	10.1
$\overline{BBEC}$		mills/kW_eh	133	128	122
Simple Payback		years	10.3	9.8	9.3

[b] All costs include installation

TABLE 3-34. Performance and Cost Summary of PFDR/R System, 0.5 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		0.1	0.3	1.0
Capacity Factor		0.495	0.484	0.517
Collection Subsystem Efficiency (Annual Average)		0.766	0.766	0.766
Transport Subsystem Efficiency[a]		1.0	1.0	1.0
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	0.308	0.792	2.86
Storage Subsystem Efficiency[a]		0.757	0.866	0.851
Conversion Subsystem Efficiency from Field[a] (@ T_{field}= 425°C)		0.254	0.253	0.254
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=)		N/A	N/A	N/A
System Efficiency (Annual Average)		0.127	0.145	0.143

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	97	97	97
	Receiver		9	9	9
Transport Subsystem		$/m² Collector	2.3	2.8	3.2
Electrical Storage Subsystem		$/$kW_e$	160	160	160
		$/$kW_e$h	16	16	16
Thermal Storage Subsystem		$/$kW_t$	-	-	-
		$/$kW_t$h	-	-	-
Conversion Subsystem	Engine	$/kW	417	417	417
	Generator	$/$kW_e$	33	33	33
Balance of Plant		$/$kW_e$	389	272	160
Total Capital Cost		$ × 10^6	0.371	0.986	3.36
O&M Costs (Average)		mills/kW_eh	8.9	9.0	8.6
$\overline{BBEC}$		mills/kW_eh	144	131	126
Simple Payback		years	11.3	10.1	9.7

[b] All costs include installation

TABLE 3-35. Performance and Cost Summary of PFDR/R System, 0.6 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		0.1	0.3	1.0
Capacity Factor		0.613	0.613	0.613
Collection Subsystem Efficiency (Annual Average)		0.766	0.766	0.766
Transport Subsystem Efficiency[a]		1.0	1.0	1.0
Average Thermal Power Collected (8784 h/yr)	$\overline{MW}_t$	0.352	1.06	0.352
Storage Subsystem Efficiency[a]		0.817	0.817	0.817
Conversion Subsystem Efficiency from Field[a] (@ T_{field}= 425°C)		0.255	0.255	0.255
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=)		N/A	N/A	N/A
System Efficiency (Annual Average)		0.138	0.137	0.138

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	97	97	97
	Receiver		9	9	9
Transport Subsystem		$/m² Collector	2.3	2.8	3.2
Electrical Storage Subsystem		$/$kW_e$	160	160	160
		$/$kW_e$h	16	16	16
Thermal Storage Subsystem		$/$kW_t$	-	-	-
		$/$kW_t$h	-	-	-
Conversion Subsystem	Engine	$/kW	417	417	417
	Generator	$/$kW_e$	33	33	33
Balance of Plant		$/$kW_e$	389	272	160
Total Capital Cost		$ × 10^6	0.431	1.25	4.05
O&M Costs (Average)		mills/kW_eh	7.6	7.6	7.6
$\overline{BBEC}$		mills/kW_eh	135	131	127
Simple Payback		years	10.5	10.1	9.8

[b] All costs include installation

TABLE 3-36. Performance and Cost Summary of PFDR/R System, 0.7 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		0.1	0.3	1.0
Capacity Factor		0.724	0.692	0.701
Collection Subsystem Efficiency (Annual Average)		0.766	0.766	0.766
Transport Subsystem Efficiency[a]		1.0	1.0	1.0
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	0.440	1.23	4.62
Storage Subsystem Efficiency[a]		0.768	0.788	0.707
Conversion Subsystem Efficiency from Field[a] (@ T_{field}= 425°C)		0.256	0.256	0.256
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=)		N/A	N/A	N/A
System Efficiency (Annual Average)		0.130	0.133	0.120

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	97	97	97
	Receiver		9	9	9
Transport Subsystem		$/m² Collector	2.3	2.8	3.2
Electrical Storage Subsystem		$/$kW_e$	160	160	160
		$/$kW_e$h	16	16	16
Thermal Storage Subsystem		$/$kW_t$	-	-	-
		$/$kW_t$h	-	-	-
Conversion Subsystem	Engine	$/kW	417	417	417
	Generator	$/$kW_e$	33	33	33
Balance of Plant		$/$kW_e$	389	272	160
Total Capital Cost		$ × 10^6	0.523	1.44	4.73
O&M Costs (Average)		mills/kW_eh	6.7	7.0	6.9
$\overline{BBEC}$		mills/kW_eh	137	132	129
Simple Payback		years	10.7	10.3	10.0

[b] All costs include installation

TABLE 3-37. Performance and Cost Summary of PFDR/R System, 0.8 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)	Plant Rating (MW_e)		
	0.1	0.3	1.0
Capacity Factor	0.808	0.808	0.808
Collection Subsystem Efficiency (Annual Average)	0.766	0.766	0.766
Transport Subsystem Efficiency[a]	1.0	1.0	1.0
Average Thermal Power Collected (8784 h/yr) $\overline{MW_t}$	0.528	1.58	5.28
Storage Subsystem Efficiency[a]	0.712	0.712	0.701
Conversion Subsystem Efficiency from Field[a] (@ T_{field}= 425°C)	0.257	0.257	0.257
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=)	N/A	N/A	N/A
System Efficiency (Annual Average)	0.121	0.121	0.119

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	97	97	97
	Receiver		9	9	9
Transport Subsystem		$/m² Collector	2.3	2.8	3.2
Electrical Storage Subsystem		$/$kW_e$	160	160	160
		$/$kW_e$h	16	16	16
Thermal Storage Subsystem		$/$kW_t$	-	-	-
		$/$kW_t$h	-	-	-
Conversion Subsystem	Engine	$/kW	417	417	417
	Generator	$/$kW_e$	33	33	33
Balance of Plant		$/$kW_e$	389	272	160
Total Capital Cost		$ × 10^6	0.640	1.88	6.13
O&M Costs (Average)		mills/kW_eh	6.3	6.3	6.3
$\overline{BBEC}$		mills/kW_eh	149	146	143
Simple Payback		years	11.7	11.5	11.2

[b] All costs include installation

TABLE 3-38. Performance and Cost Summary of PFDR/CR System, 0.3 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		0.1	0.3	1.0
Capacity Factor		0.330	0.330	0.305
Collection Subsystem Efficiency (Annual Average)		0.763	0.763	0.763
Transport Subsystem Efficiency[a]		0.950	0.941	0.920
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	0.166	0.497	1.40
Storage Subsystem Efficiency[a]		1.0	1.0	1.0
Conversion Subsystem Efficiency from Field[a] (@ $T_{field}=425^oC$)[c]		0.247	0.250	0.260
Conversion Subsystem Efficiency from Storage[a] (@ $T_{stor}=425^oC$)[c]		0.247	0.250	0.260
System Efficiency (Annual Average)		0.152	0.153	0.162

[a] $T_{ambient} = 20°C$

[c] $T_{1.0MWe} = 540^oC$

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	97	97	97
	Receiver		9	9	9
Transport Subsystem		$/m² Collector	17	19	21
Electrical Storage Subsystem		$/kW_e	-	-	-
		$/kW_eh	-	-	-
Thermal Storage Subsystem		$/kW_t	-	-	-
		$/kW_th	-	-	-
Conversion Subsystem	Engine	$/kW	380	430	480
	Generator	$/kW_e	33	32	30
Balance of Plant		$/kW_e	522	343	193
Total Capital Cost		$ × 10⁶	0.225	0.633	1.87
O&M Costs (Average)		mills/kW_eh	12.3	12.3	13.1
$\overline{BBEC}$		mills/kW_eh	136	129	125
Simple Payback		years	10.5	9.8	9.4

[b] All costs include installation

TABLE 3-39. Performance and Cost Summary of PFDR/CR System, 0.4 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		0.1	0.3	1.0
Capacity Factor		0.445	0.435	0.431
Collection Subsystem Efficiency (Annual Average)		0.763	0.763	0.763
Transport Subsystem Efficiency[a]		0.950	0.941	0.920
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	0.208	0.577	1.80
Storage Subsystem Efficiency[a]		0.616	0.757	0.798
Conversion Subsystem Efficiency from Field[a] (@ $T_{field}=425^oC$)[c]		0.250	0.252	0.264
Conversion Subsystem Efficiency from Storage[a] (@ $T_{stor}=425^oC$)[c]		0.250	0.252	0.264
System Efficiency (Annual Average)		0.165	0.173	0.178

[a] $T_{ambient} = 20°C$

[c] $T_{1.0MWe} = 540^oC$

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	97	97	97
	Receiver		9	9	9
Transport Subsystem		$/m² Collector	17	19	21
Electrical Storage Subsystem		$/$kW_e$	-	-	-
		$/$kW_e$h	-	-	-
Thermal Storage Subsystem		$/$kW_t$	93	93	93
		$/$kW_t$h	15	15	15
Conversion Subsystem	Engine	$/kW	380	430	480
	Generator	$/$kW_e$	33	32	30
Balance of Plant		$/$kW_e$	522	343	193
Total Capital Cost		$ × 10^6	0.281	0.776	2.43
O&M Costs (Average)		mills/kW_eh	9.6	9.8	9.9
$\overline{BBEC}$		mills/kW_eh	124	118	113
Simple Payback		years	9.5	9.0	8.5

[b] All costs include installation

TABLE 3-40. Performance and Cost Summary of PFDR/CR System, 0.5 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		0.1	0.3	1.0
Capacity Factor		0.526	0.504	0.515
Collection Subsystem Efficiency (Annual Average)		0.763	0.763	0.763
Transport Subsystem Efficiency[a]		0.950	0.941	0.920
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	0.250	0.659	2.20
Storage Subsystem Efficiency[a]		0.683	0.864	0.793
Conversion Subsystem Efficiency from Field[a] (@ T_{field}= 425°C)[c]		0.250	0.252	0.264
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=425°C)[c]		0.250	0.252	0.264
System Efficiency (Annual Average)		0.162	0.175	0.174

[a] $T_{ambient}$ = 20° C

[c] $T_{1.0MWe}$ = 540°C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	97	97	97
	Receiver		9	9	9
Transport Subsystem		$/m² Collector	17	19	21
Electrical Storage Subsystem		$/$kW_e$	-	-	-
		$/$kW_eh$	-	-	-
Thermal Storage Subsystem		$/$kW_t$	93	93	93
		$/$kW_th$	15	15	15
Conversion Subsystem	Engine	$/kW	380	430	480
	Generator	$/$kW_e$	33	32	30
Balance of Plant		$/$kW_e$	522	343	193
Total Capital Cost		$ × 10^6	0.326	0.883	2.87
O&M Costs (Average)		mills/kW_eh	8.5	8.8	8.6
$\overline{BBEC}$		mills/kW_eh	121	115	110
Simple Payback		years	9.3	8.8	8.4

[b] All costs include installation

TABLE 3-41. Performance amd Cost Summary of PFDR/CR System, 0.6 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)	Plant Rating (MW_e)		
	0.1	0.3	1.0
Capacity Factor	0.604	0.596	0.594
Collection Subsystem Efficiency (Annual Average)	0.763	0.763	0.763
Transport Subsystem Efficiency[a]	0.950	0.941	0.920
Average Thermal Power Collected (8784 h/yr) $\overline{MW_t}$	2.91	0.824	2.60
Storage Subsystem Efficiency[a]	0.705	0.769	0.780
Conversion Subsystem Efficiency from Field[a] (@ T_{field}= 425°C)[c]	0.250	0.253	0.264
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=425°C)[c]	0.250	0.253	0.264
System Efficiency (Annual Average)	0.160	0.166	0.170

[a] $T_{ambient}$ = 20° C

[c] $T_{1.0MWe}$ = 540°C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	97	97	97
	Receiver		9	9	9
Transport Subsystem		$/m² Collector	17	19	21
Electrical Storage Subsystem		$/$kW_e$	-	-	-
		$/$kW_eh$	-	-	-
Thermal Storage Subsystem		$/$kW_t$	93	93	93
		$/$kW_th$	15	15	15
Conversion Subsystem	Engine	$/kW	380	430	480
	Generator	$/$kW_e$	33	32	30
Balance of Plant		$/$kW_e$	522	343	193
Total Capital Cost		$ × 10^6	0.370	1.04	3.31
O&M Costs (Average)		mills/kW_eh	7.7	7.7	7.8
$\overline{BBEC}$		mills/kW_eh	119	113	109
Simple Payback		years	9.1	8.7	8.3

[b] All costs include installation

TABLE 3-42. Performance and Cost Summary of PFDR/CR System, 0.7 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)	Plant Rating (MW_e)		
	0.1	0.3	1.0
Capacity Factor	0.728	0.680	0.711
Collection Subsystem Efficiency (Annual Average)	0.763	0.763	0.763
Transport Subsystem Efficiency[a]	0.950	0.941	0.920
Average Thermal Power Collected (8784 h/yr) $\overline{MW_t}$	0.333	0.988	3.00
Storage Subsystem Efficiency[a]	0.843	0.715	0.885
Conversion Subsystem Efficiency from Field[a] (@ T_{field}= 425°C)[c]	0.250	0.253	0.264
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=425°C)[c]	0.250	0.253	0.264
System Efficiency (Annual Average)	0.169	0.157	0.177

[a] $T_{ambient}$ = 20° C

[c] $T_{1.0MWe}$ = 540°C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	97	97	97
	Receiver		9	9	9
Transport Subsystem		$/m² Collector	17	19	21
Electrical Storage Subsystem		$/$kW_e$	-	-	-
		$/$kW_eh$	-	-	-
Thermal Storage Subsystem		$/$kW_t$	93	93	93
		$/$kW_th$	15	15	15
Conversion Subsystem	Engine	$/kW	380	430	480
	Generator	$/$kW_e$	33	32	30
Balance of Plant		$/$kW_e$	522	343	193
Total Capital Cost		$ × 10^6	0.432	1.20	3.93
O&M Costs (Average)		mills/kW_eh	6.7	7.0	6.8
$\overline{BBEC}$		mills/kW_eh	114	114	107
Simple Payback		years	8.8	8.8	8.2

[b] All costs include installation

TABLE 3-43. Performance and Cost Summary of PFDR/CR System, 0.8 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		0.1	0.3	1.0
Capacity Factor		0.805	0.803	0.798
Collection Subsystem Efficiency (Annual Average)		0.763	0.763	0.763
Transport Subsystem Efficiency[a]		0.950	0.941	0.920
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	0.375	1.15	3.61
Storage Subsystem Efficiency[a]		0.825	0.768	0.787
Conversion Subsystem Efficiency from Field[a] (@ $T_{field}=425^oC$)[c]		0.251	0.253	0.265
Conversion Subsystem Efficiency from Storage[a] (@ $T_{stor}=425^oC$)[c]		0.251	0.253	0.265
System Efficiency (Annual Average)		0.166	0.160	0.165

[a] $T_{ambient}$ = 20° C

[c] $T_{1.0MWe} = 540^oC$

Economic Summary (1978 dollars)[b]					
Collector Subsystem	Concentrator	$/m² Collector	97	97	97
	Receiver		9	9	9
Transport Subsystem		$/m² Collector	17	19	21
Electrical Storage Subsystem		$/$kW_e$	-	-	-
		$/$kW_eh$	-	-	-
Thermal Storage Subsystem		$/$kW_t$	93	93	93
		$/$kW_th$	15	15	15
Conversion Subsystem	Engine	$/kW	380	430	480
	Generator	$/$kW_e$	33	32	30
Balance of Plant		$/$kW_e$	522	343	193
Total Capital Cost		$ × 10^6	0.496	1.42	4.50
O&M Costs (Average)		mills/kW_eh	6.3	6.3	6.3
$\overline{BBEC}$		mills/kW_eh	117	112	108
Simple Payback		years	9.1	8.7	8.3

[b] All costs include installation

TABLE 3-44. Performance and Cost Summary of LFDR-TC System, 0.3 Capacity Factory

Performance Summary (Efficiencies in Decimal Units)	Plant Rating (MW_e)		
	0.1	0.3	1.0
Capacity Factor	0.324	0.328	0.306
Collection Subsystem Efficiency (Annual Average)	0.597	0.597	0.597
Transport Subsystem Efficiency[a]	0.990	0.980	0.970
Average Thermal Power Collected (8784 h/yr) $\overline{MW_t}$	0.230	0.664	1.88
Storage Subsystem Efficiency[a]	1.0	1.0	1.0
Conversion Subsystem Efficiency from Field[a] (@ $T_{field}=285^0C$)	0.182	0.193	0.203
Conversion Subsystem Efficiency from Storage[a] (@ $T_{stor}=285^0C$)	0.182	0.193	0.203
System Efficiency (Annual Average)	0.089	0.158	0.100

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	85+	85+	85+
	Receiver		-	-	-
Transport Subsystem		$/m² Collector	3.42	3.82	4.22
Electrical Storage Subsystem		$/$kW_e$	-	-	-
		$/$kW_eh$	-	-	-
Thermal Storage Subsystem		$/$kW_t$	-	-	-
		$/$kW_th$	-	-	-
Conversion Subsystem	Engine	$/kW	450	500	550
	Generator	$/$kW_e$	33	32	30
Balance of Plant		$/$kW_e$	553	361	204
Total Capital Cost		$ × 10^6	0.259	0.716	2.08
O&M Costs (Average)		mills/kW_eh	12.5	12.3	13.1
$\overline{BBEC}$		mills/kW_eh	157	145	137
Simple Payback		years	12.3	11.2	10.5

[b] All costs include installation

+Includes receiver cost

TABLE 3-45. Performance and Cost Summary of LFDR-TC System, 0.4 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		0.1	0.3	1.0
Capacity Factor		0.416	0.416	0.402
Collection Subsystem Efficiency (Annual Average)		0.597	0.597	0.597
Transport Subsystem Efficiency[a]		0.990	0.980	0.970
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	0.268	0.759	2.25
Storage Subsystem Efficiency[a]		0.531	0.534	0.611
Conversion Subsystem Efficiency from Field[a] (@ T_{field}= 285°C)		0.184	0.195	0.205
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=285°C)		0.184	0.195	0.205
System Efficiency (Annual Average)		0.098	0.102	0.110

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	85+	85+	85+
	Receiver		-	-	-
Transport Subsystem		$/m² Collector	3.42	3.82	4.22
Electrical Storage Subsystem		$/$kW_e$	-	-	-
		$/$kW_e$h	-	-	-
Thermal Storage Subsystem		$/$kW_t$	200	200	200
		$/$kW_t$h	12	12	12
Conversion Subsystem	Engine	$/kW	450	500	550
	Generator	$/$kW_e$	33	32	30
Balance of Plant		$/$kW_e$	553	361	204
Total Capital Cost		$ × 10^6	0.326	0.903	2.73
O&M Costs (Average)		mills/kW_eh	10.2	10.2	10.4
$\overline{BBEC}$		mills/kW_eh	152	141	133
Simple Payback		years	11.8	11.0	10.3

[b] All costs include installation

+Includes receiver cost

TABLE 3-46. Performance and Cost Summary of LFDR-TC System, 0.5 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		0.1	0.3	1.0
Capacity Factor		0.508	0.502	0.501
Collection Subsystem Efficiency (Annual Average)		0.597	0.597	0.597
Transport Subsystem Efficiency[a]		0.990	0.980	0.970
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	0.307	0.854	3.00
Storage Subsystem Efficiency[a]		0.840	0.856	0.581
Conversion Subsystem Efficiency from Field[a] (@ T_{field}=285°C)		0.184	0.195	0.206
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}= 285°C)		0.184	0.195	0.206
System Efficiency (Annual Average)		0.104	0.110	0.103

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	85+	85+	85+
	Receiver		-	-	-
Transport Subsystem		$/m² Collector	3.42	3.82	4.22
Electrical Storage Subsystem		$/$kW_e$	-	-	-
		$/$kW_e$h	-	-	-
Thermal Storage Subsystem		$/$kW_t$	200	200	200
		$/$kW_t$h	12	12	12
Conversion Subsystem	Engine	$/kW	450	500	550
	Generator	$/$kW_e$	33	32	30
Balance of Plant		$/$kW_e$	553	361	204
Total Capital Cost		$\$ \times 10^6$	0.387	1.07	3.34
O&M Costs (Average)		mills/kW_eh	8.7	8.8	8.8
$\overline{BBEC}$		mills/kW_eh	146	137	130
Simple Payback		years	11.4	10.6	10.0

[b] All costs include installation

+Includes receiver cost

TABLE 3-47. Performance and Cost Summary of LFDR-TC System, 0.6 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		0.1	0.3	1.0
Capacity Factor		0.603	0.617	0.599
Collection Subsystem Efficiency (Annual Average)		0.597	0.597	0.597
Transport Subsystem Efficiency[a]		0.990	0.980	0.970
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	0.383	1.14	3.38
Storage Subsystem Efficiency[a]		0.764	0.725	0.775
Conversion Subsystem Efficiency from Field[a] (@ T_{field}= 285°C		0.185	0.195	0.206
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}= 285°C		0.185	0.195	0.206
System Efficiency (Annual Average)		0.098	0.101	0.109

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	85+	85+	85+
	Receiver		-	-	-
Transport Subsystem		$/m² Collector	3.42	3.82	4.22
Electrical Storage Subsystem		$/$kW_e$	-	-	-
		$/$kW_e$h	-	-	-
Thermal Storage Subsystem		$/$kW_t$	200	200	200
		$/$kW_t$h	12	12	12
Conversion Subsystem	Engine	$/kW	450	500	550
	Generator	$/$kW_e$	33	32	30
Balance of Plant		$/$kW_e$	553	361	204
Total Capital Cost		$ × 10^6	0.449	1.28	3.91
O&M Costs (Average)		mills/kW_eh	7.7	7.6	7.7
$\overline{BBEC}$		mills/kW_eh	142	133	126
Simple Payback		years	11.1	10.3	10.0

[b] All costs include installation

+Includes receiver cost

TABLE 3-48. Performance and Cost Summary of LFDR-TC System, 0.7 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		0.1	0.3	1.0
Capacity Factor		0.713	0.696	0.692
Collection Subsystem Efficiency (Annual Average)		0.597	0.597	0.597
Transport Subsystem Efficiency[a]		0.990	0.980	0.970
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	0.460	1.33	4.13
Storage Subsystem Efficiency[a]		0.775	0.705	0.716
Conversion Subsystem Efficiency from Field[a] (@ T_{field}= 285°C)		0.185	0.195	0.206
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}= 285°C		0.185	0.195	0.206
System Efficiency (Annual Average)		0.097	0.098	0.103

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	85+	85+	85+
	Receiver		-	-	-
Transport Subsystem		$/m² Collector	3.42	3.82	4.22
Electrical Storage Subsystem		$/$kW_e$	-	-	-
		$/$kW_e$h	-	-	-
Thermal Storage Subsystem		$/$kW_t$	200	200	200
		$/$kW_t$h	12	12	12
Conversion Subsystem	Engine	$/kW	450	500	550
	Generator	$/$kW_e$	33	32	30
Balance of Plant		$/$kW_e$	553	361	204
Total Capital Cost		$\$ \times 10^6$	0.531	1.45	4.51
O&M Costs (Average)		mills/kW_eh	6.8	6.9	7.0
$\overline{BBEC}$		mills/kW_eh	141	132	125
Simple Payback		years	11.0	10.3	9.7

[b] All costs include installation

+Includes receiver cost

TABLE 3-49. Performance and Cost Summary of LFDR-TC System, 0.8 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		0.1	0.3	1.0
Capacity Factor		0.794	0.790	0.801
Collection Subsystem Efficiency (Annual Average)		0.597	0.597	0.597
Transport Subsystem Efficiency[a]		0.990	0.980	0.970
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	0.575	1.61	5.26
Storage Subsystem Efficiency[a]		0.642	0.647	0.629
Conversion Subsystem Efficiency from Field[a] (@ T_{field}= 285°C)		0.185	0.196	0.207
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}= 285°C)		0.185	0.196	0.207
System Efficiency (Annual Average)		0.087	0.091	0.094

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	85+	85+	85+
	Receiver		-	-	-
Transport Subsystem		$/m² Collector	3.42	3.82	4.22
Electrical Storage Subsystem		$/$kW_e$	-	-	-
		$/$kW_e$h	-	-	-
Thermal Storage Subsystem		$/$kW_t$	200	200	200
		$/$kW_t$h	12	12	12
Conversion Subsystem	Engine	$/kW	450	500	550
	Generator	$/$kW_e$	33	32	30
Balance of Plant		$/$kW_e$	553	361	204
Total Capital Cost		$ × 10^6	0.615	1.72	5.51
O&M Costs (Average)		mills/kW_eh	6.3	6.4	6.3
$\overline{BBEC}$		mills/kW_eh	146	137	130
Simple Payback		years	11.5	10.7	10.2

[b] All costs include installation

+Includes receiver cost

TABLE 3-50. Performance and Cost Summary of FMDF System, 0.3 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		0.1	0.3	1.0
Capacity Factor		0.307	0.339	0.327
Collection Subsystem Efficiency (Annual Average)		0.481	0.481	0.481
Transport Subsystem Efficiency[a]		0.981	0.981	0.992
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	0.230	0.447	1.35
Storage Subsystem Efficiency[a]		1.00	0.827	0.890
Conversion Subsystem Efficiency from Field[a] (@ $T_{field}=425^oC$)[c]		0.248	0.251	0.261
Conversion Subsystem Efficiency from Storage[a] (@ $T_{stor}=425^oC$)[c]		0.248	0.251	0.261
System Efficiency (Annual Average)		0.069	0.114	0.122

[a] $T_{ambient} = 20°C$

[c] $T_{1.0MWe} = 540^oC$

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	100	100	100
	Receiver		17	17	17
Transport Subsystem		$/m² Collector	0.35	0.53	0.70
Electrical Storage Subsystem		$/$kW_e$	-	-	-
		$/$kW_e$h	-	-	-
Thermal Storage Subsystem		$/$kW_t$	-	93	93
		$/$kW_t$h	-	15	15
Conversion Subsystem	Engine	$/kW	380	430	480
	Generator	$/$kW_e$	33	32	30
Balance of Plant		$/$kW_e$	530	343	192
Total Capital Cost		$ × 10^6	0.322	0.812	2.42
O&M Costs (Average)		mills/kW_eh	13.0	12.0	11.4
$\overline{BBEC}$		mills/kW_eh	202	157	147
Simple Payback		years	16.1	12.2	11.4

[b] All costs include installation

TABLE 3-51. Performance and Cost Summary of FMDF System, 0.4 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)	Plant Rating (MW_e)		
	0.1	0.3	1.0
Capacity Factor	0.404	0.431	0.424
Collection Subsystem Efficiency (Annual Average)	0.481	0.481	0.481
Transport Subsystem Efficiency[a]	0.981	0.981	0.992
Average Thermal Power Collected (8784 h/yr) $\overline{MW_t}$	0.223	0.893	1.80
Storage Subsystem Efficiency[a]	0.392	0.220	0.824
Conversion Subsystem Efficiency from Field[a] (@ $T_{field}=425^{o}C$)[c]	0.249	0.252	0.263
Conversion Subsystem Efficiency from Storage[a] (@ $T_{stor}=425^{o}C$)[c]	0.249	0.252	0.263
System Efficiency (Annual Average)	0.091	0.073	0.119

[a] $T_{ambient} = 20°C$

[c] $T_{1.0MWe} = 540^{o}C$

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	100	100	100
	Receiver		17	17	17
Transport Subsystem		$/m² Collector	0.35	0.53	0.70
Electrical Storage Subsystem		$/$kW_e$	-	-	-
		$/$kW_e$h	-	-	-
Thermal Storage Subsystem		$/$kW_t$	93	93	93
		$/$kW_t$h	15	15	15
Conversion Subsystem	Engine	$/kW	380	430	480
	Generator	$/$kW_e$	33	32	30
Balance of Plant		$/$kW_e$	530	343	192
Total Capital Cost		$ × 10^6	0.352	1.22	2.99
O&M Costs (Average)		mills/kW_eh	10.4	9.9	10.0
$\overline{BBEC}$		mills/kW_eh	168	180	138
Simple Payback		years	13.2	14.2	10.7

[b] All costs include installation

TABLE 3-52. Performance and Cost Summary of FMDF System, 0.5 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		0.1	0.3	1.0
Capacity Factor		0.496	0.502	0.514
Collection Subsystem Efficiency (Annual Average)		0.481	0.481	0.481
Transport Subsystem Efficiency[a]		0.981	0.981	0.992
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	0.223	0.893	2.71
Storage Subsystem Efficiency[a]		0.850	0.417	0.792
Conversion Subsystem Efficiency from Field[a] (@ $T_{field}=425^{o}C$)[c]		0.250	0.252	0.264
Conversion Subsystem Efficiency from Storage[a] (@ $T_{stor}=425^{o}C$)[c]		0.250	0.252	0.264
System Efficiency (Annual Average)		0.111	0.084	0.116

[a] $T_{ambient} = 20°C$

[c] $T_{1.0MWe} = 540^{o}C$

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	100	100	100
	Receiver		17	17	17
Transport Subsystem		$/m² Collector	0.35	0.53	0.70
Electrical Storage Subsystem		$/$kW_e$	-	-	-
		$/$kW_eh$	-	-	-
Thermal Storage Subsystem		$/$kW_t$	93	93	93
		$/$kW_th$	15	15	15
Conversion Subsystem	Engine	$/kW	380	430	480
	Generator	$/$kW_e$	33	32	30
Balance of Plant		$/$kW_e$	530	343	192
Total Capital Cost		$\$ \times 10^6$	0.388	1.27	3.56
O&M Costs (Average)		mills/kW_eh	8.9	8.8	8.6
$\overline{BBEC}$		mills/kW_eh	150	161	134
Simple Payback		years	11.7	12.7	10.4

[b] All costs include installation

TABLE 3-53. Performance and Cost Summary of FMDF System, 0.6 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		0.1	0.3	1.0
Capacity Factor		0.606	0.614	0.600
Collection Subsystem Efficiency (Annual Average)		0.481	0.481	0.481
Transport Subsystem Efficiency[a]		0.981	0.981	0.992
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	0.447	0.893	2.71
Storage Subsystem Efficiency[a]		0.336	0.728	0.770
Conversion Subsystem Efficiency from Field[a] (@ T_{field}=425°C)[c]		0.250	0.253	0.264
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=425°C)[c]		0.250	0.253	0.264
System Efficiency (Annual Average)		0.068	0.103	0.112

[a] $T_{ambient}$ = 20° C

[c] $T_{1.0MWe}$ = 540°C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	100	100	100
	Receiver		17	17	17
Transport Subsystem		$/m² Collector	0.35	0.53	0.70
Electrical Storage Subsystem		$/$kW_e$	-	-	-
		$/$kW_e$h	-	-	-
Thermal Storage Subsystem		$/$kW_t$	93	93	93
		$/$kW_t$h	15	15	15
Conversion Subsystem	Engine	$/kW	380	430	480
	Generator	$/$kW_e$	33	32	30
Balance of Plant		$/$kW_e$	530	343	192
Total Capital Cost		$ × 10^6	0.588	1.38	4.13
O&M Costs (Average)		mills/kW_eh	7.6	7.6	7.7
$\overline{BBEC}$		mills/kW_eh	182	143	132
Simple Payback		years	14.5	11.2	10.3

[b] All costs include installation

TABLE 3-54. Performance and Cost Summary of FMDF System, 0.7 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)	Plant Rating (MW_e)		
	0.1	0.3	1.0
Capacity Factor	0.742	0.686	0.718
Collection Subsystem Efficiency (Annual Average)	0.481	0.481	0.481
Transport Subsystem Efficiency[a]	0.981	0.981	0.992
Average Thermal Power Collected (8784 h/yr) $\overline{MW_t}$	0.447	0.893	3.16
Storage Subsystem Efficiency[a]	0.536	0.927	0.834
Conversion Subsystem Efficiency from Field[a] (@ T_{field}=425°C)[c]	0.250	0.253	0.264
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}= 425°C)[c]	0.250	0.253	0.264
System Efficiency (Annual Average)	0.083	0.116	0.115

[a] $T_{ambient}$ = 20° C

[c] $T_{1.0MWe}$ = 540°C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	100	100	100
	Receiver		17	17	17
Transport Subsystem		$/m² Collector	0.50	0.53	0.70
Electrical Storage Subsystem		$/$kW_e$	-	-	-
		$/$kW_eh$	-	-	-
Thermal Storage Subsystem		$/$kW_t$	93	93	93
		$/$kW_th$	15	15	15
Conversion Subsystem	Engine	$/kW	380	430	480
	Generator	$/$kW_e$	33	32	30
Balance of Plant		$/$kW_e$	530	343	192
Total Capital Cost		$ × 10^6	0.624	1.54	4.87
O&M Costs (Average)		mills/kW_eh	6.6	7.0	6.8
$\overline{BBEC}$		mills/kW_eh	158	142	129
Simple Payback		years	12.5	11.1	10.1

[b] All costs include installation

TABLE 3-55. Performance and Cost Summary of FMDF System, 0.8 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		0.1	0.3	1.0
Capacity Factor		0.838	0.805	0.795
Collection Subsystem Efficiency (Annual Average)		0.481	0.481	0.481
Transport Subsystem Efficiency[a]		0.981	0.981	0.992
Average Thermal Power Collected (8784 h/yr)	$\overline{MW}_t$	0.447	1.34	4.06
Storage Subsystem Efficiency[a]		0.674	0.617	0.654
Conversion Subsystem Efficiency from Field[a] (@ T_{field} = 425°C)[c]		0.250	0.253	0.264
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor} = 425°C)[c]		0.250	0.253	0.264
System Efficiency (Annual Average)		0.094	0.090	0.099

[a] $T_{ambient}$ = 20° C

[c] $T_{1.0MWe}$ = 540°C

Economic Summary (1978 dollars)[b]					
Collector Subsystem	Concentrator	$/m² Collector	100	100	100
	Receiver		17	17	17
Transport Subsystem		$/m² Collector	0.35	0.53	0.70
Electrical Storage Subsystem		$/$kW_e$	-	-	-
		$/$kW_e h$	-	-	-
Thermal Storage Subsystem		$/$kW_t$	93	93	93
		$/$kW_t h$	15	15	15
Conversion Subsystem	Engine	$/kW	380	430	480
	Generator	$/$kW_e$	33	32	30
Balance of Plant		$/$kW_e$	530	343	192
Total Capital Cost		$ × 10^6	0.660	1.89	5.68
O&M Costs (Average)		mills/$kW_e h$	6.1	6.3	6.3
$\overline{BBEC}$		mills/$kW_e h$	148	147	135
Simple Payback		years	11.6	11.6	10.2

[b] All costs include installation

TABLE 3-56. Performance and Cost Summary of LCNT System, 0.3 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		0.1	0.3	1.0
Capacity Factor		0.311	0.308	0.303
Collection Subsystem Efficiency (Annual Average)		0.367	0.367	0.367
Transport Subsystem Efficiency[a]		0.989	0.981	0.970
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	0.189	0.525	1.62
Storage Subsystem Efficiency[a]		0.800	0.820	0.846
Conversion Subsystem Efficiency from Field[a] (@ T_{field}= 285°C)		0.184	0.194	0.205
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}= 285°C)		0.184	0.194	0.205
System Efficiency (Annual Average)		0.064	0.067	0.066

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	55+	55+	55+
	Receiver		-	-	-
Transport Subsystem		$/m² Collector	1.88	2.10	2.30
Electrical Storage Subsystem		$/$kW_e$	-	-	-
		$/$kW_e$h	-	-	-
Thermal Storage Subsystem		$/$kW_t$	200	200	200
		$/$kW_t$h	12	12	12
Conversion Subsystem	Engine	$/kW	450	500	550
	Generator	$/$kW_e$	33	32	30
Balance of Plant		$/$kW_e$	553	361	204
Total Capital Cost		$ × 10^6	0.286	0.784	2.41
O&M Costs (Average)		mills/kW_eh	12.9	13.0	13.2
$\overline{BBEC}$		mills/kW_eh	180	167	158
Simple Payback		years	14.2	13.1	12.3

[b] All costs include installation

+Includes receiver cost

TABLE 3-57. Performance and Cost Summary of LCNT System, 0.4 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		0.1	0.3	1.0
Capacity Factor		0.402	0.396	0.402
Collection Subsystem Efficiency (Annual Average)		0.367	0.367	0.367
Transport Subsystem Efficiency[a]		0.989	0.981	0.970
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	0.259	0.700	2.31
Storage Subsystem Efficiency[a]		0.731	0.792	0.735
Conversion Subsystem Efficiency from Field[a] (@ T_{field}= 285°C)		0.184	0.195	0.206
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}= 285°C)		0.184	0.195	0.206
System Efficiency (Annual Average)		0.060	0.065	0.066

[a] $T_{ambient}$ = 20°C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	55+	55+	55+
	Receiver		-	-	-
Transport Subsystem		$/m² Collector	1.88	2.10	2.32
Electrical Storage Subsystem		$/$kW_e$	-	-	-
		$/$kW_e$h	-	-	-
Thermal Storage Subsystem		$/$kW_t$	200	200	200
		$/$kW_t$h	12	12	12
Conversion Subsystem	Engine	$/kW	450	500	550
	Generator	$/$kW_e$	33	32	30
Balance of Plant		$/$kW_e$	553	361	204
Total Capital Cost		$\$ \times 10^6$	0.347	0.943	3.31
O&M Costs (Average)		mills/kW_eh	10.5	10.6	10.5
$\overline{BBEC}$		mills/kW_eh	166	154	146
Simple Payback		years	13.1	12.1	11.3

[b] All costs include installation

+Includes receiver cost

TABLE 3-58. Performance and Cost Summary of LCNT System, 0.5 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)	Plant Rating (MW_e)		
	0.1	0.3	1.0
Capacity Factor	0.511	0.514	0.515
Collection Subsystem Efficiency (Annual Average)	0.367	0.367	0.367
Transport Subsystem Efficiency[a]	0.989	0.981	0.970
Average Thermal Power Collected (8784 h/yr) $\overline{MW_t}$	0.259	0.875	2.77
Storage Subsystem Efficiency[a]	0.731	0.905	0.903
Conversion Subsystem Efficiency from Field[a] (@ T_{field}= 285°C)	0.184	0.195	0.206
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}= 285°C)	0.184	0.195	0.206
System Efficiency (Annual Average)	0.060	0.067	0.070

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	55+	55+	55+
	Receiver		-	-	-
Transport Subsystem		$/m² Collector	1.88	2.10	2.32
Electrical Storage Subsystem		$/$kW_e$	-	-	-
		$/$kW_e$h	-	-	-
Thermal Storage Subsystem		$/$kW_t$	200	200	200
		$/$kW_t$h	12	12	12
Conversion Subsystem	Engine	$/kW	450	500	550
	Generator	$/$kW_e$	33	32	30
Balance of Plant		$/$kW_e$	553	361	204
Total Capital Cost		$ × 10^6	0.414	1.16	3.63
O&M Costs (Average)		mills/kW_eh	8.7	8.6	8.6
$\overline{BBEC}$		mills/kW_eh	155	144	136
Simple Payback		years	12.2	11.3	10.6

[b] All costs include installation

+Includes receiver cost

TABLE 3-59. Performance and Cost Summary of LCNT System, 0.6 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		0.1	0.3	1.0
Capacity Factor		0.608	0.603	0.594
Collection Subsystem Efficiency (Annual Average)		0.367	0.367	0.367
Transport Subsystem Efficiency[a]		0.989	0.981	0.970
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	0.377	1.05	3.23
Storage Subsystem Efficiency[a]		0.863	0.877	0.894
Conversion Subsystem Efficiency from Field[a] (@ $T_{field}=285^oC$)		0.185	0.195	0.206
Conversion Subsystem Efficiency from Storage[a] (@ $T_{stor}=285^oC$)		0.185	0.195	0.206
System Efficiency (Annual Average)		0.062	0.066	0.070

[a] $T_{ambient} = 20°C$

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	55+	55+	55+
	Receiver		-	-	-
Transport Subsystem		$/m² Collector	1.88	2.10	2.32
Electrical Storage Subsystem		$/$kW_e$	-	-	-
		$/$kW_eh$	-	-	-
Thermal Storage Subsystem		$/$kW_t$	200	200	200
		$/$kW_th$	12	12	12
Conversion Subsystem	Engine	$/kW	450	500	550
	Generator	$/$kW_e$	33	32	30
Balance of Plant		$/$kW_e$	553	361	204
Total Capital Cost		$\$ \times 10^6$	0.475	1.32	4.08
O&M Costs (Average)		mills/kW_eh	7.6	7.7	7.8
$\overline{BBEC}$		mills/kW_eh	149	139	132
Simple Payback		years	11.6	10.9	10.2

[b] All costs include installation

+Includes receiver cost

TABLE 3-60. Performance and Cost Summary of LCNT System, 0.7 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		0.1	0.3	1.0
Capacity Factor		0.702	0.693	0.687
Collection Subsystem Efficiency (Annual Average)		0.367	0.367	0.367
Transport Subsystem Efficiency[a]		0.989	0.981	0.970
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	0.424	1.28	3.92
Storage Subsystem Efficiency[a]		0.913	0.803	0.831
Conversion Subsystem Efficiency from Field[a] (@ T_{field}= 285°C)		0.185	0.196	0.207
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}= 285°C)		0.185	0.196	0.207
System Efficiency (Annual Average)		0.064	0.062	0.066

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	55+	55+	55+
	Receiver		-	-	-
Transport Subsystem		$/m² Collector	1.88	2.10	2.32
Electrical Storage Subsystem		$/$kW_e$	-	-	-
		$/$kW_e$h	-	-	-
Thermal Storage Subsystem		$/$kW_t$	200	200	200
		$/$kW_t$h	12	12	12
Conversion Subsystem	Engine	$/kW	450	500	550
	Generator	$/$kW_e$	33	32	30
Balance of Plant		$/$kW_e$	553	361	204
Total Capital Cost		$ × 10^6	0.542	1.51	4.67
O&M Costs (Average)		mills/kW_eh	6.9	7.0	7.0
$\overline{BBEC}$		mills/kW_eh	146	138	130
Simple Payback		years	11.5	10.8	10.1

[b] All costs include installation

+Includes receiver cost

TABLE 3-61. Performance and Cost Summary of LCNT System, 0.8 Capacity Factor

Performance Summary (Efficiencies in Decimal Units)		Plant Rating (MW_e)		
		0.1	0.3	1.0
Capacity Factor		0.800	0.791	0.777
Collection Subsystem Efficiency (Annual Average)		0.367	0.367	0.367
Transport Subsystem Efficiency[a]		0.989	0.981	0.970
Average Thermal Power Collected (8784 h/yr)	$\overline{MW_t}$	0.636	1.69	4.85
Storage Subsystem Efficiency[a]		0.613	0.659	0.736
Conversion Subsystem Efficiency from Field[a] (@ T_{field}= 285°C)		0.185	0.196	0.207
Conversion Subsystem Efficiency from Storage[a] (@ T_{stor}=285°C)		0.185	0.196	0.207
System Efficiency (Annual Average)		0.048	0.054	0.061

[a] $T_{ambient}$ = 20° C

Economic Summary (1978 dollars)[b]

Collector Subsystem	Concentrator	$/m² Collector	55+	55+	55+
	Receiver		-	-	-
Transport Subsystem		$/m² Collector	1.88	2.10	2.32
Electrical Storage Subsystem		$/$kW_e$	-	-	-
		$/$kW_e$h	-	-	-
Thermal Storage Subsystem		$/$kW_t$	200	200	200
		$/$kW_t$h	12	12	12
Conversion Subsystem	Engine	$/kW	450	500	550
	Generator	$/$kW_e$	33	32	30
Balance of Plant		$/$kW_e$	553	361	204
Total Capital Cost		$ × 10^6	0.665	1.81	5.40
O&M Costs (Average)		mills/kW_eh	6.3	6.4	6.4
$\overline{BBEC}$		mills/kW_eh	156	143	132
Simple Payback		years	12.3	11.3	10.3

[b] All costs include installation

+Includes receiver cost


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SECTION 4.0

DECISION ANALYSIS DATA

The product of this study, a ranking of the various configurations of solar thermal powered electric generating plants, reflects the preferences of potential users of these systems. This ranking will be used to provide guidance for R&D funding decisions concerning systems to be marketed in the 1990s. Because we are attempting to sample the market and bring to bear user preferences, our approach uses a decision model that attempts to reflect the choices that would actually be made. The model incorporates the essential criteria used in the decision process into an algorithm that evaluates each system based on values for attributes that measure these criteria according to user-defined measuring functions. The method chosen to model the decision process is multiattribute decision analysis (MADA), which is explained in Appendix C of Volume I.

MADA incorporates user preferences to translate the decision variables' diverse measures into a common unit of measure evaluated by a simple multiplicative equation. This unit of measure is referred to as a value, and the equation is a value function. The value function has been normalized to a scale between 0 and 1 and is a special case called a utility function. The terms "value" and "utility" denote worth or usefulness of the system as evaluated by the decision maker.

Formation of this utility function depends on defining quantifiable attributes such as capital cost, capacity factor, etc., that can be used to measure satisfaction with the decision criteria. Appendix D, Volume I of this report details the problem structure. The units of measure for these diverse attributes are not compatible: capital cost is measured in $\$/kW_e$, capacity factor in percent, etc. Since an intermediate step must formulate a sensible utility function, a set of single attribute utility functions are solicited from participating decision makers. These functions are similar to the overall utility function insofar as they measure utility for any value of the particular attribute and they may take on values between 0 and 1. A best value (e.g., $\$1400/kW_e$ capital cost) and a worst value (e.g., $\$3400/kW_e$) are selected for each attribute and utilities of 1 and 0, respectively, are assigned to these values. The resulting evaluation for the attributes of a particular system are thus commensurable, since each has a dimensionless value between 1 and 0.

In formulating the overall utility function, one must next combine the values for the single attribute functions so that each value is weighed according to its importance in the decision. Thus, scaling factors are determined that measure the relative weight of the attributes in that final decision. The scaling factors, however, are not weights per se. Because of the imposed best and worst values, the scaling factors measure the importance of the defined range of values instead of the importance of the attribute itself. Compare the significance of capital cost with a range of values between \$1,000 and $\$1,001/kW_e$, with its significance if the range could vary between \$1,000 and $\$1,000,000/kW_e$. What defines the overall utility function is a normalizing factor that ensures the utility will range between 0 and 1 to provide comparable results from one decision maker to the next.

The equation for the overall system utility function is:

$$U(\text{System}) = \frac{1}{k} \left\{ \prod_{i=1}^{n} \left[1 + k\, k_i\, u_i(x_i) \right] - 1 \right\} . \qquad (2)$$

where

U (System) = overall system utility: $0 \leq U(\text{system}) \leq 1$,
System = system being evaluated,
x_i = individual attribute values,
$u_i(x_i)$ = single attribute utility functions,
k_i = attribute weighting factors,
k = normalizing factor,
n = number of attributes.

The single attribute utility functions $u_i(x_i)$ are exponential expressions of the form:

$$u_i(x_i) = \begin{cases} a + be^{cx_i} & \text{if } c \neq 0 \\ a + bx_i & \text{if } c = 0 \end{cases} \quad (3)$$

where a, b, and c are parameters used to fit user data into the exponential form.

The following tables give the data used to evaluate Eqs. 2 and 3 for each system studied.

4.1 1-10 MW_e DATA

Twelve options for each of eleven systems were evaluated including four capacity factors for each of three plant sizes: 1, 5, and 10 MW_e. Seven attributes define each option for the decision model. The values for these attributes are tabulated in Table 4-1 and are the x_i of Eq. 2. Table 4-2 lists the curve-fit parameters (see Eq. 3) needed to define the single attribute utility function $u_i(x_i)$ of Eq. 2. The category of decision maker is also included. The scaling factors k_i and the normalizing factor k of Eq. 1 are listed together with the category for each decision maker in Table 4-3. The range of possible values for the economic and performance attributes are listed in Table 4-4. The worst value serves as a cutoff to screen systems with unacceptable attribute values. These values bound the x_i of Eq. 2.

Table 4-5 lists the highest ranked option of each system. The accompanying data are the attribute values, x_i of Eq. 2, for these options. All the options that have not exceeded allowable bounds in attribute values are listed according to decreasing user preference in Table 4-6. Those omitted have either capital costs exceeding $\$3{,}400/kW_e$ or O&M costs larger than 15 mills/kWh in Table 4-1. NOTE: The user preferences have decided which combination of capital cost and capacity factor are highest ranked. All allowable combinations have been evaluated.

4.2 0.1-1 MW_e DATA

Eighteen options for each of ten systems were evaluated at six capacity factors for each of three plant sizes—0.1, 0.3, and 1.0 MW_e. Three attributes describe each option for the decision model. The values of these attributes are tabulated in Table 4-7. These are the x_i of Eq. 2 in Sec. 4.0. Table 4-8 lists the curve-fit parameters (see Eq. 3) needed to define the single attribute utility functions $u_i(x_i)$ of Eq. 2. The category of decision maker is included. The scaling factors k_i and the normalizing factor k of Eq. 2 are listed together with the category for each decision maker in Table 4-9. The range of possible values for the system attributes are listed in Table 4-10. The worst value serves as a cutoff to screen systems with unacceptable attribute values. These values bound the x_i of Eq. 2.

Table 4-11 lists the highest ranked option of each system. The accompanying data are the attribute values (x_i of Eq. 2) for these options. Table 4-12 lists according to descending user preference all options that have not exceeded allowable bounds in attribute values. Those omitted have capital costs in excess of \$4,000/kW_e. NOTE: User preference decided which cost and capacity factor combination are ranked highest. All allowable combinations were evaluated.


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Table 4-1. SYSTEM ATTRIBUTE VALUES (1-10 MW_e SYSTEMS)

System	Size (MW_e)	Attribute: Capital Cost ($/kW)	Capacity Factor	O&M Cost (mills/kWh)	Safety (Subjective)	Environment (Subjective)	R&D Cost (1978 $M)	Applications (Subjective)
FMDF	1	3000	0.275	14.3	2.5	2.7	138	2.5
		3460	0.400	10.5	2.5	2.7	138	2.5
		5320	0.695	6.94	2.5	2.7	138	2.5
		5730	0.752	6.58	2.5	2.7	138	2.5
	5	2340	0.261	15.0	2.5	2.7	138	2.5
		2940	0.397	10.6	2.5	2.7	138	2.5
		4760	0.704	6.9	2.5	2.7	138	2.5
		4600	0.684	7.0	2.5	2.7	138	2.5
	10	2210	0.266	14.7	2.5	2.7	138	2.5
		2720	0.378	11.0	2.5	2.7	138	2.5
		4420	0.698	6.92	2.5	2.7	138	2.5
		4810	0.757	6.54	2.5	2.7	138	2.5
LFDR-TC	1	2540	0.342	11.9	3.8	2.3	95	3
		2980	0.405	10.4	3.8	2.3	95	3
		4710	0.692	6.96	3.8	2.3	95	3
		4610	0.678	7.06	3.8	2.3	95	3
	5	2100	0.340	12.0	3.8	2.3	95	3
		2520	0.402	10.5	3.8	2.3	95	3
		4260	0.707	6.86	3.8	2.3	95	3
		4080	0.685	7.01	3.8	2.3	95	3
	10	1990	0.340	12.0	3.8	2.3	95	3
		2410	0.402	10.5	3.8	2.3	95	3
		4090	0.700	6.91	3.8	2.3	95	3
		3890	0.669	7.13	3.8	2.3	95	3

Table 4-1. SYSTEM ATTRIBUTE VALUES (1-10 MW_e SYSTEMS) (continued)

System	Size (MW_e)	Attribute: Capital Cost ($/kW)	Capacity Factor	O&M Cost (mills/kWh)	Safety (Subjective)	Environment (Subjective)	R&D Cost (1978 $M)	Applications (Subjective)
LFDR-TR	1	2950	0.239	16.2	3.8	2.0	157	3
		3960	0.402	10.5	3.8	2.0	157	3
		6300	0.703	6.89	3.8	2.0	157	3
		6680	0.755	6.56	3.8	2.0	157	3
	5	2400	0.237	16.2	3.8	2.0	157	3
		3380	0.403	10.4	3.8	2.0	157	3
		5460	0.696	6.9	3.8	2.0	157	3
		6040	0.773	6.4	3.8	2.0	157	3
	10	2300	0.239	16.2	3.8	2.0	157	3
		3280	0.405	10.4	3.8	2.0	157	3
		5570	0.699	6.9	3.8	2.0	157	3
		5930	0.759	6.54	3.8	2.0	157	3
PFCR/R	1	2610	0.332	12.2	1.8	2.1	70	3.75
		2790	0.408	10.3	1.8	2.1	70	3.75
		3970	0.709	6.85	1.8	2.1	70	3.75
		4310	0.786	6.4	1.8	2.1	70	3.75
	5	2040	0.315	12.8	1.8	2.1	70	3.75
		2300	0.404	10.4	1.8	2.1	70	3.75
		3580	0.715	6.8	1.8	2.1	70	3.75
		3760	0.769	6.5	1.8	2.1	70	3.75
	10	1730	0.302	13.3	1.8	2.1	70	3.75
		2090	0.404	10.4	1.8	2.1	70	3.75
		3320	0.702	6.9	1.8	2.1	70	3.75
		3470	0.739	6.7	1.8	2.1	70	3.75

Table 4-1. SYSTEM ATTRIBUTE VALUES (1-10 MW_e SYSTEMS) (continued)

System	Size (MW_e)	Attribute: Capital Cost ($/kW)	Capacity Factor	O&M Cost (mills/kWh)	Safety (Subjective)	Environment (Subjective)	R&D Cost (1978 $M)	Applications (Subjective)
LFCR	1	3670	0.284	13.9	2.6	2.7	160	2
		4300	0.409	10.3	2.6	2.7	160	2
		6220	0.709	6.85	2.6	2.7	160	2
		6740	0.782	6.40	2.6	2.7	160	2
	5	2800	0.297	13.40	2.6	2.7	160	2
		3140	0.403	10.40	2.6	2.7	160	2
		4540	0.702	6.90	2.6	2.7	160	2
		4960	0.788	6.40	2.6	2.7	160	2
	10	2660	0.302	13.2	2.6	2.7	160	2
		3000	0.412	10.3	2.6	2.7	160	2
		4440	0.693	6.95	2.6	2.7	160	2
		4830	0.801	6.3	2.6	2.7	160	2
PFDR/S	1	1760	0.348	13.7	2.4	2.8	210	2.5
		2240	0.417	12.0	2.4	2.8	210	2.5
		3570	0.692	8.57	2.4	2.8	210	2.5
		3660	0.727	8.32	2.4	2.8	210	2.5
	5	1520	0.348	13.7	2.4	2.8	210	2.5
		2000	0.417	12.0	2.4	2.8	210	2.5
		3340	0.692	8.6	2.4	2.8	210	2.5
		3420	0.727	8.3	2.4	2.8	210	2.5
	10	1460	0.348	13.7	2.4	2.8	210	2.5
		1950	0.417	12.0	2.4	2.8	210	2.5
		3280	0.692	8.6	2.4	2.8	210	2.5
		1460	0.348	13.7	2.4	2.8	210	2.5

Table 4-1. SYSTEM ATTRIBUTE VALUES (1-10 MW_e SYSTEMS) (continued)

System	Size (MW_e)	Attribute: Capital Cost ($/kW)	Capacity Factor	O&M Cost (mills/kWh)	Safety (Subjective)	Environment (Subjective)	R&D Cost (1978 $M)	Applications (Subjective)
PFDR/B	1	2040	0.339	12.0	3.5	3.7	205	2
		2560	0.410	10.3	3.5	3.7	205	2
		4240	0.698	6.92	3.5	3.7	205	2
		4340	0.720	6.77	3.5	3.7	205	2
	5	1742	0.328	12.4	3.5	3.7	205	2
		2260	0.399	10.5	3.5	3.7	205	2
		4020	0.698	6.9	3.5	3.7	205	2
		1742	0.328	12.4	3.5	3.7	205	2
	10	1750	0.337	12.1	3.5	3.7	205	2
		2270	0.408	10.3	3.5	3.7	205	2
		3960	0.695	6.9	3.5	3.7	205	2
		1750	0.337	12.1	3.5	3.7	205	2
PFDR/CR	1	2600	0.361	14.3	3.0	2.8	140	3.0
		2700	0.404	13.4	3.0	2.8	140	3.0
		3900	0.679	10.0	3.0	2.8	140	3.0
		4300	0.815	9.6	3.0	2.8	140	3.0
	5	2240	0.354	14.5	3.0	2.8	140	3.0
		2420	0.408	13.2	3.0	2.8	140	3.0
		3520	0.697	9.9	3.0	2.8	140	3.0
		4000	0.803	9.2	3.0	2.8	140	3.0
	10	2170	0.352	14.6	3.0	2.8	140	3.0
		2490	0.406	13.3	3.0	2.8	140	3.0
		3400	0.647	10.2	3.0	2.8	140	3.0
		4070	0.799	9.3	3.0	2.8	140	3.0

Table 4-1. SYSTEM ATTRIBUTE VALUES (1-10 MW_e SYSTEMS) (continued)

System	Size (MW_e)	Attribute: Capital Cost ($/kW)	Capacity Factor	O&M Cost (mills/kWh)	Safety (Subjective)	Environment (Subjective)	R&D Cost (1978 $M)	Applications (Subjective)
LCNT	1	2140	0.231	16.7	4.2	2.5	120	2.5
		3140	0.399	10.5	4.2	2.5	120	2.5
		4890	0.693	6.95	4.2	2.5	120	2.5
		5500	0.808	6.26	4.2	2.5	120	2.5
	5	1830	0.237	16.3	4.2	2.5	120	2.5
		2660	0.393	10.6	4.2	2.5	120	2.5
		4400	0.714	6.8	4.2	2.5	120	2.5
		4800	0.792	6.4	4.2	2.5	120	2.5
	10	1670	0.228	16.9	4.2	2.5	120	2.5
		2710	0.405	10.4	4.2	2.5	120	2.5
		4300	0.703	6.89	4.2	2.5	120	2.5
		4720	0.782	6.40	4.2	2.5	120	2.5
SSP	1	2670	0.116	31.0	4.8	3.0	105	1.5
		38400	0.392	10.7	4.8	3.0	105	1.5
				NO SYSTEM APPLICABLE				
		2670	0.116	31.0	4.8	3.0	105	1.5
	5	2340	0.116	31.0	4.8	3.0	105	1.5
		38000	0.392	10.7	4.8	3.9	105	1.5
				NO SYSTEM APPLICABLE				
		2340	0.116	31.0	4.8	3.0	105	1.5
	10	2280	0.116	31.0	4.8	3.0	105	1.5
		38000	0.392	10.7	4.8	3.0	105	1.5
				NO SYSTEM APPLICABLE				
		2280	0.116	31.0	4.8	3.0	105	1.5

Table 4-1. SYSTEM ATTRIBUTE VALUES (1-10 MW_e SYSTEMS) (concluded)

System	Size (MW_e)	Attribute: Capital Cost ($/kW)	Capacity Factor	O&M Cost (mills/kWh)	Safety (Subjective)	Environment (Subjective)	R&D Cost (1978 $M)	Applications (Subjective)
PFCR/B	1	2280	0.312	12.9	3.5	2.6	138	2.5
		2990	0.392	10.7	3.5	2.6	138	2.5
		4510	0.703	6.88	3.5	2.6	138	2.5
		4660	0.734	6.68	3.5	2.6	138	2.5
	5	1796	0.287	13.8	3.5	2.6	138	2.5
		2540	0.402	10.5	3.5	2.6	138	2.5
		4320	0.701	6.90	3.5	2.6	138	2.5
		3900	0.662	7.19	3.5	2.6	138	2.5
	10	1540	0.267	14.7	3.5	2.6	138	2.5
		2680	0.413	10.2	3.5	2.6	138	2.5
		4300	0.699	7.02	3.5	2.6	138	2.5
		4080	0.659	7.21	3.5	2.6	138	2.5

Table 4-2. DATA FOR DECISION-MAKER UTILITY CURVE DESCRIPTION (1-10 MW_e SYSTEMS)

Decision-Maker Category		Attribute						
		Capital Cost	Capacity Factor	O&M Cost	Safety	Environment	R&D Cost	Applications
Synthetic	a	-0.153	6.5328	2.0137	1.7843	3.479	-0.3878	-2.4553
	b	4.7408	-6.9219	-0.7320	-1.7843	-3.419	1.4144	2.5053
	c	-1.0099	-0.032	0.0651	-0.1644	-0.0643	-0.1897	0.0643
Investor-Owned Utility	a	4.294	1.309	1.784	0	0	1.034	0
	b	-2.353	-2.919	-0.5197	0.2	0.2	-0.3448	0.2
	c	0	-0.3208	0.08222	0	0	0	0
Public Utility	a	2.521	1.3377	1.198	1.1978	0	-0.1624	-0.1978
	b	-0.9775	-2.32	-0.0804	-1.1978	0.2	1.21	0.1978
	c	0.3158	-0.2753	0.1801	-0.3602	0	-0.4017	0.3602
Municipal Utility	a	2.273	-1.0	1.0107	1.259	0	1.053	1.001
	b	-0.9091	0.2857	-1.096E-3	-1.259	0.2	-0.5263	-1.001
	c	0	0	0.4551	-0.3163	0	0	-1.3843
Rural Electric Cooperative	a	1.5431	-0.4	-0.001	1.039	1.039	1.0204	1.4417
	b	-0.2615	0.2	31.848	-1.039	-1.039	-0.2041	-1.4417
	c	0.5221	0	-0.692	-0.6563	-0.6563	0	-0.2366
Investor-Owned Utility	a	-0.0091	1.0518	2.6021	1.005	-0.01067	1.0204	1.0176
	b	1.511E8	-21.3392	-0.9864	-1.005	0.01067	-0.2041	-0.5176
	c	-13.446	-0.86	0.097	-1.059	0.9102	0	-0.6760
Public Utilities Commission	a	-0.1978	1.1978	1.13	0.2	1.1498	1.02697	1.1351
	b	4.2257	-2.4618	-0.026	0.16	-1.1498	-0.02538	-0.9354
	c	-0.9005	-0.3602	0	0	-0.4076	0.6066	-0.387
Industry Consultant	a	1.0957	1.039	1.0957	1.0107	0	1.0275	0.5
	b	-3.244E-4	-82.56	-2.828E-2	-1.0107	0.2	-2.2767E-2	0
	c	4.0625	-1.0938	0.2438	-0.9102	0	1.9048	0

Table 4-2. DATA FOR DECISION-MAKER UTILITY CURVE DESCRIPTION (1-10 MW_e SYSTEMS) (continued)

Decision-Maker Category		Attribute						
		Capital Cost	Capacity Factor	O&M Cost	Safety	Environment	R&D Cost	Applications
R&D - Nontechnical	a	9.3007	0.25	1.4517	-0.6648	0	-0.2666	4.2592
	b	-7.5787	0.125	-0.1672	0.6648	0.2857	1.5825	-4.4535
	c	0.065	0	0.1242	0.204	0	-0.2226	-0.0892
R&D - Former Large Utility	a	-0.0958	0.16154	-1.3107	-0.25	-2.794E-6	-1.136E-3	-0.25
	b	9.2415	0.06737	3.068	0.25	1.142E-7	1.1497	0.25
	c	-1.523	0.3602	-0.0567	0	3.197	-1.384	0
R&D - Nontechnical	a	-0.0391	-0.4	-0.3851	0	0	1.2149	-0.039
	b	10.331	0.2	2.6268	0.2	0.2	-0.2075	0.039
	c	-1.6406	0	-0.128	0	0	0.3535	0.6563
R&D - Technical	a	3.0173	1.784	-0.784	-0.7843	-0.1978	1.0	1.039
	b	-1.5219	-2.479	2.691	0.7843	0.1978	0	-1.039
	c	0.2013	-0.1644	-0.08222	0.1644	0.3602	0	-0.6563
R&D - Technical	a	1.2767	1.784	1.198	1.039	1.039	1.9	1.1978
	b	-0.0949	-2.479	-0.0804	-1.039	-1.039	-0.3	-1.1978
	c	0.7646	-0.1644	0.1801	-0.6563	-0.6563	0	-0.3602
R&D - Technical	a	-0.075375	-0.039	1.5	1.1978	-0.039	-4.259	-0.7843
	b	24.5244	0.0105	-0.1	-1.1978	0.039	5.318	0.7843
	c	-1.5635	0.6563	0	-0.3602	0.6563	-0.111	0.1644
R&D - Technical	a	-0.1978	0	1.5	-0.001	0	-0.1624	-0.039
	b	4.2257	0.1	-0.1	0.001	0.2	1.21	0.039
	c	-0.9005	0	0	1.384	0	-0.4017	0.6563
R&D - Technical	a	-0.0563	1.1438	-0.784	-1	0.8	1.0	1.0176
	b	13.73	-2.5981	2.691	1.0	0.04	0	-15.2027
	c	-1.832	-0.4076	-0.08222	0	0	0	-1.352

Table 4-2. DATA FOR DECISION-MAKER UTILITY CURVE DESCRIPTION (1-10 MW_e SYSTEMS) (continued)

Decision-Maker Category		Attribute						
		Capital Cost	Capacity Factor	O&M Cost	Safety	Environment	R&D Cost	Applications
R&D - Technical	a	-1.192	-0.4	-0.784	-0.7843	1.039	1.2149	-0.7843
	b	3.358	0.2	2.691	0.7843	-1.039	-0.2075	0.7843
	c	-0.3046	0	-0.08222	0.1644	-0.6563	0.3535	0.1644
Public Utility	a	-0.1978	-0.4	1.5	0	-0.7843	1.8924	-0.039
	b	4.2257	0.2	-0.1	0.2	0.7843	-0.8789	0.039
	c	-0.9005	0	0	0	0.1644	0.1534	0.6563
Investor-Owned Utility	a	2.867	1.107	1.5	1.039	0	1.2149	-7.518E-3
	b	-1.3333	-11.46	-0.1	-4.24	0.2	-0.2075	7.518E-3
	c	0	-0.6677	0	-0.9375	0	0.3535	0.9796
R&D Former Utility	a	-0.0391	0.67115	0.15386	3.0179	1.001	-0.3704	-0.25
	b	10.331	0.0109	3.6245	-3.0179	-1.001	1.4075	0.25
	c	-1.6406	0.4867	-0.2909	-0.0805	-1.3843	-0.2670	0
R&D - Nontechnical	a	1.309	-0.4	1.1978	1.1498	-0.7843	1.4881	0
	b	-0.0803	0.2	-0.0804	-1.1498	0.7843	-0.4771	0.2
	c	0.9624	0	0.1801	-0.4076	0.1644	0.2275	0
R&D - Nontechnical	a	2.2727	-0.6667	2.0	-0.0957	0	1.0204	-0.25
	b	-0.9091	0.3333	-0.1	0.0957	1.0	-0.2041	0.25
	c	0	0	0	0.6094	0	0	0
R&D - Nontechnical	a	1.784	1.06	1.0003	6.7633	1.1452	1.0	2.1925
	b	-0.4409	-5.2254	-2.99E-8	-6.7633	-0.4573	0	-2.1925
	c	0.4111	-0.6381	1.155	-0.032	-0.2295	0	-0.1218
Synthetic Utility	a	-0.0391	-5.7633	1.7372	1.1978	-5.7633	-0.1965	-1.1752
	b	10.331	5.406	-0.4888	-1.1978	5.7633	1.2369	1.2752
	c	-1.6406	0.0320	0.0822	-0.3602	0.0320	-0.3308	0.1068

Table 4-2. DATA FOR DECISION-MAKER UTILITY CURVE DESCRIPTION (1-10 MW_e SYSTEMS) (concluded)

Decision-Maker Category		Attribute						
		Capital Cost	Capacity Factor	O&M Cost	Safety	Environment	R&D Cost	Applications
Synthetic R&D	a	-0.421	2.4752	2.2058	0	1.5188	-0.5101	-2.6372
	b	3.3297	-2.9077	-0.9081	0.2	-1.4088	1.5302	2.6372
	c	-0.6082	-0.0969	0.0567	0	-0.1998	-0.1322	0.0643
Investor-Owned Utility	a	3.333	-0.75	1.198	0	0	1.0526	-0.039
	b	-1.6667	0.25	-0.0804	0.2	0.2	-0.526	0.039
	c	0	0	0.1801	0	0	0	0.6563
Industry Consultant	a	3.333	-3.1176	1.0032	1.001	-0.039	1.25	0.5625
	b	-1.6667	0.5882	-1.801E-4	-1.001	0.039	-2.5	0.3125
	c	0	0	0.575	-1.9803	0.6563	0	0

Table 4-3. DECISION-MAKER UTILITY FUNCTION SCALING CONSTANTS (1-10 MW_e SYSTEMS)

Decision-Maker Category	Attributes							Normalizing Factor (k)
	Capital Cost	Capacity Factor	O&M Costs	Safety	Environment	R&D Costs	Applications	
Synthetic	0.2700	0.2400	0.1514	0.0893	0.0893	0.0893	0.0893	-0.1107
Syn Utility	0.2700	0.2180	0.1882	0.0814	0.0814	0.0814	0.0814	-0.1000
Syn R&D	0.2700	0.2700	0.1110	0.1110	0.0713	0.0713	0.1110	-0.1085
	0.8000	0.4234	0.6116	0.1410	0.1410	0.2351	0.4234	-0.9866
Investor	0.8000	0.8000	0.8000	0.0000	0.0000	0.0000	0.0000	-0.9961
Owned	0.8000	0.2664	0.4664	0.0664	0.1330	0.4664	0.3330	-0.9758
Utility	0.9000	0.4804	0.6604	0.5404	0.0604	0.3004	0.5404	-0.9998
Public	0.8000	0.6362	0.5462	0.0627	0.0627	0.2946	0.0627	-0.9807
Utility	0.7000	0.5015	0.1873	0.0787	0.0787	0.0600	0.0513	-0.8432
Municipal Utility	0.6348	0.6889	0.7000	0.2588	0.2588	0.2588	0.2588	-0.9916
Rural Electric Coop	0.6750	0.7500	0.1500	0.2250	0.5250	0.0450	0.3750	-0.9859
Public Utilities Commissioner	0.2460	0.4000	0.0790	0.3165	0.2460	0.1449	0.3165	-0.8000
Industry	0.4917	0.5500	0.3579	0.1598	0.1598	0.2750	0.0000	-0.8991
Consultant	0.6000	0.2498	0.5498	0.1998	0.5098	0.0998	0.0998	-0.9464
	0.6500	0.1743	0.0392	0.0781	0.2123	0.0781	0.2312	-0.7000
R&D	0.3250	0.6500	0.3250	0.1950	0.0650	0.2600	0.0650	-0.8783
Non-	0.5400	0.6000	0.4200	0.1200	0.1800	0.1200	0.2400	-0.9327
technical	0.9000	0.9000	0.0409	0.1636	0.0000	0.1636	0.1636	-0.9937
	0.8000	0.5192	0.0576	0.2165	0.0576	0.0001	0.5192	-0.9606

Table 4-3. DECISION-MAKER UTILITY FUNCTION SCALING CONSTANTS (1-10 MW_e SYSTEMS) (concluded)

Decision Maker Category	Attributes							Normalizing Factor (k)
	Capital Cost	Capacity Factor	O&M Costs	Safety	Environment	R&D Costs	Applications	
R&D Former Utility	0.6344	0.8500	0.3393	0.4841	0.4841	0.3792	0.3060	-0.9980
	0.9000	0.0589	0.1461	0.0589	0.0326	0.0326	0.0136	-0.7583
R&D Technical	0.2705	0.4000	0.3438	0.1087	0.1558	0.1999	0.3438	-0.8218
	0.3606	0.6000	0.2998	0.2998	0.1621	0.0843	0.1621	-0.8874
	0.1443	0.6000	0.0974	0.0636	0.0091	0.0636	0.2998	-0.5465
	0.4000	0.2000	0.0988	0.4000	0.0200	0.0343	0.0156	-0.3665
	0.3956	0.5000	0.0632	0.0835	0.0040	0.0000	0.1217	-0.4013
	0.2400	0.4000	0.2400	0.1600	0.1600	0.2400	0.1600	-0.7224

Table 4-4. ATTRIBUTE RANGES (1-10 MW_e SYSTEMS)

Attribute	Range		Units
	Best	Worst (Cut-Off Value)	
Capital Cost	1400	3400	$/kW$_e$ Capacity Installed
Capacity Factor	90	No Storage	%
O&M Costs	5	15	mills/kWh
Safety	5	0	Subjective
Environment	5	0	Subjective
Applicability	5	0	Subjective
R&D Cost	10	500	$M Required between 1980 and 1990 for Development

Table 4-5. SYSTEM VALUES FOR HIGHEST RANKED OPTIONS (1-10 MW_e SYSTEMS)

System	Size (MW_e)	Attribute: Capital Cost ($/$kW_e$)	Capacity Factor	O&M Costs (mills/kWh)	Safety (Subjective Scale)	Environment (Subjective Scale)	R&D Costs (1978 $M)	Applications (Subjective)
PFCR/R	10	3320	0.702	6.9	1.8	2.1	70	3.75
PFDR/S	10	1460	0.348	13.7	2.4	2.8	210	2.5
PFDR/CR	10	3400	0.647	10.2	3.0	2.8	140	3.0
PFCR/B	10	1540	0.267	14.7	3.5	2.6	138	2.5
PFDR/B	10	1750	0.337	12.1	3.5	3.7	205	2.0
LFDR-TC	10	2410	0.402	10.5	3.8	2.3	95	3.0
LCNT	10	2710	0.405	10.4	4.2	2.5	120	2.5
LFDR-TR	10	3280	0.405	10.4	3.8	2.0	157	3.0
FMDF	10	2720	0.378	11.0	2.5	2.7	138	2.5
LFCR	10	3000	0.412	10.3	2.6	2.7	160	2.0
SSP	No options satisfactory							

Table 4-6. COMPLETE SYSTEM RANKING FOR ALL DECISION-MAKERS (1-10 MW_e SYSTEMS)

Rank	System	Size (MW_e)	Capacity Factor	Rank	System	Size (MW_e)	Capacity Factor
1	PFCR/R	10	0.702	28	PFCR/R	1	0.408
2	PFDR/S	10	0.348	29	PFDR/S	1	0.417
3	PFDR/S	10	0.692	30	PFDR/B	1	0.339
4	PFDR/S	5	0.692	31	PFDR/CR	5	0.408
5	PFDR/S	5	0.348	32	PFCR/R	5	0.315
6	PFDR/CR	10	0.647	33	LCNT	1	0.399
7	PFCR/B	10	0.267	34	PFDR/CR	10	0.406
8	PFCR/R	10	0.404	35	LFDR-TR	10	0.405
9	PFDR/B	10	0.337	36	LFDR-TC	1	0.342
10	PFDR/B	5	0.328	37	PFCR/B	1	0.392
11	PFCR/R	10	0.302	38	LFDR-TR	5	0.403
12	PFDR/S	10	0.417	39	FMDF	5	0.397
13	PFCR/R	5	0.404	40	LFCR	10	0.412
14	LFDR-TC	10	0.402	41	PFDR/CR	1	0.404
15	PFDR/S	5	0.417	42	FMDF	10	0.378
16	LFDR-TC	10	0.340	43	PFCR/B	1	0.312
17	PFDR/B	10	0.408	44	PFDR/CR	10	0.352
18	LFDR-TC	5	0.402	45	LFCR	5	0.403
19	PFDR/S	1	0.348	46	PFDR/CR	5	0.354
20	PFDR/B	5	0.399	47	PFCR/R	1	0.332
21	LFDR-TC	5	0.340	48	PFDR/CR	1	0.361
22	PFCR/B	5	0.287	49	FMDF	10	0.266
23	LCNT	10	0.405	50	LFCR	10	0.302
24	PFCR/B	10	0.413	51	FMDF	1	0.275
25	PFCR/B	5	0.402	52	FMDF	5	0.261
26	LCNT	5	0.393	53	LFCR	5	0.297
27	PFDR/B	1	0.410	54	SSP	1	0.200

Table 4-7. SYSTEM ATTRIBUTE VALUES (0.1-1 MW_e SYSTEMS)

System	Size (MW_e)	Attribute: Capital Cost ($/kW)	Attribute: Payback (Years)	Attribute: Capacity Factor
LCNT	0.1	2860	14.2	0.311
		3470	13.1	0.402
		4140	12.2	0.511
		4750	11.6	0.608
		5420	11.5	0.702
		6650	12.3	0.800
	0.3	3110	14.8	0.323
		3533	13.5	0.396
		4233	12.4	0.514
		4767	11.8	0.603
		5500	11.4	0.713
		6633	12.3	0.800
	1.0	2410	12.3	0.303
		3000	11.3	0.402
		3630	10.6	0.515
		4080	10.2	0.594
		4670	10.1	0.687
		5400	10.3	0.777
PFCR/B	0.1	2370	12.0	0.306
		3140	11.3	0.422
		3750	11.3	0.499
		4640	11.2	0.617
		5300	11.1	0.709
		6410	11.7	0.807
	0.3	1907	9.5	0.310
		2640	9.5	0.422
		3180	9.5	0.503
		4000	9.6	0.617
		4567	9.6	0.710
		5533	10.1	0.810
	1.0	1500	7.3	0.316
		2110	8.0	0.402
		2670	8.0	0.501
		3280	8.0	0.610
		3700	7.9	0.692
		4550	8.5	0.791
PFDR/CR	0.1	2250	10.5	0.330
		2810	9.5	0.445
		3260	9.3	0.526
		3700	9.1	0.604
		4320	8.8	0.728
		4940	9.1	0.805
	0.3	2423	9.8	0.330
		2587	9.0	0.435
		2943	8.8	0.504
		3467	8.7	0.596
		4000	8.8	0.680
		4733	8.7	0.803
	1.0	1870	9.4	0.305
		2430	8.5	0.431
		2870	8.4	0.515
		3310	8.3	0.594
		3930	8.2	0.711
		4500	8.3	0.799
PFDR/R	0.1	2130	10.3	0.317
		2830	10.3	0.418
		3710	11.3	0.495
		4310	10.5	0.613
		5230	10.7	0.724
		6400	11.7	0.808
	0.3	1993	9.7	0.317
		2553	9.8	0.397
		3260	10.1	0.484
		4167	10.1	0.613
		4800	10.3	0.692
		6267	11.5	0.808
	1.0	1650	8.4	0.305
		2570	9.3	0.418
		3360	9.7	0.517
		4050	9.8	0.613
		4730	10.0	0.701
		6130	11.2	0.808

Table 4-7. SYSTEM ATTRIBUTE VALUES (0.1-1 MW_e SYSTEMS) (continued)

System	Size (MW_e)	Attribute: Capital Cost ($/kW)	Attribute: Payback (Years)	Attribute: Capacity Factor
PFDR/B	0.1	1540	7.9	0.301
		2560	8.3	0.467
		2950	8.4	0.525
		3490	8.4	0.619
		4300	8.5	0.748
		4930	9.1	0.800
	0.3	1530	7.2	0.327
		2300	7.8	0.443
		2813	8.0	0.525
		3217	8.1	0.594
		3767	8.1	0.690
		4800	8.8	0.800
	1.0	1350	6.5	0.319
		1910	7.4	0.391
		2490	7.7	0.484
		3140	7.7	0.604
		3800	8.2	0.692
		4600	8.4	0.808
PFCR/R	0.1	2510	11.9	0.324
		2900	10.9	0.405
		3500	9.8	0.536
		3890	9.5	0.609
		4460	9.3	0.709
		5070	9.3	0.806
	0.3	2223	11.2	0.307
		2697	9.9	0.413
		3053	9.1	0.501
		3600	8.7	0.612
		4100	8.6	0.706
		4633	8.6	0.798
	1.0	1860	9.4	0.305
		2250	8.3	0.409
		2730	8.1	0.506
		3100	7.9	0.586
		3630	7.5	0.717
		4010	7.5	0.791
PFCR/S	0.1	1970	10.0	0.303
		2700	10.2	0.400
		3320	9.6	0.520
		4010	10.0	0.600
		4470	9.3	0.713
		5640	10.3	0.807
	0.3	1663	8.3	0.308
		2420	9.1	0.403
		3050	9.1	0.505
		3600	8.9	0.606
		3933	8.3	0.702
		4833	8.9	0.799
	1.0	1440	6.9	0.324
		2040	7.5	0.412
		2530	7.6	0.503
		3090	7.4	0.625
		3560	7.5	0.706
		4350	8.0	0.803
FMDF	0.1	3220	16.1	0.307
		3520	13.2	0.404
		3880	11.7	0.496
		5880	14.5	0.606
		6240	12.5	0.742
		6600	11.6	0.838
	0.3	2706	12.2	0.339
		4067	14.2	0.431
		4233	12.7	0.502
		4600	11.2	0.614
		5133	11.1	0.686
		6300	11.6	0.805
	1.0	2420	11.4	0.327
		2990	10.7	0.424
		3560	10.4	0.514
		4130	10.3	0.600
		4870	10.1	0.718
		5450	10.2	0.789

Table 4-7. SYSTEM ATTRIBUTE VALUES (0.1-1 MW_e SYSTEMS) (concluded)

System	Size (MW_e)	Attribute: Capital Cost ($/kW)	Attribute: Payback (Years)	Attribute: Capacity Factor
PFDR/S	0.1	1450	6.7	0.337
		2090	6.8	0.466
		2450	7.0	0.531
		2810	7.3	0.580
		3380	6.9	0.734
		4230	7.9	0.804
	0.3	1207	5.8	0.322
		1710	6.5	0.404
		2200	6.7	0.501
		2590	6.6	0.596
		3113	6.6	0.711
		3710	7.0	0.806
	1.0	979	5.1	0.302
		1600	6.0	0.411
		2030	6.1	0.509
		2480	6.2	0.602
		2950	6.3	0.706
		3810	7.0	0.808
LFDR-TC	0.1	2590	12.3	0.324
		3260	11.8	0.416
		3870	11.4	0.508
		4490	11.1	0.603
		5130	11.0	0.713
		6150	11.5	0.794
	0.3	2387	11.2	0.328
		3010	11.0	0.416
		3567	10.6	0.502
		4267	10.3	0.617
		4833	10.3	0.696
		5733	10.7	0.790
	1.0	2080	10.5	0.306
		2730	10.3	0.403
		3340	10.0	0.501
		3910	9.7	0.599
		4510	9.7	0.692
		5510	10.2	0.801

Table 4-8. DATA FOR DECISION-MAKER UTILITY CURVE DESCRIPTION (0.1-1 MW_e SYSTEMS)

Decision Maker Category		Attribute: Capital Cost	Payback	Capacity Factor	Decision Maker Category		Attribute: Capital Cost	Payback	Capacity Factor
R&D	a	1.333	1.7839	-0.514286	Minerals Industry	a	1.309	-0.1498	-0.4246
	b	-0.333	-0.6651	-0.17143		b	-0.191	1.7284	0.2279
	c	0.	0.03289	0.		c	0.4812	-0.08153	0.2075
Small Community	a	1.4837	6.7567	1.0083	Small Community	a	-0.7839	-0.7839	-0.4246
	b	-0.3329	-5.5752	-11.87		b	2.3464	2.1028	0.2279
	c	0.3736	0.0064068	-0.8219		c	-0.2741	-0.03289	0.2075
Small Community	a	-0.09574	-0.19778	1.4246	Military Base	a	-0.7839	-0.7839	-0.4246
	b	2.46931	1.71718	-2.655		b	2.3464	2.1028	0.2279
	c	-0.812504	-0.072043	-0.2075		c	-0.2741	-0.03289	0.2075
Military Base	a	4.2613	-0.7839	-0.7035	Agriculture	a	-0.30902	-0.7839	-0.1624
	b	-2.9831	2.1028	0.4465		b	2.118	2.1028	0.05902
	c	-0.8915	-0.03289	0.1516		c	-0.4812	-0.03289	0.3374
Minerals Industry	a	1.309	-0.1498	-0.514286	R&D	a	-0.309	-0.7839	-0.1624
	b	-0.1910	1.7284	0.17143		b	2.118	2.1028	0.05902
	c	0.4812	-0.08153	0.		c	-0.4812	-0.03289	0.3374
Agriculture	a	1.30902	1.2	0.1624	Institution	a	1.01763	1.7839	-0.4246
	b	-0.19098	-0.04	0.05902		b	-0.00456	-0.6651	0.2279
	c	0.4812	0.	0.3374		c	1.351949	0.03289	0.2075
Institution	a	1.309	1.7839	1.4246	Small Community	a	1.333	1.7839	1.4246
	b	-0.1910	-0.6651	-2.655		b	-0.333	-0.6651	-2.655
	c	-0.4812	-0.03289	-0.2075		c	0.	0.03289	-0.2075

Table 4-9. DECISION-MAKER UTILITY FUNCTION SCALING CONSTANTS (0.1-1 MW_e SYSTEMS)

Decision-Maker Group	Attributes			
	Capital Cost	Payback	Capacity Factor	Normalizing Factor (k)
Minerals Industry	0.1714	0.6000	0.1919	0.2000
	0.4500	0.9000	0.3460	-0.9415
Small Communities	0.2296	0.8500	0.5908	-0.9231
	0.3499	0.1750	0.7000	-0.5620
	0.0558	0.5000	0.0366	7.314
	0.0406	0.0798	0.8000	0.8000
Military Bases	0.6500	0.4891	0.3024	-0.7507
	0.1427	0.8500	0.2296	-0.6821
Agriculture	0.5107	0.7000	0.4270	-0.8612
	0.6500	0.2134	0.2134	-0.2521
Institutional	0.6000	0.5570	0.5302	-0.8696
	0.5210	0.7500	0.1532	-0.7995
R&D	0.3750	0.7500	0.3750	-0.8000
	0.3413	0.5500	0.2749	-0.4183

Table 4-10. ATTRIBUTE RANGES (0.1-1 MW_e SYSTEMS)

Attribute	Range		Units
	Best	Worst (Cut-Off Value)	
Capital Cost	1000	4000	$/kW$_e$ Capacity Installed
Simple Payback Period	5	30	Years
Capacity Factor	88.3	(No Storage)	%

Table 4-11. SYSTEM VALUES FOR HIGHEST RANKED OPTIONS (0.1-1 MW_e SYSTEMS)

System	Size (MW_e)	Capital Cost ($/$kW_e$)	Payback (Years)	Capacity Factor
PFDR/S	1.0	2030	6.1	0.509
PFDR/B	1.0	1350	6.5	0.319
PFCR/S	1.0	1440	6.9	0.324
PFCR/B	1.0	1500	7.3	0.316
PFCR/R	1.0	3100	7.9	0.586
PFDR/R	1.0	1650	8.4	0.305
PFDR/CR	1.0	2430	8.5	0.431
LFDR-TC	1.0	2080	10.5	0.306
FMDF	1.0	2990	10.7	0.424
LCNT	1.0	3630	10.6	0.515

Table 4-12. COMPLETE SYSTEM RANKING FOR ALL DECISION-MAKERS (0.1-1 MW_e SYSTEMS)

Rank	System	Size (MW_e)	Capacity Factor	Rank	System	Size (MW_e)	Capacity Factor	Rank	System	Size (MW_e)	Capacity Factor
1	PFDR/S	1.0	0.7	42	PFDR/CR	1.0	0.5	83	LFDR-TC	1.0	0.3
2	PFDR/S	1.0	0.3	43	PFCR/S	0.3	0.3	84	PFDR/CR	0.1	0.3
3	PFDR/S	1.0	0.6	44	PFDR/B	0.3	0.7	85	PFDR/R	0.1	0.4
4	PFDR/S	1.0	0.5	45	PFDR/B	0.1	0.5	86	PFCR/R	0.1	0.6
5	PFDR/S	1.0	0.4	46	PFDR/CR	1.0	0.6	87	LFDR-TC	1.0	0.5
6	PFDR/S	0.3	0.7	47	PFDR/CR	1.0	0.4	88	PFDR/R	0.3	0.5
7	PFDR/S	0.3	0.3	48	PFDR/R	1.0	0.3	89	LFDR-TC	1.0	0.6
8	PFDR/S	0.3	0.6	49	PFDR/B	1.0	0.7	90	PFCR/B	0.3	0.6
9	PFDR/S	0.3	0.5	50	PFDR/B	0.1	0.6	91	FMDF	1.0	0.4
10	PFDR/S	0.3	0.4	51	PFDR/CR	1.0	0.7	92	PFCR/R	0.3	0.3
11	PFDR/S	0.1	0.7	52	PFCR/S	0.3	0.7	93	PFCR/R	0.1	0.4
12	PFDR/S	0.3	0.8	53	PFDR/CR	0.3	0.5	94	LFDR-TC	0.3	0.3
13	PFDR/S	0.1	0.4	54	PFCR/R	1.0	0.8	95	FMDF	1.0	0.5
14	PFDR/S	1.0	0.8	55	PFDR/CR	0.3	0.4	96	LFDR-TC	0.3	0.4
15	PFDR/S	0.1	0.5	56	PFDR/CR	0.3	0.6	97	FMDF	1.0	0.3
16	PFDR/B	1.0	0.3	57	PFCR/S	0.3	0.4	98	LFDR-TC	0.3	0.5
17	PFDR/S	0.1	0.3	58	PFCR/R	0.3	0.6	99	PFCR/B	0.1	0.3
18	PFDR/S	0.1	0.6	59	PFCR/S	0.3	0.5	100	LCNT	1.0	0.5
19	PFCR/S	1.0	0.3	60	PFCR/R	0.3	0.5	101	LCNT	1.0	0.4
20	PFCR/S	1.0	0.6	61	PFDR/R	1.0	0.4	102	PFCR/B	0.1	0.4
21	PFDR/B	0.3	0.3	62	PFCR/S	0.3	0.6	103	PFCR/R	0.1	0.3
22	PFCR/S	1.0	0.4	63	PFCR/R	1.0	0.3	104	LCNT	1.0	0.3
23	PFCR/S	1.0	0.4	64	PFDR/CR	1.0	0.3	105	FMDF	0.3	0.3
24	PFCR/S	1.0	0.5	65	PFCR/B	0.3	0.3	106	LFDR-TC	0.1	0.3
25	PFCR/S	1.0	0.7	66	PFCR/B	0.3	0.4	107	PFCR/S	0.1	0.6
26	PFCR/B	1.0	0.3	67	PFDR/CR	0.3	0.7	108	PFDR/R	0.1	0.5
27	PFCR/R	1.0	0.7	68	PFDR/CR	0.1	0.5	109	LFDR-TC	0.1	0.4
28	PFDR/B	1.0	0.5	69	PFDR/CR	0.1	0.4	110	PFCR/B	0.1	0.5
29	PFDR/B	1.0	0.6	70	PFDR/R	0.3	0.3	111	LFDR-TC	0.1	0.5
30	PFDR/B	0.3	0.4	71	PFDR/CR	0.1	0.6	112	FMDF	0.1	0.5
31	PFCR/R	1.0	0.6	72	PFCR/B	0.3	0.5	113	LCNT	01	0.4
32	PFCR/B	1.0	0.4	73	PFDR/R	0.3	0.4	114	FMDF	0.1	0.4
33	PFCR/B	1.0	0.5	74	PFCR/S	0.1	0.3	115	LCNT	0.1	0.3
34	PFDR/B	0.3	0.5	75	PFCR/R	0.3	0.4	116	LCNT	0.3	0.4
35	PFCR/B	1.0	0.5	76	PFCR/S	0.1	0.5	117	LCNT	0.3	0.3
36	PFDR/B	0.1	0.3	77	PFDR/R	1.0	0.5	118	FMDF	0.1	0.3
37	PFCR/B	1.0	0.6	78	PFDR/R	0.1	0.3	119	PFDR/R	1.0	0.6
38	PFCR/B	1.0	0.7	79	PFCR/S	0.1	0.4	120	FMDF	0.3	0.4
39	PFDR/B	0.3	0.6	80	PFDR/CR	0.3	0.3	121	PFCR/R	0.3	0.7
40	PFDR/B	0.1	0.4	81	PFCR/R	0.1	0.5	122	FMDF	1.0	0.6
41	PFCR/R	1.0	0.4	82	LFDR-TC	1.0	0.4	123	LCNT	1.0	0.6


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16. Abstract (Limit: 200 words)

This report is part of a two-volume set summarizing the results of a comparative ranking of generic solar thermal concepts designed specifically for electric power generation. The original objective of the study was to project the mid-1990 cost and performance of selected generic solar thermal electric power systems for utility applications and to rank these systems by criteria that reflect their future commercial acceptance. This study considered plants with rated capacities of 1-10 MW_e, operating over a range of capacity factors from the no-storage case to 0.7 and above. Later, the study was extended to include systems with capacities from 0.1-1 MW_e, a range that is attractive to industrial and other nonutility applications.

Volume I summarizes the results for the full range of capacities from 0.1 to 1.0 MW_e. Volume II presents data on the performance and cost and ranking methodology.

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a. Descriptors: Central Receivers; Distributed Receivers; Point-Focus; Line-Focus; Parabolic Collectors; Tower-Focus Collectors; Parabolic Dish Collectors; Parabolic Trough Collectors; Heliostats; Solar Ponds; Solar Tracking; Solar Heat Engines; Stirling

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