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# Financing Solar Thermal Power Plants

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# FINANCING SOLAR THERMAL POWER PLANTS

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## ABSTRACT

The commercialization of concentrating solar power technology took a major step forward in the mid 1980s and early 1990s with the development of the SEGS plants in California. Over the years they have proven that parabolic trough power technologies are the most cost-effective approach for commercial scale solar power generation in the sunbelt countries of the world. However, the question must be asked why no additional solar power plants have been build following the bankruptcy of the developer of the SEGS projects, LUZ International Limited. Although many believe the SEGS projects were a success as a result of parabolic trough technology they employ, in truth, the SEGS projects were developed simply because they represented an attractive opportunity for investors. Simply stated, no additional projects have been developed because no one has been able to put together a similarly attractive financial package to potential investors. More than $1.2 billion in private capital was raised in debt and equity financing for the nine SEGS plants. Investors and bankers who make these investments are the real clients for solar power technologies. They are not interested in annual solar to electric efficiencies, but in risk, return on investments, and coverage ratios. This paper will take a look at solar power projects from the financier's perspective. The challenge in moving forward is to attract private investors, commercial lenders, and international development agencies and to find innovative solutions to the difficult issues that investment in the global power market poses for solar power technologies.

## INTRODUCTION TO SOLAR POWER INVESTMENTS

A widespread belief among the solar community is that financing alternatives will not affect the outcome and thus do not need to be included in an economic analysis when comparing different technologies. This is true when various alternatives have a similar financial structure and are very similar in nature. On the other hand, if one project is capital intensive and the other is not, or a grant or low-interest rate financing is available for only one technology, then the financing structure can have a significant effect on the conclusions and must be included.

Whereas a conventional power plant depends on fuel that is purchased as a continuous string of payments during the lifetime of the plant, a solar power plant needs to finance its "fuel costs" through capital investment at the beginning of the project. This investment for the solar equipment must be repaid through principal and interest payments on the loan during the operation of the plant. In a typical parabolic trough SEGS-type plant, the solar field represents approximately 50% of the total plant's investment costs (Figure 1). Due to real and perceived technology risk, the interest rate and financing costs for the solar capital investment can be significant. As a result the cost of power from solar power projects is particularly sensitive to financing conditions and schedules, and it can vary dramatically with a simple change in the project ownership or financing structure.

In addition to the financing cost penalty, the capital investment in a solar field is typically taxed differently than expenditures for fossil fuels. As a result, solar power facilities must typically bear an inequity in taxes as well (Trieb, 1996). Jenkins and Reilly (1995) found that appropriately developed tax policy could be used to eliminate this burden.

The lifetime of solar plants is comparable to that of conventional plants (i.e., 25–30 years). For fossil plants, the risk of significant fuel price variations during this period must be also considered. However, for a solar plant once it is built the "solar fuel" is free, resulting in less uncertainty in the cost of power over the life of the project.

An additional barrier is that it is in developing countries where this type of generation seems to be possible, and these countries do not have sufficient budgetary resources to pay for the high up-front investment characteristic of solar power

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plants. This lack of financial resources and the insufficient credit rating of such countries could be rectified by private investment — provided that the legal situation of the specific countries allows private investors to enter the power market. The worldwide deregulation of the power market is changing the way new power investments are made and has significant implications for the future development of solar power technologies.

## SOURCES OF CAPITAL

There are three general sources of capital available for a renewable power project: equity, debt, and grant financing. An equity investment is to purchase ownership in the project. A debt investment is a loan to the project. For example, in the purchase of a house, the person buying the house is the equity investor, and the mortgage is the debt. In addition, since most solar power projects cannot compete with conventional fossil power technologies today, a number of organizations have offered grant financing to help buy-down the non-economic portion of the project. These grants typically are made available to help account for environmental, developmental, and economic externalities that would not otherwise be accounted for during a normal competitive project selection.

## FINANCING AND OWNERSHIP STRUCTURES

There are two types of financing and ownership structures used for financing power facilities:

- "Corporate finance" with investor-owned utility ownership.
- "Project Finance" with private ownership.

Corporate financing, also known as internal or equity financing, is characterized by the use of corporate credit and general assets of a corporation, typically a utility, as the basis for credit and collateral. Utility ownership is potentially attractive for solar power projects because it has a potential for cost saving due to:

- A partial offset of the specific project risk to the utility/corporate portfolio, ignoring the variance in risks associated with different projects. Here the overall credit rating of the company is used to estimate debt and equity costs rather than project specific capital costs in a standalone project finance model.
- A better credit standing, and hence lower interest rates, increased debt amortization periods, and less restrictive loan covenants, called debt service coverage ratios (DSCR).

However, due to high investment costs, most of the utilities — especially those in developing countries — are not in a position to generate sufficient corporate finance resources regardless of the advantages of corporate financing. As a result the concept of project financing was developed.

Project financing can be defined as the arrangement of debt, equity, credit enhancement for the construction of a particular facility in a capital-intensive industry where lenders base credit appraisals on the estimated cash flows from the facility rather than on the assets or credit of the promoter of the facility (Short, 1995). The impetus behind the move toward project finance is to change the focus of financing power plants based on the credit rating of the host country to the merit of the project itself. According to Nevitt (1995), the term "project financing" is defined as the financing of a project in which a lender is satisfied to look initially to the cash flows and the earning of that project as the source of funds from which a loan will be repaid and to the assets of the project as collateral for the loan.

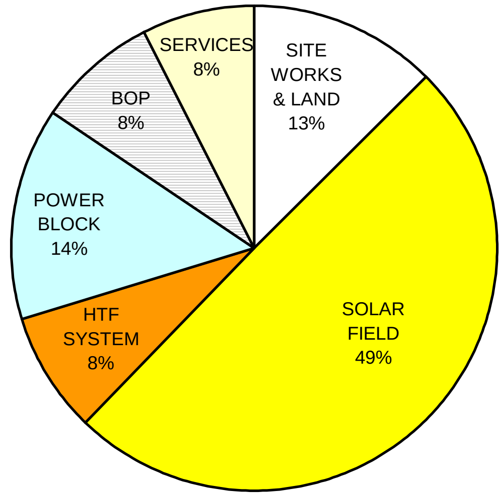


**Figure 1: Typical Cost Distribution of Parabolic Trough Power Plant**

Project finance is the primary financing structure used by all independent power producers (IPPs). Unfortunately there exists a widespread confusion between the terms "independent power producer" and "project finance": IPP represents the entire project environment, which includes project financing, planing, construction, and operation of the facility. However, since an IPP project is making use of the method of Project Finance it is sometimes a difficult task to separate them. For a better overview, the concept of independent power producers will be discussed in a separate chapter later.

## CHARACTERISTICS OF PROJECT FINANCING

### Cash Flow–Related Lending

The crucial criterion by which lenders assess the financial feasibility and credit rating of a project is the ability of the project to cover the annual operation and maintenance (O&M) costs and debt service with sufficient cash flow. Therefore, a lender with a long-term credit exposure is mainly interested in the ability of the project cash flow to service debt over the entire loan life cycle. The lender evaluates this ability by analyzing the capital structure of the project, the major sources and uses of funds, its profitability over the loan period, and its projections of future profitability.

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## Risk Sharing

A major incentive for many investors is the fact that project financing undertakings (e.g., IPP projects) can be made to stand alone as a self-financing entity, so that the investor can benefit from its success and can be isolated from its failure. Project finance allows the (potential) investor to transfer specific risk to the lender of the debt. The purest, but least common, method of financing offers the lender no recourse against the project owners. Depending on the “recourse-possibilities” of the lender against the owners “non-recourse financing” or “limited financing” are synonyms for project finance.

## Off-Balance-Sheet Financing

The ultimate goal in IPP projects is to arrange a borrowing for a project which will be beneficial for the private investor and at the same time be completely non-recourse to the other activities of the parent company and in no way affecting their credit standing or balance sheet. Indeed, project financing is sometimes called off-balance-sheet financing. However, there is a popular misconception that the project financing means off-balance-sheet financing to the point that the project is completely self-supporting without guarantees or undertakings by the parent company of the investor. A short summary of the advantages and disadvantages of the different financing ownership structures is depicted in Table 1.

| Corp. Fin. / Utility-Owned | Project Fin. / IPP |
|---|---|
| **ADVANTAGES** | |
| • Offset of project risk | • Brings fresh capital |
| • Better credit rating<br>→ lower interest rate debt<br>→ lower equity costs | • Introduces market force and competition to keep consumer prices down |
| • Longer debt amortization period | • Takes risk from public entities and distributes risk under project sponsors. |
| • Less arrays of restrictive loan covenants<br>→ high debt leverage | • Diversifies energy supply sources |
| **DISADVANTAGE** | |
| • Projects with sophisticated or new technologies will not be realized. | • Complicated contractual relationships<br>→ large transaction costs<br>→ high legal fees |
| • Public projects tend to be more expensive than private ones | • Need to generate a decent dividend to private shareholders |

**Table 1. Comparison of Corporate Finance/Uitility-Owned and Project Finance/Private-Owned Power Projects**

## RISK MANAGEMENT

Successful financing will continue to be a major challenge for all renewable power projects. The key to successful project financing is to structure the financing with as little recourse as possible to the private investor while at the same time providing sufficient credit support through guarantees of project investors or third parties that the lender of the debt will be satisfied with the credit risk. Typical applications for project financing are capital-intensive projects associated with high risks. There are certain risks which investors and lenders have to take into consideration:

- Country risk
- Political risk
- Foreign exchange risk
- Inflation risk
- Interest rate risk
- Appraisals
- Availability of permits and licenses
- Operating performance risk
- Fuel prices
- Force majeure risk
- Legal risk

At the end, the lender will gauge the project’s ability to withstand the risks involved, especially critical ones, by looking primarily at the different debt service coverage ratios (DSCR). The DSCR is a function of the specific project risk.

Debt service coverage ratios are designed to analyse the financial charges of a project to its ability to serve them. In any project financing the payments on the loan should correspond as closely as possible to the ability of the project to generate cash. Lenders want to be sure that during the entire project lifetime the generated cash always covers the required debt service. One of the most important loan covenants is the annual debt service coverage ratio (ADSCR), which is simply the ratio of pre-finance cash flow after tax to the amount of interest payment and principal repayment for the period. Lenders normally claim that during every stage of the project the ADSCR never falls short of the minimum required ADSCR. A typical value for the minimum annual debt service coverage ratio (ADSCR) required by most lenders is between 1.2 and 1.5, but depends on the specific project risks and the way they are handled by the web of contractual arrangements. In addition to the ADSCR, other coverage is important, including the project life coverage ratio (PLCR) and the loan life coverage ratio (LLCR). The PLCR is the ratio of the present value (PV) of cash available for debt service over the entire project lifetime to the outstanding debt. The LLCR is only interested in the financial vitality of the project for the time period of the loan life. The mathematical formulas used in the above-mentioned cash-flow model are shown in the attached equation box (equations 1-3).

The equity investors, on the other hand, will be interested in the Internal Rate of Return (IRR) offered by the project. The minimum acceptable rate will depend on the project’s risk as

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characterized by the type and location of the project, the risk sharing arrangements and the investor's cost of capital. The IRR is defined as the rate of discount which makes the net present

$$ADSCR(t) = \frac{CF_{PreFin}(t) - Tax(t)}{D_{service}(t)} \qquad [1]$$

$$PLCR(t) = \frac{\sum_{t''=t}^{t_{0,comoper}+T_{life}-1} \left[ \left( CF_{PreFin}(t'') - tax_{inc}(t'') \right) \cdot (1+r)^{t-t''-1} \right]}{D - \sum_{t^{*}=t_{0,comoper}}^{t-0,5} D_{repay}(t^{*})} \qquad [2]$$

$$LLCR(t) = \frac{\sum_{t''=t}^{t_{0,comoper}+T_{repay}-1} \left[ \left( CF_{PreFin}(t'') - tax_{inc}(t'') \right) \cdot (1+r)^{t-t''-1} \right]}{D - \sum_{t^{*}=t_{0,comoper}}^{t-0,5} D_{repay}(t^{*})} \qquad [3]$$

$CF_{Prefin}$ = Pre-finance cash flow
$D$ = Total debt at the start of commercial operation
$D_{service}$ = Debt service (interest and principal for the period)
$D_{repay}$ = Principal repayment of debt
$tax_{inc}$ = Income tax
$t'$ = full year period, $t^{*}$ = half year period

**Equations 1-3. Debt Coverage Ratios**

value (NPV) zero. To calculate the NPV, we discount expected future payoffs by the rate of return offered by comparable investment alternatives. This rate is also referred to as the hurdle rate, or opportunity cost of capital. It is called the opportunity cost because it is the return foregone by investing in the project rather than investing in securities (Brealey, 1991). IRRs of 16%–20% are generally expected from IPP projects, although depending on specific project risk, significantly higher IRR may be required. The formula for calculating the IRR is shown in equation 4.

To better explain the important financial parameters to the debt and equity investors, we performed a detailed financial analysis for a proposed 25-MW parabolic trough plant to be located in Spain with a cash-flow model developed at the Plataforma Solar de Almería. The project assumes a 100% solar share, 25-year economic lifetime, 0% grant, and 21¢/kWh electricity price. A sensitivity analysis was run to investigate the elasticity of the annual debt service coverage ratio (ADSCR) and the internal rate of return (IRR) as a function of the project capital structure (percentage of equity). The results of this sensitivity analysis are depicted in Figure 2. The various coverage ratios often bind in the first years of operation and restrict the amount of low-cost debt that can be used by the project. The equity share represents a crucial figure for a financially feasible project. In Figure 2 it is evident that financial success — mainly represented trough the IRR — is strongly dependent on the equity share. If lenders continue to require restrictive coverage ratios, front-loading of contract payments and/or a back loading of debt payment could help to achieve a higher debt leverage (Wiser, 1996).

## INDEPENDENT POWER PRODUCERS

The concept of independent power producers (IPP) originated in the United States in the 1970s as a result of the 1972 Public Utility Regulatory Policies Act (PURPA). PURPA provided a mechanism to allow for the development of the first private non-regulated power projects. The first international IPP project was completed in the early 1980s in Turkey and was named after the Turkish Prime Minister at that time "Özal-Model".

IPPs — long-term power projects "independent" of public funds — are gaining more and more importance in the today's power market, not only in developing countries but also in the industrialized countries. The global power market has seen a record amount of new IPP projects in recent years. For instance, from the beginning of the fourth quarter of 1995 through the end of the third quarter of 1996, 51 power projects were financed privately worldwide, totaling more than $20 billion. This is nearly twice the previous year's $10.87 billion, and more than double 1994's $9.48 billion. These impressive figures indicate a vigorous global IPP marketplace, where projects are proceeding to financial closing in numerous countries. Forecasts indicate that after the new millennium the stake of IPP projects will account for 40%–50% of worldwide power sector investments.

With their high investment requirements, the success of independent renewable power projects will primarily depend on the ability to attract private investors, commercial lenders, and international development agencies. As a first step, the European Commission has pushed its member countries to give renewable IPPs a market chance by incentive laws that facilitate and reward the private generation of renewable power.

$$NPV = -\sum_{i=1}^{11} C_i\left(t_{construc}\right) + \sum_{t=T_{comoper}}^{T} \frac{\left[ R_t - \left[ C_{O\&M}(t) + D_{ser} + tax \right] \right]}{(1+IRR)^{(t-t_0)}} = 0 \qquad [4]$$

$C_{O\&M}(t)$ = fix & variable O&M costs
$C_i(t_{construc})$ = Investment costs of cost category I
$R_{t\ comoper}$ = Revenues during commercial operation
$t_{construc}$ = Construction period, $T_{comoper}$= Start of commercial operation
$t_0$ = Base year for all econ. assumpt., $T$ = End of com. operation

**Equation 4 : IRR / NPV calculation**

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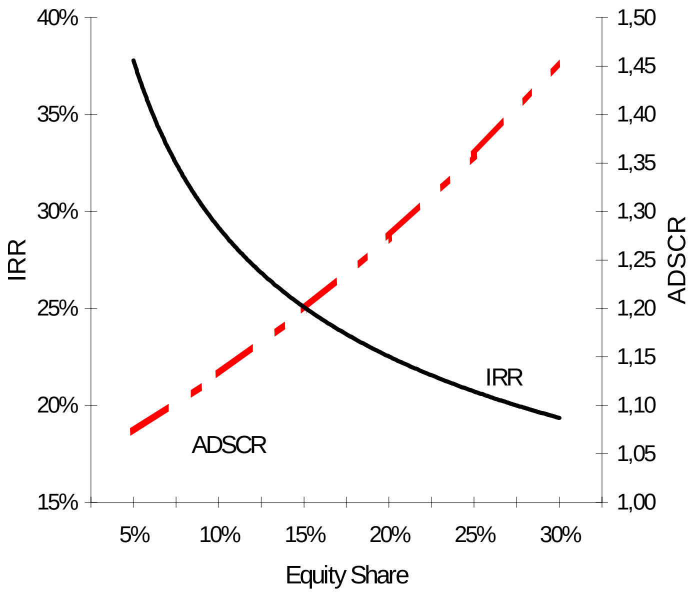


**Figure 2 : Results of Debt/Equity Sensitivity Analyses**

IPP projects require a tailor-made financing solution that represents a major challenge for all parties involved, especially equipment suppliers. Providing tailor-made financing concepts is typically a major challenge for any equipment supplier but those who are successful gain a lead against other players in the electricity supply industry. However, IPP projects require the risk to be allocated among participants, especially to the equipment suppliers. This means that equipment suppliers are becoming equity investors in the projects and often provide some guarantee for project performance.

## STRUCTURE OF IPP MODELS

In view of the flexibility of the IPP structure and its variants, the legal and company structure differs from project to project. A detailed list of different IPP-models can be found in Table 2. The most common IPP models are BOO (build, own, operate) and BOOT (build, own, operate, transfer), hence we will only focus on these two approaches. Generally, IPP models such as BOO and BOOT are essentially a concession or global service contract offered by a government and financed and undertaken by private investors. Thus, BOO/BOOT models involve long-term relationships that require trust between those two parties. The heart of each IPP project is the "project company" which is normally established in the host country. It is desirable that the equipment suppliers, the fuel supplier, the plant operating company and the power purchaser/utility are taking a share within the project company. In a typical IPP model the equipment vendors and developers will typically design and construct a project under a turnkey contract for the project owner. The structure of a typical BOOT project — if there is a typical one — is shown in Figure 3. A BOOT project involves a number of important contractual arrangements between the participants, represented by the numbers (1) to (8) within the web:

(1) The shareholders of the project consortium enter into a "shareholder agreement," which governs the relationship among them and describes how the project will be managed. There is considerable scope for conflict of interest to arise between the role of shareholders as investors and as contracting parties with the company.

(2) Shareholders attempt to maximize the stake of low-cost loan up to an 80-20 debt-to-equity ratio. Recently a 169-MW natural gas–fired, combined cycle merchant plant in the United States achieved a 100% debt financing (Burr, 1998). Hence, lenders provide substantial amounts of money through a "loan agreement." The lender's security is limited to the revenues to be received by selling the electricity to the purchaser/utility. Here, an export credit agency can facilitate to minimize the debt cost by providing securities in terms of "guarantee agreements".

(3) An agreement is made between the general contractor and project company for a fixed price design-and-build-contract, called a "turnkey contract" which implies some of the risks. Financing is facilitated if a general contractor takes responsibility for the design risk for a longer period than he would under a standard construction contract. The equipment suppliers will operate as a "subcontractor" to the general contractor during the construction period, but can also enter in a "spare part contract" during the life of the project.

(4) The insurer can mitigate some of the project's risk in terms of a "insurance contract" by providing funds for some period of time if there are machinery break-downs or solar field failures which reduce the available capacity.

| | |
|---|---|
| BLOT | build, lease, operate, transfer |
| BOD | build, operate, deliver |
| BOL | build, operate, lease |
| BOO | build, own, operate |
| BOOST | build, own, operate, subsidize, transfer |
| BOOT | build, own, operate, transfer |
| BRT | build, rent, transfer |
| BTO | build, transfer, operate |
| DBOM | design, build, operate, maintain |
| DBOT | design, build, operate, transfer |
| FBOOT | finance, build, own, operate, transfer |

**Table 2: Possible IPP Models (Zur, 1997)**

(5) In the "operating agreement" the lender has to be assured that an experienced operator will be available in an early stage. The operating company can make a considerable contribution to the design process, helping to ensure that the plant will be operated in the most efficient way given existing cost constrains.

(6) The "offtake contract" or power purchase agreement (PPA) is the key contract, because it addresses the concern that

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there will sufficient revenues generated from the project to service the debt for the lenders and decent dividends for the equity investors.

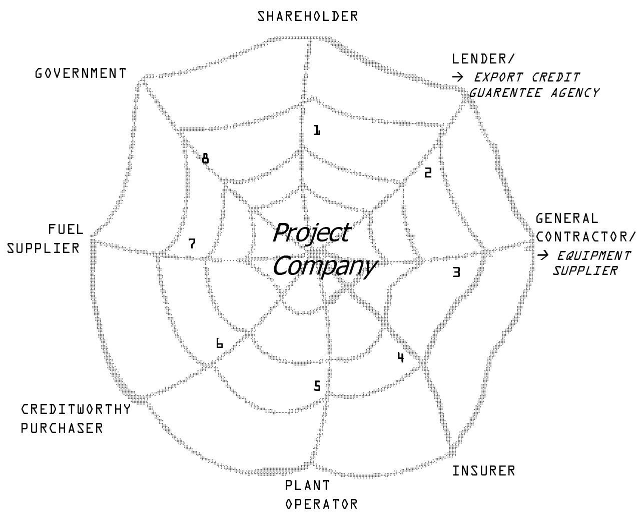


**Figure 3: The BOOT Web of Participants and Contracts**

(7) Lenders normally require a long-term "fuel agreement" to assure that the plant will actually be operable.

(8) In a "concession agreement" the host government will set out the obligations and the benefits that will be received by the project company.

One major concern of the private sector parties in the BOO/BOOT model is the high expenditures at the front end coupled with no assurance that they will win the contract and no assurance that the project actually will be built. The project sponsors/equipment suppliers, therefore, require that the risk will be balanced by decent rewards. In addition, the equipment supplier is exposed to a greater responsibility for the performance of their products, extending the normal guarantee period to the economic lifetime of the project.

On the other hand, a BOOT mode allows equipment suppliers additional income during the operation period through spare part and maintenance contracts. And an early involvement in the project helps the project developer/equipment supplier to optimize selection of plant and equipment.

## CONCLUSION

The aim of this paper is to demonstrate the strong correlation between the financial structure of a concentrating solar power project and its financial feasibility, hence its successful development. In general, the larger the capital investment of the project, the stronger the correlation.

The deregulation of the power market in almost all countries of the world led to the emergence of independent power producers and project finance techniques. By means of a cash-flow model, an IPP case study was performed and demonstrated the impact of financing on project financial feasibility. For instance, the internal rate of return can increase dramatically by reducing the equity share slightly. One reason for this is an inequity between conventional power projects and renewable power projects due to the higher up-front investment of solar projects. As a result, the "solar community" has to open its horizon to consider renewable energy projects not only as environmentally friendly and high-tech, but also as cash-generating opportunities.

On the other side, one could obviously see that IPP structures such as BOOT contain a large cobweb of contracts and agreements, the establishment and maintenance of which can be daunting. One of the basic ideas of all IPP structures is an equal allocation of the project risk among all participants which makes each IPP project a large challenge, especially for the involved equipment suppliers.

## REFERENCES

Anderson, J., Burr, M.T., 1997, "Making Strides – 1997 State of the Industry Report" Independent Energy Magazine Jan./Feb. 1997.

Backhaus, K., Sandrock, O., Schill, J., Ueckermann, H., 1990, "Projektfinanzierung", ISBN 3-7910-0531-6, C.E. Poeschel Verlag, Stuttgart, Germany.

Brealey, R., Myers, S. , 1991, "Principle of Corporate Finance", ISBN 0-07-100756–3, Fourth Edition, McGraw-Hill, Inc., New York, USA.

Bur, M.T, 1998, "The New Model," Independent Energy, June 1998.

Flachglas Solartechnik GmbH, 1994, "Pre-Feasibility Study on Solar Thermal Trough Power Plants for Spain," Köln, Germany.

IEA, 1991, "Guidlines for the Economic Analysis of Renewable Energy Technology Application," Quebec, Canada.

Jenkins, A., Reilly, H., 1995, "Tax Barriers to Solar Central Receiver Generation Technology," Proceedings of the 1995 ASME/JSME/JESE International Solar Energy Conference, March 19-24, 1995, Maui, Hawaii, USA.

Meinecke, W., Trieb, F., Langniß, O., 1997, "Guidance for Solar Thermal Power Systems Performance and Costs, to Permit Comparative Assessment for Different Technologies", in SolarPACES Technical Report No. III-3/97 "Introductory Guidelines for Preparing Reports on Solar Thermal Power Systems."

Navitt, P., Fabozzi, F., 1995, "Project Finance," ISBN 1-855-642999, Sixth Edition, Euromoney Publication, Rochester, Great Britain.

Pilkington Solar International, 1996, "Status Report on Solar Thermal Power Plants", ISBN 3-9804901-0-6, Köln, Germany.

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Short, W., Packey, D.J., Holt, T., 1995, “A Manual for the Economic Evaluation of Energy Efficiency and Renewable Energy Technologies”, NREL/TP-462-5173, Golden, USA.

The Solar Finance Consulting Group, 1996, “Financing a Solar Thermal Power Plant on the Base of the Build, Own, Operate (BOO) Concept in the Haschemite Kingdom of Jordan”, London, Great Britain / Geneva, Switzerland.

Trieb, F., 1996, “Advantages of Solar Thermal Power Stations under Financial Point of View”, Eurosolar Conference Finance for Renewable Energies, Amsterdam, Netherlands.

Wiser, R., Kahn, E., 1996, “Alternative Windpower Ownership Structure: Financing Terms and Project Costs”, LBNL-38921 / UC 1321, Berkley, USA.

Zur, E. 1997, “BOT - Finanzierung im internationalen Anlagenbau” in Internationalisierung - Eine Herausforderung für die Unternehmensführung, ISBN 3-540-61843-0, Springer Verlag Berlin, Germany.

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