FINANCING LARGE-SCALE INCREASES IN PV PRODUCTION CAPACITY THROUGH INNOVATIVE RISK-MANAGEMENT STRUCTURES AND CONTRACTS

ERIC INGERSOLL
Lucid, Inc.
Cambridge, Mass.
(617) 547-1200; eric@lucidinc.net

ROBERT DIMATTEO
Draper Laboratories
Cambridge, Mass.
(617) 258-3052; rdimatteo@draper.com

ROMANA A. VYSATOVA
J.F. Kennedy School of Government
Cambridge, Mass.

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I. THE NEED FOR LARGE-SCALE INCREASES IN PV PRODUCTION CAPACITY

The conventional fossil fuel-burning energy sector produces most of the greenhouse gas carbon dioxide and a large part of the air pollution that results in environmental and health damage. Photovoltaics (PV)—a clean and renewable-energy-generation technology—gives us an opportunity to address these problems, as well as to provide power to people in areas that are not cost-effectively served by the conventional electric power grid. In order to make a significant difference in reducing the problems with carbon-generating fossil fuels, however, the scale of the PV industry will have to expand dramatically.

By the end of 1998, the total installed capacity of PV will be approximately 1,000 megawatts (MW), and annual PV production will reach 150 MW. [1] By comparison, the net annual additions to the world's grid-connected generating capacity are approximately 125,000 MW (representing approximately $125 billion in annual investment). Just to meet this additional annual demand for electricity, the PV industry would need to expand by roughly 5,000 times, to 500,000 MW, assuming a PV capacity factor of 20%. There are two cost implications of this expansion:

- Assuming a price of $1 million per MW of PV production capacity, $500 billion of capital would be required to finance this massive expansion of PV manufacturing capacity. (And this is a conservative estimate as net additions to the world energy grid are also expanding at between 6% and 8% annually.)
- An additional $500 billion would be needed annually to finance the purchase of PV systems produced by these manufacturing facilities by end users, assuming a competitive average price of $1.00 per installed watt of PV.

These projected costs of a massive expansion of PV are high. Nonetheless, there is sufficient depth in the world capital markets to finance PV infrastructure projects at this scale, particularly because they would displace investments in conventional power generation and distribution technologies.

PV will have to replace *existing* carbon-generating power sources, not just new additions, if it is to have a significant impact in mitigating the sources of global climate change. This means that PV must become economically competitive with conventional power sources in the United States and other industrialized nations.

[1] In order to compare the generating capacity of PV with conventional sources, it is necessary to multiply the number of watts by a capacity factor: The worldwide average capacity factor for PV is approximately 20%. This brings the true generating capacity of the PV industry's annual production to only 30 MW.

The current wholesale price of PV modules is high—about $4/watt. The effective price of electricity generated from PV translates to a range of approximately 28¢/kilowatt hour (kWh) (for a PV power plant with an installed cost of $4.50/watt) to 50¢/kWh (for distributed/residential use with an installed price of $8/watt: $4 module cost plus $4 for balance of system and installation).[2] By comparison, most new conventional sources internationally are natural gas-fired advanced combined-cycle (GACC) plants with target electricity prices between 2.8¢/kWh and 3.5¢/kWh. The lowest prices in the United States are in the Midwest; there the marginal cost of electricity from fully amortized coal plants is less than 1¢/kWh.

PV production facilities have tended to be small because of the PV industry's orientation toward research and development and early commercialization activities rather than full-scale production. Even the larger facilities (e.g., Siemens, ASE Americas, AstroPower, and Solarex) tend to be demonstration scale-ups rather than full-scale production facilities.

The PV industry is still relatively immature since a significant portion of its revenues come from government-sponsored R&D activities. Although R&D is an important activity for the industry to continue in order to achieve greater efficiency and bring costs down, a greater focus on business planning and risk-management strategies will be necessary to attract capital for these large-scale PV projects. New financial and legal infrastructures will be needed to permit such a focus.

Rapid technological innovation in the PV industry is improving PV product and production efficiency and bringing down costs. Despite the improvements, however, the industry has yet to capture significant economies of scale. Cost reductions derived from scale economies and learning-by-doing have been demonstrated across a variety of manufacturing industries. The formula used to approximate scale effects in manufacturing is that capital costs for a fixed increase in capacity declines by 40% with each successive expansion.[3]

The Boston Consulting Group analyzed historical production data for over 50 distinct manufactured products in a variety of industries and found this approximate relationship to hold.[4] Where the total market is growing, scale economies apply not just to production but to all operations—including marketing, accounting, and overhead functions. Furthermore, industries that have actually encountered the limits of scale economies and experienced declining returns from scale have tended to be in large and mature sectors with stagnant or declining markets (e.g., utilities and steel).

With large untapped demand, dynamic technological innovation, and currently small R&D-scale manufacturing facilities, scale economies in the PV industry have just barely begun to be captured.[5] Costs for several sizes of turnkey PV manufacturing facilities supplied by the Spire Corporation

[2] These kWh calculations assume an 18% capacity factor, fixed interest rate of 7.5%, a 20-year term, no tax benefits assumed.

[3] Bruce Henderson, *The Logic of Business Strategy* (Cambridge, Mass.: Balinger Publishing Co., 1984), p. 54.

[4] Boston Consulting Group, " Experience Curve Background Data," internal study, Boston, undated.

[5] Confidential communications with PV industry executives.

(polycrystalline PV) and Energy Photovoltaics Inc. (thin-film PV) show declining capital costs per unit of output.[6] [7]

Strong demand for PV is keeping prices high. Even though the demand for PV is projected to be large and growing fast relative to supply of PV, the demand has not proved reliable enough in the near term to support the construction of large PV manufacturing facilities. There are three main reasons that the demand for PV has not proved reliable.

- Approximately one-third of world demand for PV is driven by government programs that are subject to political whims.[8]
- Developing countries with PV markets are often politically and economically unstable.
- Developing countries lack robust market channels for PV.

To support substantial and sustained growth in the demand for, and the supply of, PV,[9] a financial and market infrastructure must be established. Several suppliers of PV manufacturing equipment as well as PV manufacturers believe that the technology to make PV competitive with conventional energy generation already exists. What is needed is investment in production facilities on a scale sufficient to apply PV technology effectively.

Unfortunately, investors remain wary of the PV industry because of the perceived business, market, and technology risks (i.e., the risk that the technology will not perform or will become obsolete) associated with PV. Much of the overall risk is related to the uncertainty of demand for PV product in the United States, where because of the extensive coverage of the electrical grid, high-value opportunities for PV are perceived as "niche" markets even though in aggregate they may stimulate as much as 10 times current U.S. production at current prices.

Extensive survey data suggests that a range of potential customers exist, even given a price premium for PV.[10] The magnitude of this premium is important, though—and at current levels, the premiums exceed what most customers are willing to pay. The result is a classic vicious cycle inhibiting large-scale investment in PV manufacturing (see Figure 1). Because the PV product is not affordable and easily available from the perspective of potential customers, investors do not see sufficient demand for the product; thus, manufacturers see a shortage of investment capital for PV.

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[6]R.G. Little and M.J. Nowlan (of the Spire Corporation, Princeton, N..J.), "Crystalline Silicon Photovoltaics: The Hurdle for Thin Films," *Progress in Photovoltaics: Research and Applications*, Vol. 5, 309-315, June 1997; and "Summary Proposal: 2.5 MW a-Si Photovoltaic Module Manufacturing Plant," Spire Corporation, Princeton, N.J., June 1998.

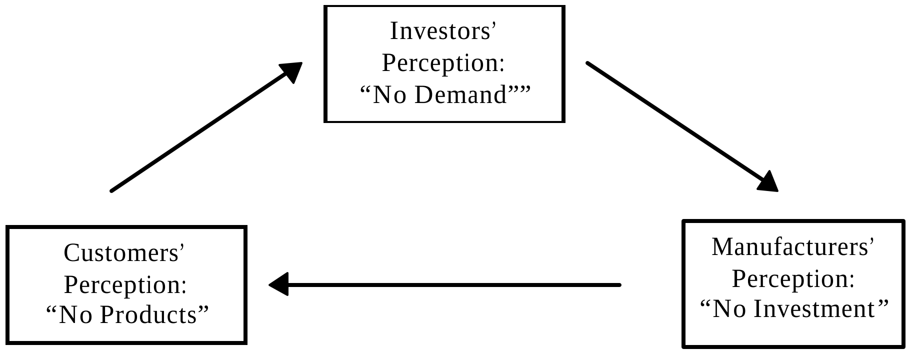
[7]It is beyond the scope of this paper to attempt to determine what size manufacturing will yield appropriate price reductions to enable a project financing. This will be determined by entrepreneurs and engineers as part of their business plan.

[8]President of Siemens Solar, as quoted in Renewable Energy Policy Project (REPP) scoping paper, *Action Recommendations for a Project to Expand Markets for Photovoltaics* (Washington, D.C.: REPP, 1998).

[9]Rockefeller Brothers Fund, *Selling Solar: Financing Household Solar Energy in the Developing World*, Pocantico Paper No. 2 (New York 1996).

[10]B.C. Farhar and J. Buhrmann, "Public Responses to Residential Grid-Tied PV Systems in Colorado: A Qualitative Market Assessment," National Renewable Energy Laboratory, Golden, Colo., July 1998.

Figure 1: The Vicious Cycle Inhibiting Large-Scale Investment in PV Manufacturing



II. PROJECT FINANCE FOR PV PROJECTS: A POTENTIAL SOLUTION

Project finance is a financing technique whereby lenders and investors look primarily to the cashflow of the project to repay loans and to the assets of the project as collateral. Project finance entails careful financial engineering to allocate the risks and rewards associated with a project among a variety of stakeholders. Project financing evolved to support specific projects which sponsor companies either could not or did not want to finance on their balance sheets or with their own equity.

Many of the $300 to $500 billion worth of annual worldwide infrastructure investments utilize project finance methodology and access the capital markets for sourcing investment capital and/or for implementing risk-management strategies. We are proposing the use of a project finance model for the PV industry for the same reasons it is used throughout the world for major infrastructure projects, and power projects in particular. Building the scale of PV plant envisioned would not be feasible using conventional financing—using a firm's direct credit. Few companies—especially companies in the PV industry—have the financial strength to sponsor projects of this scale. Furthermore, this approach to financing permits more flexible allocation of the financial risks and rewards associated with a project than conventional financing. Furthermore, multiple parties working in concert can better handle the complexity and multitude of risks involved. As two analysts explain:

> Project financing permits the sharing of operational and financial risks among the various interested parties, and it does so in a more flexible manner than financing on the sponsors' general credit. Risk sharing is advantageous when economic, technical, environmental, or regulatory risks are of such magnitude that it would be impractical of imprudent for a single for a single party to undertake them. A financing structure that facilitates multiple ownership and risk sharing is particularly attractive for projects such as electric-generating plants, where significant economies of scale are possible and the project will provide benefits to several parties.[11]

[11]F.J. Fabozzi and P. Nevitt, *Project Financing: Sixth Edition* (New York: Euromoney, 1986), p. 9.

Project finance also makes it possible to expand the debt capacity of the project sponsor. This means that smaller project sponsors, such as PV companies, can build large-scale, capital-intensive facilities. A whole range of risk-management infrastructure, strategies, and providers have developed which has enabled project financing, as a means of financing, to attract hundreds of billions of dollars of capital each year. All of the major players necessary to make a deal happen: investment banks, institutional investors who loan money and invest in projects, the insurance underwriters, etc., who provide credit support—already exist and have experience financing projects.

Project finance is especially beneficial when demand for a project's output is strong enough that purchasers would be willing to enter into forward purchase contracts, and where those contracts have provisions to assure a lender to advance funds for construction based on those contracts. Forward contracts for the purchase of power are customarily used in the independent power industry to secure financing for new generation facilities. What distinguishes project financing from conventional financing is that the project is a distinct legal entity—with project-related assets, contracts, and cashflow largely segregated from the sponsoring entity.

Each case of project financing consists of a series of complex arrangements and bilateral contracts among a set of parties tailored to suit the specific characteristics of the project. Project financing, therefore, takes many forms. Recently, project financing has expanded beyond traditional infrastructure projects to include manufacturing facilities. Some of these projects involving manufacturing facilities have included long-term forward contracts with creditworthy customers to help provide the credit strength to satisfy lenders and enable project financing.

In 1989, for example, $105 million in project financing was provided by GE Capital for Bev-Pak Inc.[12] At the time, the project's output represented 40% of the total steel beverage can output in the United States; its new production technology allowed it to sell tin-plated steel cans at a lower price than aluminum cans. The technology also gave it the flexibility to switch to aluminum cans if the price dropped. Sponsors of Bev-Pak included beverage manufacturers, competitors in the downstream beverage market. These companies had take-or-pay contracts to purchase low-priced cans.

Related industries—including conventional power generation, real estate development, natural resource extraction, etc.—have long used project finance. The industries that have used this approach tend to be mature industries, in which producers enjoy substantial market power or where demand is dependable. The essential characteristic of such projects has been predictable revenue and costs. The PV industry and its product differ from industries that have used project financing, primarily in that PV is a technologically innovative substitute for an existing product with a large market, but as yet has only a small market itself. Consequently, these tools need to be adapted and appropriate project financing structures developed for PV.

[12] H. Chen, J.W. Kensinger, and J.D. Martin, "Project Financing as a Means of Preserving Financial Flexibility," working paper, University of Texas, Austin, Tex., 1989.

III. ASSESSING AND MANAGING INVESTMENT RISKS

In a market system, capital formation occurs when investors see attractive opportunities for capturing financial rewards. These rewards are supposed to be commensurate with risks; therefore, the speed and scale of capital formation is also a function of risk management. It is generally held that investors have a range of appetites with respect to risk. In reality, however, there are few investors (and even fewer lenders) interested in deals where there are too many risks, and there are certain risks that lenders are never willing to take.

Many of the investment risks associated with the PV industry exist to varying degrees in other industries. A wide range of mitigation strategies has been developed to eliminate or transfer these risks to entities that can evaluate and bear them most efficiently. The risks to be considered by investors deciding whether to supply capital to build a PV manufacturing facility on a traditional project finance basis are outlined below.[13]

To provide financing for a project, lenders must be convinced that a project is technically feasible, economically viable, and creditworthy:

- ***Technical feasibility***: A project that is technically feasible is one that will be completed on schedule and within budget and the facility will operate at its design capacity.
- ***Economic viability:*** A project that is economically viable is one that will generate sufficient cashflows to cover its cost of capital.
- ***Creditworthiness:*** A project that is creditworthy is one that, even in reasonably adverse circumstances, will generate sufficient cashflows to cover both operating expenses and debt service**.**[14]

Because a project cannot have an established credit record prior to completion, lenders want to protect their interests and to prepare for contingencies as much as possible:

> Lenders to a project will require that they be protected against certain basic risks. Lending to a project prior to the start-up of construction, without protection against the various businesses and financial risks, would expose project lenders to equity risks. But lenders, who are often fiduciaries, find it imprudent to assume technological, commercial, or other business risks. Therefore, they require assurances that creditworthy parties are committed to provide sufficient credit support to the project to compensate fully for these contingencies.[15]

Assessments of investment risk are fundamentally subjective: All that credit rating agencies can do is observe the (approximate) frequency with which companies with certain characteristics (expressed as financial ratios) subsequently fail to make scheduled payments (default).

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[13] There is a distinction between risks of project development/completion and operating risk. The clearest example of the distinction between development and operating financing is in commercial real estate, where construction lenders are generally wholly different entities from permanent lenders (e.g., banks v. insurance companies). The analogy for tolling is the special case of hotel development, where the operator (e.g., Hilton) generally does not own the real estate.

[14] The following discussion about risks is based on J.D. Finnerty, *Project Financing: Asset-Based Financial Engineering* (New York: John Wiley & Sons, 1996).

[15] J.D. Finnerty, *Project Financing: Asset-Based Financial Engineering* (New York: John Wiley & Sons, 1996), pp. 40-1.

A. Credit Risk

Project financings are generally highly leveraged, with expected cashflows the only source of funds from which loan payments will be made. The predictability of revenue and expenses, therefore, is critical for credit risk assessment.

In general, investors want to be able to gauge the credit risk they are assuming and prefer "investment grade" debt that is not speculative or high risk. Rating agencies and commercial lenders (to determine the degree of risk inherent in an existing or proposed credit) use a standard system of risk classification.[16] This helps lenders decide whether to lend and at what price and terms.

The definition of credit risk from the perspective of a lender is the possibility of failure to pay back the loan according to the contractual terms. Industry and company characteristics are considered principal factors in determining credit risk according to the risk classification (see Table 1).

Table 1: Factors in Determining Credit Risk

Industry characteristics	• Industry structure and economics • Maturity • Stability
Company characteristics	• Size • Diversification of revenue sources • Product characteristics (differentiation, substitutes, patents) • Management (experience, qualifications, depth and turnover rate, reputation) • Financial condition (debt and capitalization, liquidity, cashflow, profitability, quality of assets, and quality of earnings) • Capital sources (equity—breadth of ownership, liquidity, market demand) • Long-term debt—access to private and/or public markets • Investment demand • Commercial and investment bank relationships (size and stature of bank, strength of relationship)

The PV industry is immature (based on lifecycle, the ease of entry, and the rate of capacity additions) and unstable (chronic supply/demand imbalances, vulnerability to technological innovation, and production and distribution changes, etc.) and therefore not likely to qualify as "investment grade." Furthermore, many of the general company characteristics in the PV industry would also put them at a severe disadvantage in raising capital in terms of the standard criteria for credit risk assessment.

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[16] J.D. Finnerty, *Project Financing: Asset-Based Financial Engineering* (New York: John Wiley & Sons, 1996), pp. 383-90.

B. Business Risk

Business risks are not normally accepted knowingly by lenders. Some business risks may be assumed by lenders, however, including country risk, sovereign risk, political risk, foreign exchange risk, inflation risk, interest rate risk, operating performance risk, enforceability of contracts for product and raw materials, refinancing risk, etc.[17] By means of contracts, guarantees, supplemental credit support arrangements, and insurance, a project's business risks can be allocated to various stakeholders involved in the project and third parties to provide the credit support necessary to obtain financing. These stakeholders can include the project owners, purchasers of the project's output, suppliers of raw materials, and governmental agencies, for example.

Several categories of business risks that are relevant to an investment in a PV manufacturing facility are shown in Table 2. These types of risks, and management strategies for addressing the different types of risks from an investor's standpoint, are discussed below.

Table 2: Business Risks Relevant to Investments in a PV Manufacturing Facility

Type of risk	What is the risk?
Completion risk	Will a project be completed and commissioned as planned—either on schedule or within budget?
Technology risk	Will critical new technologies perform as projected? Will they be superseded by cheaper technologies before repayment is complete?
Economic risk	Will there be demand for the product? Will the price rise or fall beyond profitability?
Financial risk	Will movements in interest rates or currency impair the project's cashflows?
Political/regulatory risk	Will the necessary regulatory approvals be obtained? Will critical government tax and/or legal legislation be changed?
Force majeure risk	Will a catastrophic event negatively affect the operations of the project?

1. Completion Risk

Completion risk refers to the risk that a project may not be completed and commissioned as planned—i.e., that the project may not be completed on schedule or within budget. A variety of contingencies—including technical problems, permitting delays or refusals, strikes by construction workers, underestimation of required construction time, etc.—could cause a project to be terminated, delayed, or to require additional capital. Such occurrences could impair the project's profitability, rate-of-return, and ability to service debt in a timely manner.

Examples of completion risks in the case of a PV facility, for example, with respect to a PV facility include the risk of delay in receiving equipment from the supplier or failure of equipment to function properly.

[17] F.J. Fabozzi and P. Nevitt, *Project Financing: Sixth Edition* (New York: Euromoney, 1986), pp. 35-38.

2. Technology Risk

Technology risk refers to the risk either 1) that the production technology will not perform according to specification once the project is commissioned, or 2) that the production technology may become obsolete (e.g., no longer cost-effective) before the end of the project lifecycle. This type of risk is common in industries undergoing rapid technological innovation, as in the PV industry.

Technology risk of any sort is generally not accepted in most project finance deals, and proven technologies are almost always required. Even venture capitalists, by reputation the least risk-averse investors, do not commit significant funds to a company until technology risk is considered low.

Nonetheless, a project finance structure is possible even if there is technology risk if creditworthy entities other than capital sources are willing to assume the risk—e.g., the engineering firm or supplier of the technology guarantees product performance or a customer enters into firm contracts to purchase future output to protect lenders from technology performance and obsolescence risk.

Technology performance risk is usually managed by assessing the previous performance of the supplier (in the case where the equipment is purchased) and through a performance bond or other type of performance insurance. A key constraint on suppliers of PV manufacturing equipment is whether they can afford to pay to put up the bond and/or whether they are insurable (e.g., if a supplier does not have a long enough track record, an insurance company may not have enough information to cover the supplier). With rapidly changing technology and the small size of companies, managing technology performance risk for suppliers is a challenge.

3. Economic Risk (Market and Price Risk)

Economic risk—or market and price risk—is the risk that revenues are insufficient to cover the operating costs and debt service of the project. Insufficient revenues could result from a decline in price for output, increase in input costs, reduced operating efficiency, or poor management.

Management should have appropriate responses to such contingencies, as well as appropriate responses to the anticipated acts of competitors. Typically, project *pro formas* will analyze the sensitivity of the project to service debt in the event of cost overruns, interruptions in project operations, fluctuations on product price, and changes in operation cost. Market risk—whether there is enough demand at a given price at which the plant could sell to provide revenue to cover projected operating costs (including capital asset charges) and debt service—is a fundamental obstacle for large-scale investments in PV manufacturing facilities.

An appropriate level of due diligence on the part of the management team, clear reporting structures and processes, audits, and a well-defined scope of business are necessary. In addition, market and price risk are typically managed through a variety of purchase and sale contracts that obligate a buyer to purchase the project's output at a given price.

Take-or-pay and take-if-offered contracts obligate the buyer only if the project actually produces the product but do not protect the lender if the project is not completed or the production technology does not perform. Thus, these contracts protect lenders only if the project is operating as projected.

Lenders will normally require additional credit support to protect them from events that could seriously impair the performance of the project.

Benefits to the seller from these types of contracts are guaranteed price and demand. Benefits to the buyer are dependable supply and a price that is often below market. This type of contract is particularly attractive to buyers with highly predictable needs, such as utilities, industrial users, and, in the case of PV, households. This risk can also be managed using futures contracts, as is done for lumber, short-term electricity, and cotton.

4. Financial Risk

Financial risk is the risk that arises from the possibility that movements in interest rates or currency will impair a project's ability to meet its debt service obligations. Financial risk is easily mitigated through utilization of financial instruments. The use of fixed-rate debt (typically from insurance companies and pension funds) eliminates interest-rate risk, while floating rates may be hedged with interest rate swaps or futures. Currency risk can be managed using swaps, forwards, or futures.

5. Political and Regulatory Risk

The political risk relevant to project finance in the United States is limited to obtaining the necessary legislative and regulatory approvals to allow the project to proceed. There is also the possibility that changes in tax, legal, or environmental legislation may negatively impact the project's schedule and profitability, for instance, by removing tax incentives favorable to investments in PV. The risk that the environmental effects of a PV project might cause delays or redesign is largely a permitting issue that falls in this category of risk.

6. Force Majeure Risk

Force majeure risk refers to the risk that some catastrophic event might cause delays or prevent the operation of a project after it has been completed and commissioned. Like other business risks, this risk can be shared among the various parties involved in a project.

C. Other Conventional Risk Mitigation Strategies

1. Supplemental Credit Support

Depending upon the project's completion agreements and sale contracts, it may be necessary to provide supplemental credit support through additional security arrangements. Supplemental credit support—which backs up completion and sale contracts in part or in full and enables a project to service its debt—can take the following forms:

- ***Letter of credit:*** A letter of credit is a guarantee purchased from a financially sound entity, such as an insurance company, bank, or credit insurer, to provide credit support for the obligations of the project.

- ***Escrow fund:*** An escrow fund is typically established with funds to cover 1 to 2 years' of debt service to insure that payments are made in a timely manner.
- ***Cash deficiency agreement***: A cash deficiency agreement covers cash shortfalls that would impair the project's ability to service its debt. These are usually entered into with customers and cash contributions are treated as advances toward future purchases of output from the project.
- ***Capital subscription agreement:*** A cash subscription agreement requires a creditworthy entity to purchase securities issued by the project entity for cash to enable the project to make up for any cash shortfall that would impair debt service.

2. Insurance

Insurance may be required against "force majeure" risks, those which are not covered by other contracts and agreements, but which would impair the project's ability to service its debt. Risks covered by insurance would include natural disasters, business interruption, and other specialized events. Lenders may require agreements with the project sponsors to provide additional funds to the extent insurance proceeds are inadequate to restart operations.

IV. FORWARD PURCHASE AGREEMENTS AND STRUCTURED DEMAND CONTRACTS (SDCS)

As noted earlier, a principal risk associated with PV project financing is market risk—that is, the risk that the revenues generated by a project will not be adequate to cover operating expenses and debt service. Unlike a conventional power plant that might have only one customer, a large PV manufacturing project is likely to have multiple customers (or end users). Thus, revenue risk may not be offset by purchase commitments from a small number of customers, unless the commitments are very large.

One possible solution to this problem is the creation of a secure, transferable *forward purchase agreement.* A collection of forward purchase agreements could be pooled together by an intermediary—e.g., power marketers, municipal utilities, energy service companies, purchasing cooperatives, real estate developers, or retail financial institutions—to form a *structured demand contract (SDC)* that would lower or eliminate the market risk for a PV production facility.

Forward contracts could be structured in a number of ways. The commitment to purchase could be secured by a mortgage on the buyer's property, or secured by personal credit, or backed up by a guarantor. The forward contract would confer significant benefits to the producer/seller by eliminating market and price risk. To achieve this, the offer to the prospective buyer must be made as attractive as possible by stripping away all the risks associated with entering into the contract to purchase a PV system.

Enabling intermediaries to create SDCs would allow the demand for PV to be tied directly to investments in new PV production facilities. Furthermore, even in developed countries where distribution channels and consumer finance for PV is underdeveloped, intermediaries could initially serve the functions necessary for larger markets for PV to develop. Large-scale PV production will provide a stable supply of PV and low prices to enable intermediaries to enter the market.

A. Contract Terms

An SDC contract would be a combination of a "take-or-pay" and "take-if-offered" contract. It would be a modified take-or-pay to the purchaser who agrees to take delivery of the PV system at contract price with a cancellation fee if the purchaser decides not to take delivery. This purchase could be backed-up by a "put" (an option to sell at a set price) to a creditworthy back-up purchaser whose take-if-offered contract requires them to purchase and take delivery of the system at a contract price thus reducing the liability of the purchaser. The cancellation fee would be equal to the price of the put option. A back-up buyer would be unnecessary if the contract were not cancelable and secured by a lien on the purchaser's real property.

Individual bilateral forward contracts would be secure purchase agreements. The pool of these forward contracts, or SDC, could represent a stable source of demand for PV and be used to secure an investment in a PV manufacturing facility. The credit risk of the SDC—an aggregated individual mortgage-backed, or guaranteed purchase agreements—could be assessed by a rating agency. Some or all of the output of that plant would be spoken for, eliminating demand and price risk. Technology and performance risk would be managed with a performance guarantee/bond. The aggregator could then go to the bond market to finance the project. This approach would allow the financing of a PV plant in the same way that a conventional power plant project would be structured, with secured contracts for the output used as collateral for a loan.

In the case of a residential system, the purchaser would sign a contract for a PV system that could either be secured by the purchaser's home, unsecured, guaranteed by a third party, or backed-up by an alternative buyer. The contract would be for the delivery of a PV system for a specified price (or in a given range) and time (or in a given time frame). If the financing entity and seller are distinct, and the buyer would like to finance the purchase, the purchase obligation, as well as the title to the system could be transferred to the financing entity as security. The following terms would need to specified:

- timeframe for delivery (price could be a function of delivery time);
- price of PV system and factors affecting price (i.e., the customer would be offered a guaranteed price for the PV system, which insures that current payments for the system for a certain period of time not longer than the financing period would not exceed their cost of electricity through the grid);
- warranty and system performance guarantee (for at least as long as the term of the financing);
- obligation in the event of termination by the seller; and
- obligation in the event of termination by the buyer.

B. Buyer's Risks Associated with a Forward Contract

1. PV Price Risk

For a buyer of a forward contract, the main risk of a forward contract is that PV market prices will drop below the contract price (including the value of any contracting cost, e.g., a deposit) prior to delivery of the PV system. Given the widespread expectation that PV prices will in fact decline, this is a very significant disincentive to forward purchasing at a fixed price.

This risk can be offset by offering a price protection clause that refunds to the customer any premium the customer paid for the product over the life of the forward contract if the price of PV falls below the contract price. It is extremely unlikely that this price protection would be activated, given that the facility in question would most likely be the low-cost producer in the market.

2. Electricity Price Risk

For grid-tied applications of PV, movements in the price of electricity will effect the economics of the decision to purchase a PV system for the buyer. The risk is that the purchaser is locking into a 10-20 year price for electricity (or whatever is the life of the equipment) because of the purchase of the PV system.

The seller can assume this risk from the buyer by offering the buyer a guarantee that current payments for the PV system for a certain period of time, not longer than the financing period, would not exceed the buyer's cost of electricity through the grid. The seller could manage this risk by purchasing electricity futures to cover this exposure.

3. Product Performance Risk

The risk to the purchaser that the product will not perform as advertised and/or will not perform at that level for its expected useful life can be assumed by the seller or a third party through an appropriate warranty and performance guarantee.

4. Risk of Buyer Backing Out

It is possible that the buyer may have reason to back out of the contract. This risk to the seller is mitigated by the fact that the contract price for the PV is expected to be substantially less than the market price. Thus, the seller could easily dispose of the system on the spot market and more than likely receive a higher price than from the execution of the original contract. As an additional means of security, a creditworthy backup buyer could be arranged who would guarantee a price and a "market" for any and all systems which are not purchased by their contracted buyers. This would eliminate the risk to the seller of not being able to sell a system at the contracted price and would limit the liability of the purchaser to the difference between spot price and contract price less transaction costs, if this is less than zero.

5. Risk of Seller Failing to Deliver PV According to Terms of Contract

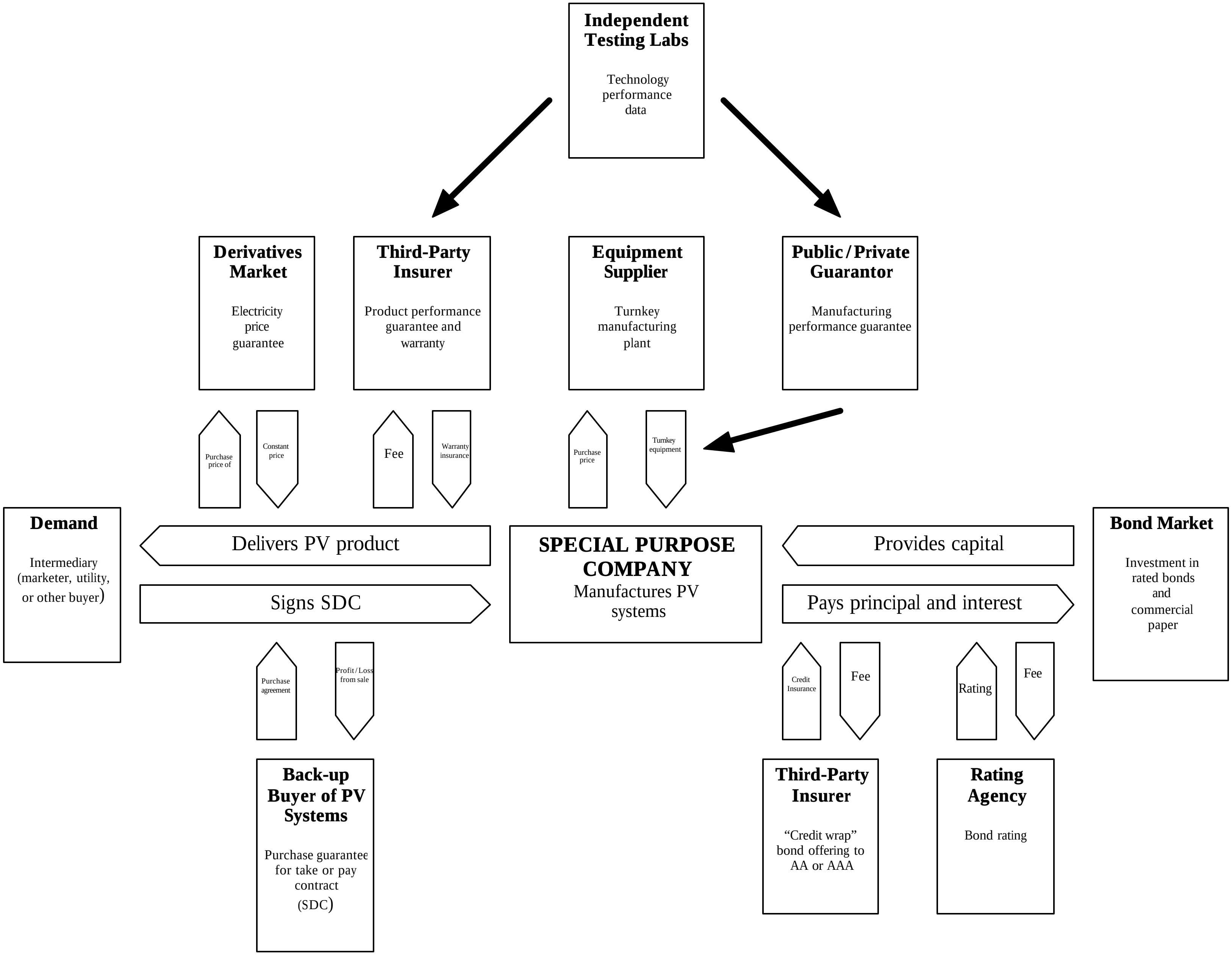
There is a risk to the buyer that the seller might fail to deliver the PV system within the time frame or terms of the contract. Performance insurance could mitigate this risk or offering the buyer the right to terminate or renegotiate the contract in such an event could also mitigate this risk to the buyer.

C. How SDC-Based Project Financing Would Work: An Illustration

Figure 2 below illustrates how structured demand contract (SDC) project financing for a PV manufacturing plant might work. Although the customers used in this example are the residential retrofit market, the customers could be any entity currently buying PV or who would be a buyer at the price offered by the new manufacturing facility.

- First, the developer of a PV manufacturing factory enters into agreements with the entity that will be marketing PV to customers.
- When the developer has pooled enough forward contracts to guarantee a sufficient level of demand over the proposed financing period for the facility, the project financing for the manufacturing plant can be initiated.
- The performance guarantor and technology lab reviews the manufacturing technology, and the project documents are reviewed by the bond insurer and rating agency.
- At the closing, capital is delivered to the developer of the PV manufacturing facility; fees are paid to guarantors and insurers (and lawyers), and construction can begin.
- After construction is complete, the PV manufacturing plant is commissioned and begins operation.
- As PV product is produced, it is delivered to customers holding forward purchase contracts.
- Payment is received and used for PV manufacturing operations and to make principal and interest payments on project debt.

Figure 2: PV Project Financing via a Structured Demand Contract (SDC)



D. Secondary Markets for PV Structured Demand Contracts

The project financing techniques described above have many benefits. As particular transactions become more standardized, however, it is quite possible we will see a move from customized transactions involving banks or other financial intermediaries to the use of a market-based trading approach.

"Disintermediation" (the removal of intermediaries) through financial markets has accelerated recently because of innovations in information technology and associated reductions in the cost of market trading.[18] This process removes a financial intermediary (often a bank) and standardizes, or "securitizes", the instruments by which organizations that need capital provide opportunities to institutions looking for attractive investment opportunities.

> The process of "securitization" is essentially the removal of (nontraded) assets from a financial intermediary's balance sheet by packaging them in a convenient form and selling the packaged securities in a financial market. This process of reducing the total size of the assets or "footings" of intermediaries and transferring them to markets is already widespread for mortgages, auto loans, credit card receivables, and leases on consumer durables. Now established as a legitimate process, its application to other types of…assets is likely to move forward even more rapidly than in the past.[19]

Key aspects of the project financing techniques outlined above for PV could be standardized and traded in markets like a physical commodity market, where producers and users would buy and sell forward contracts for the delivery of PV modules. This type of market could also trade forward contracts to buy modules. A futures market in which users could hedge the risk of future price movements associated with their demand or supply would develop on top of the "physical" market. Manufacturers and investors could use the futures market to hedge their market and technology risks, while buyers concerned about supply instability would diminish their risks as well.

In this scenario, a developer interested in building a PV manufacturing facility would buy forward purchasing contracts as described above, use them as collateral to finance the manufacturing facility, and go to the bond market to finance the manufacturing facility. PV could be purchased to protect buyers or sellers against price movements where they have exposure. At this scale, the PV industry would have enough depth of supply that performance insurance for new production technologies could also hedge much of their risk through futures contracts.[20]

The creation of a liquid and transparent market that allows buyers and sellers to easily trade PV will assist in risk management, provide the PV industry access to the capital markets, and speed the rate of innovation in the industry. Figure 3 shows a proposed interface between the PV commodity market and PV futures market.

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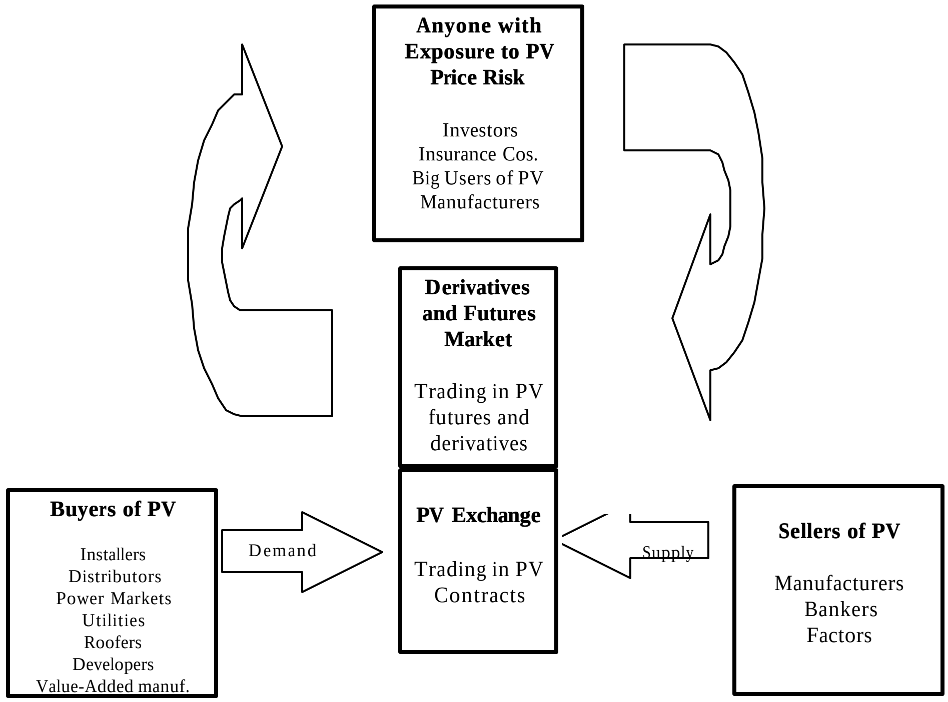
[18] Dwight B. Crane, et al., *The Global Financial System*: *A Functional Perspective* (Boston: Harvard Business School Press, 1995), p. 20.

[19] S. Mason et al., *Cases in Financial Engineering: Applied Studies of Financial Innovation* (Upper Saddle River, N.J.: Prentice Hall, 1995), p. 17.

[20] The downside of having to deliver on forward contracts would be limited to the futures premium plus the difference between bid at time of delivery and the future strike price.

Figure 2: The PV Commodity Market and PV Futures Market



V. ACTION RECOMMENDATIONS: FINANCING

Judging by the scale of project financing for infrastructure projects worldwide, it is likely that capital would be available for PV projects with attractive returns. To offer attractive returns to the bond markets, returns can be quite low, relative to equities, but investment risks of the project must be reduced as much as possible. The project financing technique, which has been used to finance infrastructure, power generation, real estate, and even manufacturing facilities, has developed the financial (deal) and legal tools required for these projects to access the capital markets. These mechanisms, and the financial service companies who provide them, offer a variety of solutions which can be adapted to the capital formation needs of the PV industry.

Nevertheless, there will be significant transaction costs associated with the first few large projects. PV companies, which tend to be small, are unlikely to invest in the near future in developing the relevant information necessary to bring providers of financial services and capital up the learning curve, and developing the appropriate set of project-related contracts and documents. This necessary financial infrastructure, which will enable the financing of large-scale production facilities, represents a public good to the extent that the benefits created may not be made proprietary and will reduce these costs for subsequent transactions. Furthermore, achieving lower prices by enabling private markets through the approach outlined in this chapter is potentially a far more cost-effective way to stimulate the PV industry than the singular pursuit of traditional policies such as direct subsidies of output or direct loans for plant and equipment. Thus, it would be appropriate to spend public funds to help create this infrastructure, which should include educated financial services companies and green power marketers for subsequent transactions.

By utilizing approaches to project risk management, the key obstacles to financing large-scale manufacturing facilities on a project basis can be overcome. Although these approaches are already available, they will need to be adapted for use by the PV industry. Some of the key tasks to accomplish this adaptation are outlined in the recommendations below.

Consistent with the basic nature of our proposal, which represents an instrument of voluntary corporate policy rather than one of mandated government policy, we do not specify who should carry out these steps. To go forward, it will be necessary for a variety of private sector players to undertake distinct but interrelated activities of their own volition, because they believe that the financial tool we propose makes business sense.

⇒ ***The private sector should take the following steps required to demonstrate economic feasibility of PV projects:***

- Develop project *pro formas* necessary for bond issuers, etc.
- Model all financing and risk-management-related costs.
- Determine optimal capital structure for projects.

***Outcome*:** Production costs at which PV projects will be feasible and detailed economic feasibility model.

⇒ ***The private sector should take the following steps required for PV manufacturers to gain access to the bond market:***

- Work with bond issuers/investment banks to determine possible deal structures and standardized methodology for risk analysis and its application to PV projects.
- Determine which other players are needed (i.e., a letter of credit or guarantee).

***Outcome*:** Development of relationships between PV manufacturers and capital providers, as well as the development of a consensus about possible deal structures and methodology for risk identification and analysis for PV projects.

⇒ ***The private sector should take the following steps required to create performance insurance for PV projects:***

- Work with performance insurers to determine their requirements for providing performance guarantees.
- Work with manufacturing equipment suppliers and national laboratories to produce reliability and cost data.
- Compare with performance guarantees for existing products.

***Outcome*:** Develop a prototype performance guarantee for PV projects.

⇒ ***The private sector should take the following steps required to create viable forward purchase contracts for PV projects:***

- Explore alternative structures for the forward contract and evaluate based on marketability and the level of security required by lenders and other stakeholders.
- Work with mortgage issuers and insurers, including Fannie Mae and banks, to develop prototype contract.

***Outcome*:** Develop a prototype forward purchase contract for PV projects.

⇒ ***The private sector should take the following steps required to create structured demand contracts (SDCs) for PV products:***

- Work with marketers to develop an offering for their customers.
- Explore security issues and solutions such as distributed consumer-mortgage-backed SDCs, back-up-buyer-guaranteed SDCs, and large-buyer SDCs.
- Test market offers to customers and incorporate customers' feedback into such offers.

Outcome: Develop a prototype offer for consumers of PV systems.