system-capacity expansion for a given load growth in order to determine the alternative cost of electricity, or a simpler approach might be just the utility's cost of peaking power. The problem with the simpler approach is that it may not adequately consider issues such as reserve capacity.

Step 8: annual energy value. In order to calculate the project value measures in Step 9, the value of the annual energy production is needed. For grid-connected, customer-side systems, the value is the cost avoided by not purchasing the annual energy produced (Step 5). The value is calculated from the electric utility rate and the energy production. Where the rate is multitiered or has seasonal components, the energy production as a function of time would need to be taken into account in order to value the energy properly.

Step 9: project value. Several financial measures for PV systems have been defined in equations (21.10 to 21.13): NPW($), IRR(%), PB(years), and DPB(years). Each one depends on the net equity cash flow, X_n, defined by equation (21.9), which includes a revenue term, R, which is the value of the electricity purchase avoided by the use of the PV system. The annual electric energy produced by the PV system is implicitly included in R.

When the computed economic measure is NPW, IRR, PB or DPB, it is compared to the threshold (NPW′, IRR′, PB′, DPB′) values that the owner considers appropriate. If the owner is a commercial firm, the NPW or IRR measures would typically be used. If the decision is between two competing energy sources, say, PV and a fuel cell, the one with the higher NPW or IRR would be preferable. It should be noted that since the fuel-cell system is dispatchable (i.e. provides energy at any time on demand), the PV system is not comparable unless it includes storage. The two systems must be designed to meet the same load profile in order to be compared by a single measure such as NPW or IRR. If the decision for the commercial user is just whether to buy a PV system for a stated purpose, the issue then is whether the NPW or IRR is greater than some threshold value. In this instance, the PV system competes for capital with other capital needs of the firm, and the threshold may be set by considering the NPW or IRR associated with alternative capital expenditures. The firm may even look at the decision in both ways: is the PV system the best choice from among several systems *and* is it a better use of capital than nonenergy expenditures.

The payback (PB) and discounted payback (DPB) measures are more typically appropriate to homeowners or others without tax considerations in the purchase decision, although nothing prevents others from considering these criteria. The payback for the PV system can be compared to the life of the system as a decision criterion. If the payback is shorter than the life, then in a simple view the energy is free after the payback period. Another use of the payback measures is to compare two or more systems by calculating their payback; the one with the shortest payback is preferred.

21.2.3 Case Studies

To illustrate some of the methodologies for the economic analysis of PV systems, brief summaries of three studies in which the authors participated are presented here. Each study considered PV technology operated in a large-scale (25–50 MW) electric-utility setting. The first study [3] compared the required module price in $/W$_p$ of several Si-cell technologies. The second study [4] covered silicon and copper indium diselenide (CIS)