systems were evaluated as so-called "demand side management" options where the on-site distributed photovoltaics is used to reduce demand rather than increase supply [47]. Although American utilities lost interest in PV in the late 90s due to deregulation, grid-connected applications in Europe and Japan began to grow rapidly, primarily owing to strong government support. Both small- and large-scale grid connected PV installations are blossoming in these countries [48, 49].

Yet another important development in the application of PV in the late 1990s, was building integrated PV (BIPV [50]), where PV cells are incorporated into a standard building product, such as a window or a roof shingle, or into an architectural feature like an exterior sun awning or semitransparent skylight. In this way, the cost of the PV is partially offset by the cost of the building materials, which would have been required anyway, so the incremental cost of the photovoltaics is much lower. BIPV is discussed in Chapter 22. The success of grid-connected residential or BIPV commercial applications has been possible because several countries led by Germany have established high rates to pay for the PV electricity produced by solar installations in private houses. In this scheme, the installation owner receives \$0.5/kWh for the electricity they feed into the public electric grid (as of 2001). But the owner buys the electricity consumed in their own house at the normal cost of ~\$0.1/kWh from the grid. Additionally, German banks provided generous loans for purchasing the installation. Similar concepts are used in Spain, the Netherlands, and other countries in Europe. But, the success has been still bigger in Japan where homebuilders receive a rebate from the government for about 30% of the PV system cost. Then, their electric bill is determined by the utility using the "net metering" where the customer pays only the net difference between what they used and what they generated. Rebates and net metering are available in some, but not all, states in the USA as of 2002. Interestingly, government support of photovoltaics in Japan has been decreasing while the market for PV homes has continued showing an impressive growth rate.

1.5 PV COSTS, MARKETS AND FORECASTS

In the first 20 years of PV research, from the mid 1960s to the mid 1980s, the main focus was to make the product more efficient so it produced more power. Impressive gains in cell and module efficiency were made. Costs also fell dramatically as solar cells moved from pilot scale to semiautomated production.

Although the important figure of merit for cost is \$/kWh, typically \$/W_P is often used. Modules are rated in Watts of peak power (W_P). This is the power the module would deliver to a perfectly matched load when the module is illuminated with 1 kW/m^2 of luminous power of a certain standard spectrum while the cell temperature is fixed at 25°C. (By the way, these "standard test conditions" or STC rarely occur in real outdoor applications! See Chapter 16 for a complete discussion of testing conditions and Chapter 20 for real outdoor conditions.).

Figure 1.5 shows costs (\$/W_P) and production measured in MW_P over the commercial history of photovoltaics. Up until about year 2000, these values represent mostly c-Si solar cell technology. These two curves are typical of most new technologies. Initially, prices are high since volume production is low, so development and start-up