Appendix B

DECENTRALIZED PHOTOVOLTAIC MODEL

Estimating the busbar costs for a house or industrial plant power station, whether connected to the grid or stand-alone, may involve somewhat different assumptions than for a central power station. For one thing, the homeowner's access to capital is different than that of the utility. In addition, the tax liabilities are different and arise from a different conceptual framework.

In order to compare most directly the busbar costs of a decentralized photovoltaic technology with the centralized terrestrial case and with the solar power satellite, OTA has adopted the case of decentralized systems leased by a utility to an individual owner. The choice to calculate the costs this way represents neither a preference nor a prediction on the part of OTA for the way in which dispersed photovoltaic systems will be marketed in the future. The costs so calculated are the costs to the utility and do not reflect the price to the consumer. They therefore are directly comparable to the busbar costs of electricity from the solar power satellite.

For homeowners who would prefer not to continue to rely on a central structure for their power, leasing equipment from a utility may not be an acceptable arrangement. Many, however, will not wish to accept the relatively high capital investment and subsequent maintenance which an in stallation requires and will prefer leasing to purchase.

Household and Industrial Photo voltaics: costs and efficiencies

System assumptions:

Array efficiency–18 percent*
Degradation – 5 percent first year, stable thereafter
Systems life– 30 years*
Inverterefficiency—90 percent
Battery efficiency– 75 percent round trip
Array cost — $35 m^2*
Additional installation costs assuming roof replacement — $0.0
Additional installation costs assuming array flat on roof — $1 3/$m^2$
Additional installation costs assuming array on ground – $80/$m^2$
Operation and maintenance–1 percent of initial costs per year
Lightning protection:
Household – $500
Industry– $0
Inversion and power conditioning–$82/kW
Battery lifetime **(deep cycles) –2,000**
Battery initial costs ($/kWh capacity)–$49/kWh
Battery O&M cost (¢/kWh discharged) –O.038¢/kWh
Battery total cost (¢/kWh discharged): 4.3¢/kWh
Battery housing and related costs ($/kWh capacity)– $6.4/kWh
Backup generator, residential –$306/kW
Industrial cogenerator steam turbine–$1,446/kW
Percent backup in system with storage–60 percent

Sample Calculation

The following equations apply, assuming there are no variable O&M costs and no fuel costs.

Busbar costs (¢/KWh) = levelized capital cost/levelized output + levelized fixed O&M/levelized output
Levelized capital cost = FCR X initial capital cost ($/100$m^2$) x 100 ¢/$
FCR (fixed charge rate)= CRF (i/N) + T

$$\text{CRF (i/N) = capital recovery factor} = \frac{1}{1-(1+i)-N}$$

where:

I = weighted cost of capital
N = economic life = book life
T = levelized income taxes =(t/(l-t))(CRF(i/N) -1) x P – (TD – 1/N)
TD = tax allowance for accelerated tax depreciation**
= CRF (i/N) x ((2 x (M – (1/CRF(i/M)))/(M X (M+ 1)X i))
M = tax life
Levelized output = kWh/year/100m2 array
Levelized fixed O&M= O&M($/100m2/yr)X1000/$ X AF(e,i,N)
AF(e,i,N) = CRF(i/N) X (1 – ((1 + e)/(1 + i))N)/(i – e)) X (1 + e)
where e = apparent escalation rate (inflation rate)
Financial assumptions:

I = 0.10
t = 0.30
e = 0.06
N = 30 years for array
= 6 years for batteries
M = 20 years

Example–

A household 100m^2 array mounted on the roof in Boston generates *22,017* kWh/yr:

Cost of array	**.$3,500**
Lightning protection	**$ 500**
Power conditioning ., ...	**$ 650**
Structural support ., ..	**$1,300**
Total ... .,	**.$5,950**

'Assumptions of SPS reference system

**Assumes sum-of-the-years digits depredation method

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O&M costs/year = 1 percent capital costs = $59.56
FCR = 0.12504
Levelized capital cost= 0.125 X 5,956 X 100
= 74,450 ¢/l00m^2/year
Levelized fixed O&M = 9,705 ¢/100m^2/year

Busbar costs (¢/kWh) =

$$\frac{74{,}450}{22{,}017} + \frac{11{,}233}{22{,}017} = 3.9\text{¢/kWh}$$