Renewable Electric Energy Systems EE—546

Social, Economic, Environmental Aspects

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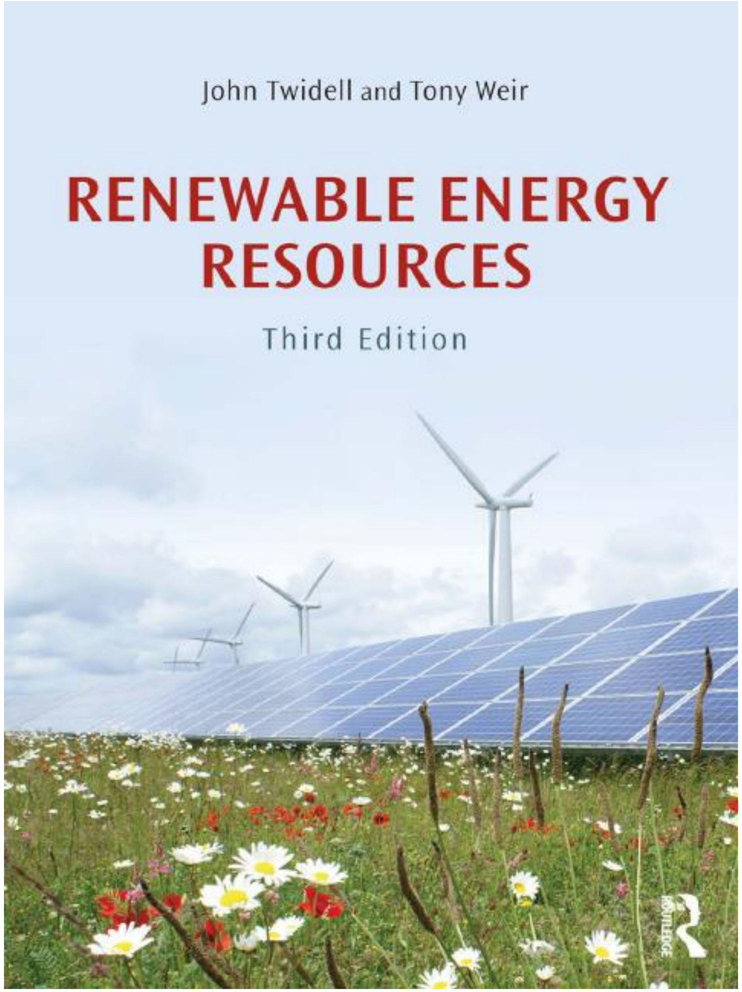
Slides are prepared from: (Various Chapters)



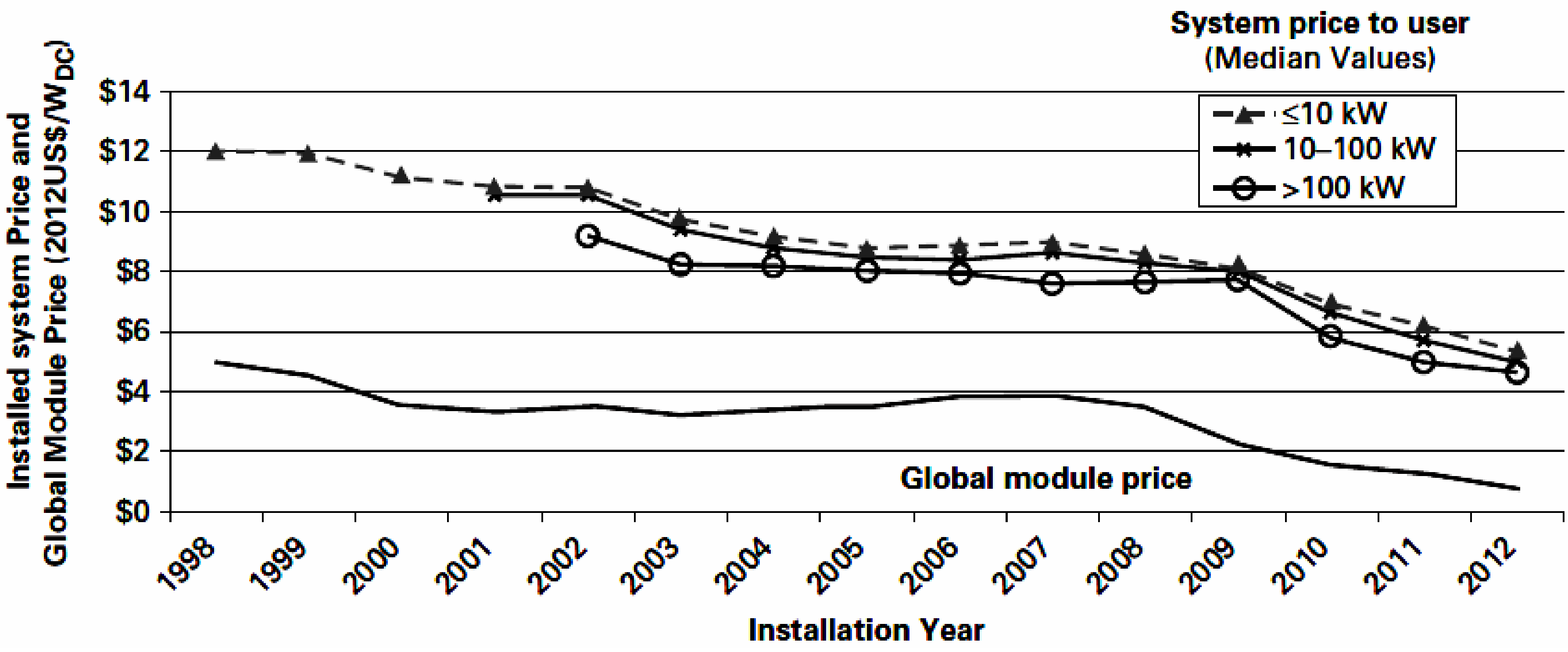
John Twidell and Tony Weir—
Renewable Energy Resources

Photovoltaic—Social, Economic and Environmental Aspects

1. Prices
2. Grid-connected systems
3. Stand-alone systems
4. PV for rural electrification and Urban Areas
5. Environmental impact

Prices

The technology and commercial application of photovoltaic power increased rapidly from the 1980s when ex-factory costs were initially **~$US40/W** but by 2013 had reduced to **~$US1/W**.



Prices

Associated factors include:

(i) The continuing efficiency improvement in the technology and manufacture;

(ii) Public acceptance;

(iii) Minimal environmental impact.

Of particular importance has been the strong demand for PV installations in countries with 'institutional support mechanisms', such as feed-in tariffs (e.g. Germany). These market mechanisms relate to policies to abate climate change emissions from fossil fuels and to increase energy security.

The slight increase in module price around 2006 to 2007 was because the supply of Si for solar cells could not keep up with the growth in demand before new Si foundries were opened in response.

Grid-connected systems: Social and Economic Impact

The major growth in demand for PV has been for grid-connected systems. For example, the sunfacing roof area of the majority of suburban houses in Europe, when mostly covered in grid-connected photovoltaics, generates annually an amount of electricity equal to 50 to 100% of the household's electricity demand. Such householders use their own microgenerated electricity in the daytime, while selling any excess to the grid utility, then at night they buy imported power.

Government institutional support mechanisms help microgenerators establish cost-effective systems by one or more of: (a) mandating utilities to pay for microgenerated electricity at preferential rates (b) subsidizing the initial capital cost of the solar array; and (c) establishing payments for carbon-abatement 'credits' obtained in proportion to the renewable energy generated.

Grid-connected systems: Social and Economic Impact

The economics and ease of construction are improved by the development of ‘structural’ PV panels as made a part of buildings and roofs.

It is reasonable to expect that within a few decades PV will become as incorporated into standard roof structures as glass is into windows now.

Stand-alone systems: Social and Economic Impact

Stand-alone systems which depend on storage batteries are typically twice as expensive per unit capacity as grid-connected systems.

For stand-alone applications, the most important measure is the relative cost of *service delivered at a particular site* (e.g. comparing a PV-powered light of a certain light intensity with a kerosene-fueled light of similar intensity).

Regarding the efficiency of the solar electricity, there is a trade-off between system components (e.g. better energy-efficient appliances require smaller panels and less balance of system cost), so investing in energy efficiency nearly always gives long-term reductions in lifetime expenditure.

Photovoltaic: Environmental Impact

Photovoltaics are environmental-friendly, with no emissions and no noise, although manufacture involves some fully controlled noxious chemicals and uses energy.
Module guaranteed-life by manufacturers is typically at least 20 years, but most modules will generate acceptably for very much longer, perhaps to ~100 years for modules with crystalline cells in good encapsulation.

At end-of-life, modules should be returned for specialist recycling; BUT such facilities are not (yet) common.
The time for a given PV module to generate electricity equal in energy to that used in its manufacture (its *energy payback*) depends on the site insolation and the method of manufacture.

For a typical temperate climate, this energy payback time for single-crystal silicon encapsulated modules is about two to three years; for thin film technologies and for sunnier locations it is less.

Hydropower: Social and Environmental Aspects

Hydropower is a mature technology worldwide.
About 16% of world electricity is hydroelectricity. Hydroelectric plant is not thermally stressed and operates steadily; therefore it is long-lasting with relatively low maintenance requirements: many systems, both large and small, have been in continuous use for over 50 years and some early installations still function after 100 years.

The relatively large initial capital cost has been long since written off, with the 'levelized' cost of electricity produced (i.e. the cost per kWh averaged over the life of the system) much less than other sources,

For hydro plant with an ample supply of water, the flow can be controlled to produce either baseload or rapidly peaking power as demanded; if the water supply is limited, then sale of electricity at only peak demand is easy and most profitable.

Hydropower: Social and Environmental Aspects

Most large dams are built for multiple purposes: electricity generation, water for potable supply and irrigation, controlling river flow, mitigating floods, and providing road crossings, leisure activities, fisheries, etc.

National Social and economic development always requires electricity and water supply, so large-scale projects appeal to national development.

Hydropower: Social and Environmental Aspects

Hydropower, like all renewable energy sources, mitigates emissions of the greenhouse gas CO^2.

Estimates of the life cycle greenhouse gas (GHG) impact of hydropower systems are less than **40 gCO^2-eq/kWh**, which is an order of magnitude less than for fossil systems

Wind Technology: Social and Environmental Aspects

The nation benefits from the use of wind power because electricity from wind power mitigates the emissions and and therefore decreases impact causing climate change. There are also employment and national energy security benefits. The **proprietors** of turbines benefit by income from exported power, and often by their own use of their power.

The key factor for successful wind power is the site wind speed. Generally wind velocity should be $>$**5 m/s** at 10 m height, but windier sites are very worthwhile owing to the u^3 dependence of power output.

Wave—Power: Social and Environmental Aspects

Wave power is relevant to countries with shorelines and offshore rights.

Safety of personnel at sea is of paramount importance, especially as the devices and the work on them in operation are individually new and distinctive.

National policies may favor wave power because of the positive benefits of:

1. The mitigation of greenhouse gas emissions.
2. Increasing national energy security with local generation of electricity.
3. Increased employment and investment.
4. Cooperation and integration with offshore wind farms and other
5. marine resources.

Negative Impacts Of Wave Power Devices

1. Air turbines operating with wave periodicities may be acoustically noisy.
2. Underwater noise, possibly confusing fish and, especially, marine mammals.
3. On-shore structural and visual damage to coastlines.
4. Leaks of hydraulic oils and anti-fouling chemicals may damage marine life.
5. Obstruction to fishing.
6. Distraction by lights at night to birds, including migrating birds.
7. Danger at all times to boats and shipping or broken floating structures with poor visibility and radar profile.
8. Danger of floating devices leading to unknown hazard to shipping.
9. At a very large scale of implementation, changes to marine currents and energy fluxes may be detrimental to marine ecology.