ISSN : 2466-0744

MULTIDISCIPLINE PROCEEDINGS OF

DIGITAL FASHION CONFERENCE

KOREA, REPUBLIC OF

Multidiscipline Proceedings of

DIGITAL FASHION CONFERENCE

August 2022 *(Volume 2, No.4)*

Available at digitalfashionsociety.org
Published:
서울 합정역
파주출판도시
ISSN 2466-0744
Seoul
Korea, Rebuplic of

EDITORIAL BOARD

MAIN CHARACTERISTICS AND DEVELOPMENT OF RENEWABLE ENERGY

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The term "renewable" is generally applied to those energy resources and technologies whose common characteristic is that they are non-depletable or naturally replenish able.

Renewable resources include solar energy, wind, falling water, the heat of the earth (geothermal), plant materials (biomass), waves, ocean currents, temperature differences in the oceans and the energy of the tides. Renewable energy technologies produce power, heat or mechanical energy by converting those resources either to electricity or to motive power. The policy maker concerned with development of the national grid system will focus on those resources that have established themselves commercially and are cost effective for on-grid applications. Such commercial technologies include hydroelectric power, solar energy, fuels derived from biomass, wind energy and geothermal energy. Wave, ocean current, ocean thermal and other technologies that are in the research or early commercial stage, as well as non-electric renewable energy technologies, such as solar water heaters and geothermal heat pumps, are also based on renewable resources, but outside the scope of this Manual.

For the purposes of establishing a legal regime governing and encouraging private-sector investment in renewable resources and technologies, the policy strategist will make use of three conceptual approaches. As well as the foregoing technical definition, both political definitions and legal definitions, factor into a policy definition of what resources deserve discrete treatment as "renewable resources".

From the political perspective, renewable energy resources can be divided into numerous categories depending upon the political goals or objectives under consideration. For example, in a given country, renewable resources may be distinguished by categorizing those which are well established versus those which are underdeveloped; those which have immediate development potential versus those which do not; and those with potential rural versus those with urban customer bases. The political perspective of the policy maker in one country may be to justify different treatment for established resources such as large hydroelectric from nascent resources such as geothermal. In another country, the reverse may be true. Likewise, all of the renewable resources may be treated differently for urban application than for rural application.

Avoid operational definitions. For example, if different types of hydropower are to be treated differently for political or legal reasons, address such treatment in operational language, not by definition. From the legal perspective, existing laws such as land use, water, mining, and hydrocarbon laws need to be scrutinized to determine their potential jurisdiction over and applicability to renewable resources. It is important to define what technologies are to be considered "renewable" for the purposes of any piece of legislation. Such legislation can define "renewable resources" as appropriate, given the state of development of the natural resources in that country. If a court, legislator or executive interprets a law strictly, the term "renewable resources" as used in a piece of legislation means what that specific piece of legislation says it means, but only for the purposes of that specific legislation. Thus, if a law defines coal as "renewable", but omits wind, this legal definition will prevail without reference to the technical characteristics of either fuel. In most legal regimes, however, the term "renewable energy" is used to distinguish naturally replenishable fuels from those fuels of which the earth is endowed with fixed stocks.

The commercial renewable energy technologies. Establish an objective, specific to each renewable resource, which is designed to achieve national goals. Fundamentally, the answer depends on why the question is being asked, and in which country the policy is being applied. There are, however, guidelines which may prove useful to policy strategists making this determination in any country. Essentially, form must follow function. In other words, it is essential that the policy strategist understand the nature of each of the renewable resources and the nature of the process by which each of those resources is developed.

Although any resource that relies on the heat or motion of the earth, the moon or the sun (or the sun's radiation) to produce power for human consumption is a renewable resource, the ways one harnesses the resources are sufficiently different that laws and regulations governing these resources usually deal with each resource on an individual basis - treating each resource as unique. At present, the major commercial grid-connected renewable resources are hydroelectric, geothermal, biomass, wind energy and solar. In the majority of legal regimes, hydroelectric and geothermal resources are identified as owned in common by the people of the country and husbanded by the government for their benefit.

Geothermal resources require extraction (and reinjection). Drilling for geothermal resources involves many of the same discrete considerations involved with drilling for petroleum (hydrocarbons) and individual treatment is prudent.

Hydroelectric resources are inextricably linked with surface water rights, including potable water, navigation, irrigation, navigation and recreational rights. The historical complexities of sorting out these juxtaposed rights usually dictate individual treatment of hydroelectric resource issues.

Wind energy and solar draw on resources - wind and sun energy - generally thought of as being free for the taking.The principal resource issue with both of these renewables is surface land. Therefore there is no general technical requirement for individual treatment.

Biomass is a broadly inclusive term, often encompassing wood and wood waste, agricultural waste and residue, energy crops, and - sometimes - landfill gas resources. Resource availability and cost can be highly variable, and resources may require management of a type not frequently required for other renewables. Individual treatment is one method of addressing this complication.

Renewable energy applications generally break down into two categories or applications, "on-grid" and "off-grid". A "grid" may be defined as an integrated generation, transmission, and distribution system serving numerous customers. Characteristically, a grid is a portfolio of generating units operating under the control of a central dispatch center. Grids may be national, regional or local (in the latter case they are typically referred to as "mini-grids"). "On-grid" and "off-grid" are terms which describe how electricity is delivered. Technically, every one of the commercial renewable resources can be and have been installed both on-grid and off-grid. Furthermore, although larger megawatt installations tend to be on-grid, large renewable plants may profitably be built "inside the fence" - a term describing a self-generator, a plant built to supply a single customer such as a mine, a manufacturing plant or an agribusiness. Hydroelectric, biomass and geothermal facilities tend to be economical at capacity levels well in excess of one megawatt (1 MW) and, therefore, are typically - but not necessarily - developed and financed as "base load" electricity resources (i.e., the normally operated generating facilities within a utility system) and connected to a grid. Solar arrays and "wind farms" also can be grid-connected.

"Off-grid" applications, in general, serve only one load, such as a home or small business. Off-grid applications can take many forms, from photovoltaic for an individual village home to centralized windmills to power a village water pump or a commercial battery charging facility. These off-grid applications are most generally used in remote or rural settings.

"Mini-grids" have begun to be developed by system engineers over the past few years, for isolated communities. These systems may integrate wind, solar energy and, in some cases, diesel generators and/or storage systems to provide power from a mix of resources to more than one customer, typically a village or cooperative.

For more discussion of off-grid and mini-grid issues, see below, Chapter 5a (Universal Electrification Policy: Renewable Technologies & Universal Electrification Efforts). The following charts illustrate common on-grid. and off-grid applications for which renewable energy is best suited.

Policy benefits of renewable energy facilities. Although a complete list of the benefits of renewable technologies can be very extensive, they can be categorized under four headings: environment, diversification, sustainability and economics.

Table 1. Main characteristics of alternative energy resources

On-Grid Uses						
	Hydro	**Wind**	**PV**	**Goo-thermal**	**Bid-mass**	**Solar thermal**
Mini-grid power for village, island, industry, military, tourism, etc	+	+	+	+	+	+
Individual systems for house, clinic school, store, more	+	+	+		+	+
Water pumping, water treatment	+	+	+		+	+
Unattended loads (e.g., telecom)	+	+	+	+		+
Space heating, water heating	+	+		+	+	+
Process heat, cogeneration				+	+	+

Renewable energy facilities generally have a very modest impact on their surrounding environment. The discharges of unwanted or unhealthy substances into the air, ground or water commonly associated with other forms of generation can be reduced significantly by deploying renewables. Clean technologies can also produce significant indirect economic benefits. For example, unlike fossil-fuel facilities, renewable facilities will not need to be fitted with scrubbing technology to mitigate air pollution, nor will a country need to expend resources in cleaning up polluted rivers or the earth around sites contaminated with fossil-fuel by-products. Furthermore, they provide greenhouse gas reduction benefits and should a worldwide market for air emission credits emerge as has been predicted, countries with a strong portfolio of renewable energy projects may be able to earn pollution credits, which can be exchanged for hard currency. Finally, having a clean environmental profile enhances the attractiveness of renewable projects in the eyes of investors, especially the multilateral development agencies, many of whom operate under guidelines that require the promotion of non-polluting technologies.

Cost-effectiveness of renewable energy. Universally, the goal of electric power generation planners is to deliver electricity to the maximum number of customers at the lowest possible price. The political acceptability of power generated from any source will depend upon the ultimate tariff to the consumer relative to the benefits delivered.

On a total cost basis, a new, renewable energy, generating facility is often cost competitive with a conventional fuel facility provided that the cost calculation considers long-term fuel costs - and even more so when one considers environmental costs and benefits. Since this generalization is not true in every situation confronting the policy planner, the policy planner will need to apply cost-effectiveness criteria adapted to each situation.

Any given electric generating technology (including renewables) may be cost effective in one market or application and not in another. There is no simple calculus a policy maker can apply, but a number of established criteria will assist in determining the financial viability of renewable energy generation.

The quality and quantity of the resource. Quality and quantity of renewable resources may be determined by a government-conducted resource assessment, but private-sector developers commonly have their own pre-feasibility and feasibility studies which can be more accurate measures of the commercial viability of a given project. The measures of resource quality and quantity are unique to each resource, but for each of the renewables, resource quality and quantity affects the energy input to, and the effective capacity of a generation facility. In geothermal resource development, for example, the temperature of the resource and the dissolved impurities determine the requisite production equi pment.The cost of production equi pment, in turn, affects the installed cost and the per-kilowatt-hour cost of delivered power. In biomass, the quality and BTU content of the fuel will influence installed costs, and operations and maintenance costs.

The location of the resource. Proximity of a resource to a customer base directly impacts costs, as does proximity to an existing infrastructure (roads, transmission lines, etc.), to industry support facilities (concrete plants, etc.), and to the developer's technology manufacturing base. In the case of geothermal, the depth of the resource is a major cost factor. For the hydro, wind and solar technologies, climatic variations (rainfall, cloud cover, intense storms) affect cost. For biomass, transportation distances between the fuel source and the generating facility may significantly affect the electricity cost.

Government-imposed costs. For the private-sector developer, time is money. The time expended in responding to bid proposals, in obtaining requisite permits, licenses and concessions, and in negotiating contracts increases the costs of renewable projects. The policy maker should consider policies that organize and simplify the local institutional processes. Such policies may prevent adding major costs and time delays to what would otherwise be a highly cost-effective facility. Similarly, government-imposed taxes, fees, tariffs and royalty payments are all passed to the electricity consumer and effect the kilowatt-hour cost of delivered power.

Cost of Electricity. Since renewable energy projects are front-end-loaded, the costs of capital significantly affects installed cost. High risk factors associated with initial projects developed in new resource areas also translate into higher costs of capital. The challenge for the country policy maker - especially in a country which seeks to attract initial projects to a new resource area - is to implement new mechanisms to lower financing costs. Development of such mechanisms may prove more productive if done in consultation with the private-sector developer.For example, in some situations, munici pal customers may have access to tax-exempt or low interest bonds that can be used to finance energy projects at a lower cost than if they were financed with conventional borrowing.

In a rapidly advancing technological era, the most prudent course for a decision maker is to avoid reliance on old information as to whether a given renewable technology can fulfill a given energy need.

Table 2. Main and important quality characteristics of alternative energy resources

Important Characteristics			
	Options	**Status**	**Capacity**
Small hydro	Low to high head turbines and dams. Run of river.	Virtually all are commercial.	Factor Intermittent to base load.
Wind	Horizontal and vertical axis wind turbines. Wind Pumps.	Commercial. New designs under development.	Variable, 20 to 40%.
Solar	Photovoltaic. Active thermal (low to high temp for heat or electricity). Passive thermal.	Most commercial. Some under development or refinement.	W/o storage: <25%, intermittent W/thermal storage: 40 to 60%, intermediate.
Geothermal	Cycles: Dry steam, Flash, and Binary	Commercial. Exploration and drilling improvements underway.	High, base load.
Bioenergy	Combustion. Fermentation. Digestion. Gasification. Liquefication.	Many commercial. More under development or refinement.	US wood plants average 95+%. Intermediate, peaking also possible.

System costs. The cost or cost-savings of integrating a given renewable energy generator into a system is difficult to quantify. By diversifying the energy supply mix, a system can protect or buffer the ratepayer from the potential financial risks and volatility of changing fuel prices, changing environmental requirements, and common design flaws that can result in large operational and maintenance costs. Reliance on imported fuels may be eliminated and balances of payment problems thereby reduced. With the exception of biomass, there are no intrinsic fuel costs for an established renewable energy generating facility. Consequently, an established renewable facility serves as a hedge against inflation in an inflationary market.

For an example of a renewable facility as an inflationary hedge one may examine the history of the older hydroelectric power dams. The following chart illustrates the renewable technologies which are currently available in the marketplace.

All six renewable energy sectors offer technologies which are proven and are available in the marketplace. All can be purchased today in forms that are reliable and cost-competitive.