# Alternative Energy Technologies – A Review of Current Applications and Merits

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**Abstract –** Alternative energy technologies nowadays include many renewable energy and energy efficiency technologies that are cost effective and well established in the marketplace. In this paper, it is presented here those "alternative" choices for policymakers that may not have considered renewables or efficiency as a way to increase energy security, create new economic markets, and lower air pollution levels in their areas. Their applications and possible merits are reviewed with typical examples.

## INTRODUCTION

Alternative energy technologies are of increasing importance worldwide mainly due to both environmental considerations and the concern of non-renewable energy resources shortage in the future. We may classify alternative energy technologies into two major types of technologies in current use.

**(1) Renewable Energy**
Renewable energy comes from sources that are essentially inexhaustible. These energy supplies can be endless resources such as the sun, the wind, and the heat of the Earth, or they can be replaceable fuels such as plants. In contrast, fossil fuels-oil, coal, and natural gas-form so slowly in comparison to our rate of energy use that they are considered finite or limited resources.

The sun is an infinite source of energy for our planet. Current technologies allow us to harness this solar energy for heating, lighting, cooling, and electricity. The sun's energy can be converted to electricity either directly through photovoltaic cells (solar cells) or indirectly by concentrating the sun's heat and using it to run a steam turbine. The sun's heat can be used for hot water heating or solar cooling. The sun's heat drives the winds, which produce energy that is captured with wind turbines. And sunlight causes plants to grow, yielding stored energy in the form of biomass that can be converted into fuels or burned to produce electricity.

Geothermal energy-heat from the Earth-is considered a renewable energy resource since it is so vast as to be inexhaustible. And hydropower energy-using the energy of water in rivers-can also be a source of renewable energy.

**(2) Energy Efficiency**
Energy efficiency means doing the same work—or more—with less energy. Energy efficiency increases the comfort levels in schools, homes, business and government buildings. By using the sun's heat and creatively structuring the building's envelope, natural light augments artificial to create comfortable ventilation, heating, and air conditioning. Energy efficient features can include:

- Shading or coatings on windows to minimize heat gain in the summer and allow heat in the winter
- Efficient lighting, including compact fluorescent bulbs augmented by skylights and windows for daylight
- Innovative technologies for heating and air conditioning
- Efficient insulation, a tight building structure, and a well-managed ventilation system to keep in heat or air conditioning
- Energy efficient appliances and equipment for office, home, and school
- Computer system to optimize energy use.

Energy efficiency is cheaper than building new power plants. For this reason, energy efficiency has been a major supply source in recent decades. Over the past 30 years, the United States saved as much energy through efficiency as it produced from all new American oil and gas wells, coal mines, and power plants. This section gives a general background and review of the paper or work done by other engineers in the field. It should be well supported by citations. Moreover, the citations are served as a guide for those who want to learn more about the field.

**Main Types of Alternative Energy Technologies**

(1) Renewable Energy Types :

Wind

Solar (Photovoltaics, Solar Thermal, Concentrating Solar Power)

Hydropower

Biomass & biofuels

Geothermal

(2) Energy Efficiency Types :

Appliances

Lighting, heating & cooling

Building controls and design

Combine heat & power (Co-generation)

Combine cycle & pumped storage

WIND ENERGY

## Wind Power Technology Overview

Wind turbines convert the power in the wind into electricity. By extracting the kinetic energy in the wind, wind turbines generate mechanical power. In the past, mechanical wind machines were widely used for specific tasks, such as pumping water or grinding grain. Today, wind turbines commonly use this mechanical power to generate electricity.

Fig.1 Large wind turbines for utility electricity generation in mid-USA.

Wind technology is versatile and adaptable. A small stand-alone wind turbine can provide enough power for a typical U.S. household, while groups of larger turbines combine to generate utility-scale electricity. These large arrays, called wind farms or wind plants, deliver power to an integrated grid. This setup is very reliable: at any time, several wind turbines at a wind plant may be shut down for maintenance, but most of the turbines will still be running. ( Fig. 1 )

PV Technology

## Technology Overview of PV

Photovoltaic (or PV) cells are devices that use semiconductor materials—similar to those used in computer chips—to convert sunlight directly into electricity. The electric current can either be used immediately, or it may be stored, as in a battery, for later use.

A typical PV or solar cell might be a square that measures about 4 inches (10 centimeters) on a side. A cell can produce about 1 watt of power—more than enough to power a watch, but not enough to run a radio.

When more power is needed, some 40 PV cells can be connected together to form a "module."( Fig. 5 ) A typical module is powerful enough to light a small light bulb. For larger power needs, about 10 such modules are mounted in PV "arrays," which can measure up to several meters on a side. The amount of electricity generated by an array increases as more modules are added.

Hydropower

## Technology Overview of Hydropower

Hydropower is the kinetic energy of flowing water, which when captured can be used to power machinery or converted to electricity. Typically, hydropower plants dam a river or stream to store water in a reservoir. When the water is released from the reservoir, it flows through a turbine, causing it to spin and activating a generator to produce electricity.

Fig.2 Large hydropower plants such as the Bonneville power plant on the Columbia River provide most of the electricity in the Northwest United States.

Plants that do not require dams may channel a portion of a river or stream through a small canal containing a turbine, or they may pump water to a holding area from where it can be released to generate electricity.

Today's hydropower plants range in size from small, local projects producing several hundred kilowatts to huge dams and reservoirs that generate 10,000 MW or more and supply energy to millions of people.

By the early 1900s, hydroelectric power accounted for more than 40% of the nation's supply of electricity. In the 1940s, hydropower provided about 75% of all the electricity consumed in the West and the Pacific Northwest and about one third of the total United States' electrical energy. With the increase in development of other forms of electric power generation, hydropower's percentage has slowly declined and today provides about one tenth of the nation's electricity.

Still, hydropower is the nation's leading renewable energy source. It accounts for 81% of the nation's total renewable electricity generation.

Energy Efficient Building Controls

## Technology Overview of Energy Efficient Building Controls

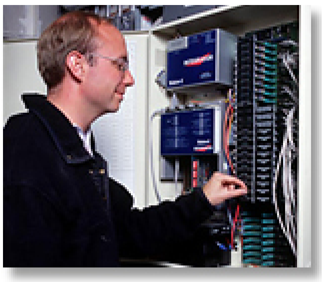


Fig. 3 Energy management system in a retail complex, Colorado, USA.

Within buildings, many systems work together and directly affect one another. For example, changes in a lighting system will have a direct impact on the energy used by the building's heating and cooling system.

In the past, conventional design and construction treated these systems separately. Today, most major building projects use building management technology to analyze the building as a whole, optimizing all of the systems with the goal of minimizing overall energy use as well as providing a comfortable environment. This is called Whole Building Design.

The Rocky Mountain Institute estimates that as much as 40% of a building's cooling load during summer months can be spent cooling the heat made by inefficient lighting systems. New, advanced building systems involve computers, sensors, monitoring devices, actuators, and controllers that respond to changes in energy use—usually minimizing energy consumption. ( Fig. 6 )

Building management technology or automation/control systems are intended to optimize the performance of the building's various sub-systems. These systems use computer-based monitoring to optimize building control subsystems such as:

- Heating, Ventilation, and Air Conditioning (HVAC)
- Elevators
- Fire
- Electrical monitoring/management
- Lighting
- Security &
- closed circuit TV
- Life safety
- Access control

## Technology Overview of Lighting

Fig. 4 A Shopping Center in Silverthorne, Colorado, USA uses natural daylighting and compact fluorescent bulbs to improve energy use.

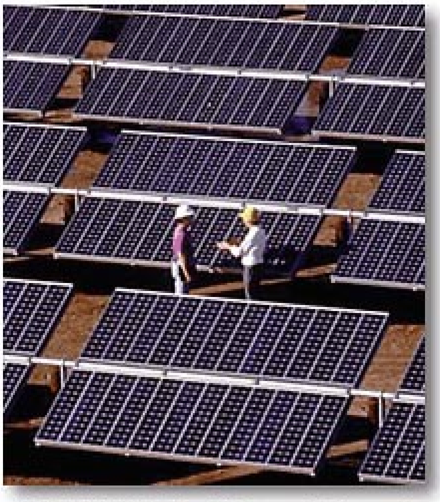
According to the US Environmental Protection Agency's ENERGY STAR Program, lighting consumes 25%-40% of the energy used in commercial buildings and is a primary source of waste heat.

The Department of Energy estimates that technology developed over the past 10 years can help cut lighting costs 30%-60% while enhancing lighting quality and reducing environmental impacts. The improvements in technology over the last decade have primarily focused on:

- More energy-efficient lamp and ballast (devices that control the electricity used) technology
- Innovations in lighting control systems
- More use of daylighting in building design.

The change by commercial users to the energy-efficient fluorescent bulbs with electronic ballasts has saved consumers more than $1 billion in avoided energy costs. Further efficiency gains have come from switching to smaller fluorescent bulbs (T12 to T8). This market success has led to the development of compact fluorescent light bulbs (CFLs) as an energy-efficient alternative to the common incandescent bulbs in residential, commercial, and industrial use. Not only do CFLs use less energy, but they have a dramatically increased life per bulb. For more information see the Energy Star Web site.

Yet lighting energy can still be squandered if it is not well managed. Lighting controls that use both occupancy sensors and scheduling to reduce the lighting of unoccupied spaces, as well as photo-sensors to integrate daylight, can reduce lighting energy consumption by at least 30%-35% compared to an already efficient electronic ballast system. This reduction can lower building operating costs by 10% or more.



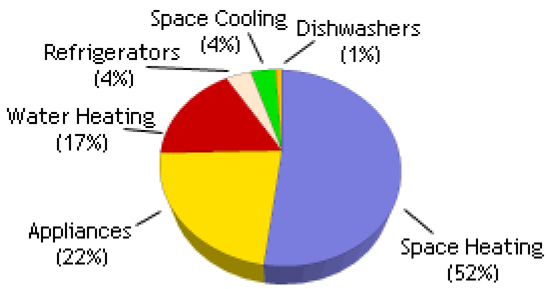
A 210-kW flat-plate PV array that is used for grid support.

Fig. 5 Photovoltaic application example

## Conclusion

This paper reports on selected alternative energy technologies that include many renewable energy and energy efficiency technologies that are cost effective and well established in the marketplace. In particular, we present here those "alternative" choices for policymakers that may not have considered renewables or efficiency as a way to increase energy security, create new economic markets, and lower air pollution levels in their areas. Their possible applications and benefits are reviewed with reference to environmental merits as well.

**Fig. 6 Average Energy Use in Homes in USA**




Source: Energy Information Administration

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