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Advance Techniques of Harvesting Energy by Using Versatile Energy Regeneration and Energy Reservoir Network

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Abstract: ***Apart from so many conventional and non-conventional energy resources available nowadays, this paper is about advance techniques of regenerating/recycling energy from various phenomena we use and experience in day to day life just by implementing some innovative approach. We can reserve the regenerated energy in Energy Reservoirs for further use. Here we are introducing the new innovative approach of creating "Energy Reservoir Network". This network can fulfill the various requirements like hospital's emergency generators, lighting the streets or running and the common water pumps etc. The idea is similar to that of connecting all rivers of country and providing water to dry areas using canals. Here, various methods for regeneration and recycling of energy are discussed and how we can contribute to Energy Reservoir Network.***

Keywords: Regeneration of Energy, Energy Reservoir Network, Energy Harvesting, Energy Recycling, Reusing the Energy

1. Introduction

With the increasing problems of climate change, global warming and pollution, it is desirable to find the solution in which the use of energy resources is marginal and their efficiency maximum. We use mechanical energy, light energy, heat energy and sound energy; all converted from electrical energy in our house hold or commercial appliances. Once the energy gets converted into our desired application, the full efficiency is not achieved and energy gets wasted. Our approach, hereby, is to regenerate the converted energy in other usable form. We have discussed here the various techniques of regeneration/recycling of converted energy. This regenerated energy can be used again in house or in commercial unit for power saving and remaining energy gets stored in nearby energy reservoir and all such reservoirs are connected in network, which is also discussed in detail here. The common and ubiquitous energy usage like lighting the streets, running emergency generators in hospital or even charging the electric transport can be fulfilled with this network. Though the energy contribution by each house or commercial unit will be less comparatively, the final energy contribution in reservoir network will be so high enough considering the mass population and energy used by them.

2. The Requirement of Energy Regeneration

To achieve the shortage of energy requirement in coming years considering the factors of estimated GDP, our investment in Energy Sectors and availability of various resources, a huge gap is going to be created between demand and supply of energy. According to FDI research analysis report, an estimated total of 199,877 MW was generated during the 11th Plan. During the 12th Plan (i.e. 1 April, 2012 to 31 March, 2017), an estimated 4,000 MW is expected to be lost due to old and inefficient power plants being taken out of the grid. The shortfall and growing demand for energy is holding India's economy back. In previous years, India's imports of energy products amounted to about 24% of its total primary energy consumption, and approximately a third of its commercial energy consumption. These proportions will rise to around 28% of total primary consumption, or 32% of its commercial consumption in 2030 under the most energy-efficient scenario. The projected change in the mix of generation by fuel source sees a major realignment. Renewable sources will account for 9% of power generation in 2017, up from 6% in 2012; they will then increase again to 16% in 2030. On the other hand, power from hydro-capacity is expected to fall from 15% in 2012 to 11% in 2030.

Table 1: Energy Availability vs. Requirement (Source: FDI)

Estimated Energy Demand and Availability in India to 2030				
	6% GDP growth		9% GDP growth	
Year	Availability (MWh)	Requirement (MWh)	Availability (MWh)	Requirement (MWh)
2022-2023	135,0970	147,5694	147,5557	156,3417
2023-2024	139,8593	153,8556	154,4625	164,3502
2024-2025	146,1028	158,4480	163,2590	170,9702
2025-2026	150,8974	165,3073	171,0152	180,3428
2026-2027	156,3755	171,7948	179,6590	189,5032
2027-2028	162,9881	177,3016	189,8458	198,0141
2028-2029	168,3787	184,7725	199,2190	208,9603
2029-2030	174,9042	191,2633	210,1358	219,2571

India's share of the world's supply of fossil fuels is expected to be between 3.7% and 10.9% by the year 2032 with the most energy efficient scenario considered. Importantly, India's growing demand for commercial energy could account for 13% of the world's incremental supply of commercial energy. India faces an uphill task to secure these quantities since it will face strong competition for finite energy sources. Other developing countries with high growth rates have already moved to try to secure their share of the world's commercial energy supplies. Furthermore, these countries will wish to further enhance those shares. Given the finite resources available, the price of energy will consequently increase, until major alternative sources and technologies become available. Therefore, India will have to follow the most efficient way to fulfil the gap between availability and requirement. [1]

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3. Energy Regeneration by Various methods

Leaving aside the conventional and non-conventional methods, here, we are going to discuss how we can regenerate or recycle the energy after used by appliances. There are various forms in which electric energy gets converted into, like kinetic energy, mechanical energy, thermal energy, light energy and vibrational energy. All possible regeneration techniques are discussed below;-

3.1 Using Kinetic Energy and Mechanical energy

Mini or Micro turbines can be connected with water pipes in such a way when there's water flow through the pipe, turbines gets rotated. It, further, rotates the conducting coil kept inside magnetic field, which generates emf. It is desirable to keep this arrangement with high pressure water flow pipe. The more is the pressure in the water pipe, the more are the rpms of turbines and hence more emf can be generated.

The same phenomenon can be used with fuel gas pipes. LPG or PNG gas reaches to the appliances like stove or geyser with the flow of pressure, Micro turbines attached with these pipes can serve the purpose.

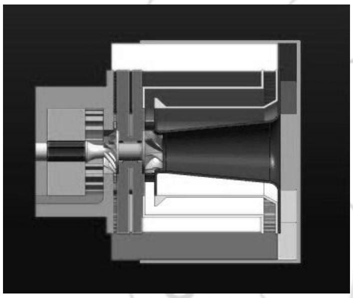

Figure 1: Micro Turbine with 20mm rotor diameter and Piezoelectric Diaphragm

Above figure shows the general layout of the micro turbine. The compressor and turbine impellers are 20 mm in diameter. An exhaust diffuser is added to create a sub-ambient pressure at the turbine exit, such that more power can be extracted. To avoid demagnetisation of the magnets, the generator is located away from the hot parts and the inlet air is aspirated through cooling channels in the generator stator. Generator, compressor and turbine are mounted on a single shaft for simplicity and reliability. Other than this, external rotors are attached with fans, motors and any parts of machinery having rotational motion. This appliances converts electrical energy into mechanical energy, we want to convert it again to electrical energy using rotors connected to turbines and then to mini generators. The conducting coil will rotate against magnetic field and the emf will be induced. Long durable magnets are used in generators to provide sustainable magnetic field. [2]

3.2 Using Vibrational Energy in Piezoelectric Diaphragm

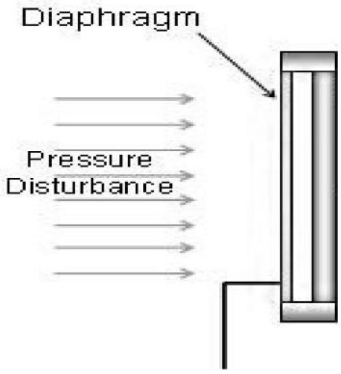

Figure 2: Piezoelectric Diaphragm

Piezoelectric based generators use thin membranes or cantilever beams made of piezoelectric crystals as a transducer mechanism. When the crystal is put under strain by the kinetic energy of the vibration a small amount of current is produced thanks to the piezoelectric effect. These mechanisms are usually very simple with few moving parts, and they tend to have a very long service life. This makes them the most popular method of harvesting the energy from vibrations. These mechanisms can be manufactured using the MEMS (Microelectromechanical Systems) fabrication process, which allows them to be created on a very small scale. The ability to make piezoelectric generators on such a small scale is the main advantage of this method over the electromagnetic generators, especially when the generator is being developed to power microelectronic devices. The linear electrical behaviour of the material is

$$D_i = \varepsilon_{ij} E_j$$

Where D = Electric Charge Density Displacement
ε = Electric Permittivity
E = Electric Field Strength

Even human movements produce more harvestable energy than others, with repetitive motions like left-right, up-down and back-forth. This is illustrated by the researchers' finding that writing with a pencil or opening a drawer produces more harvestable energy (10-30 microwatts) than a plane flight at its most turbulent intervals (5 microwatts). For comparison, walking produces somewhere in the region of 100-200 microwatts. The researchers found that intentionally shaking an object, as demonstrated by shake flashlights, creates more than 3,000 microwatts (3 mW).

Table 2: Energy Harvesting by Human Vibrational Motion

Scenario	$\overline{P}$
Taking a book off a shelf	<10 μW
Putting on reading glasses	<10 μW
Reading a book	<10 μW
Writing with a pencil	10–15 μW
Opening a drawer	10–30 μW
Spinning in a swivel chair	<10 μW
Opening a building door	<1 μW
Shaking an object	>3,000 μW

In the above table, the microwatt (μW) figures are from the point of view of the object; as in, the object itself is equipped with an inertial energy harvester.

As we can see that most of our interactions with the environment do not produce a lot of energy. According to the researchers this is exacerbated by objects, such as doors and drawers, being dampened for human comfort. If the inertial harvester could be placed in the damper, at the time of production, much more energy could be produced. [3]

3.3 Using Seebeck Effect in Thermocouple and Using Photovoltaic Cell Panels

When there is a temperature difference two different conducting materials connected with each other, the generated emf is observed. This is because the electron energy levels in each metal are different and a voltage difference between the junctions creates an electrical current and therefore a magnetic field around the wires. The Seebeck effect is a classic example of an electromotive force and leads to measurable conductivity. The emf produced due to Seebeck effect is given by

$$V = a\,(T_h - T_c)$$

Where V = Voltage produced between two ends
a = Seebeck Co-efficient
T_h = Temperature of hot junction
T_c = Temperature of cold junction

A thermoelectric circuit is composed of materials of different Seebeck coefficient (p-doped and n-doped semiconductors), configured as a thermoelectric generator. [4] Another regeneration task can be fulfilled by placing a series of small photovoltaic cells placed near all household and commercial light sources. These panels can be positioned above the LED bulbs or other intense lighting devices. [5]

4. Forming the Energy Reservoir Network

Though energy regenerated or recycled by each of the above methods will have the less efficiency as the derived output power is always less than the input power due to power dissipation in all systems. The energy efficiency can be achieved by collecting all such small segments of recycled energy and fed them to Energy reservoirs. Each energy reservoir units are made of either electrochemical or electrical storage technology.

Electrochemical Storage includes Lead Acid battery. Stationary lead acid batteries have to meet far higher product quality standards than starter batteries. Typical service life is 6 to 15 years with a cycle life of 1500 cycles at 80% depth of discharge, and they achieve cycle efficiency levels of around 80% to 90%. Lead acid batteries offer a mature and well-researched technology at low cost. There are many types of lead acid batteries available, e.g. vented and sealed housing versions (called valve regulated lead acid batteries, VRLA). Other batteries which are widely used are Nickel Cadmium (NiCd) and Nickel Metal Hydride (NiMH) battery, Lithium ion battery, Sodium Sulphur (NaS) battery, Sodium Nickel Chloride (NaNiCl) battery.

In classification of electrical storage systems, DLCs (Double Layer Capacitors) are widely used. They are also known as super capacitors. They fill the gap between classical capacitors used in electronics and general batteries, because of their nearly unlimited cycle stability as well as extremely high power capability. This technology exhibits a large development potential which has greater capacitance and energy density than conventional capacitors, thus enabling compact designs. The two main features are the extremely high capacitance values, of the order of many thousand farads, and the feasibility of very fast charging and discharging due to extraordinarily low inner resistance which is normally not possible with other conventional batteries. There are other advantages are like durability, high reliability, no maintenance, long lifetime and operation over a wide temperature range and in diverse environments (hot, cold and moist). The lifetime reaches one million cycles (or ten years of operation) without any degradation, except for the solvent used in the capacitors whose disadvantage is that it deteriorates in 5 or 6 years irrespective of the number of cycles. They are environmentally friendly and easily recycled or neutralized. The efficiency is typically around 90 % and discharge times are in the range of seconds to hours.

They can reach a specific power density which is about ten times higher than that of conventional. Because of their properties, DLCs are suited especially to applications with a large number of short charge/discharge cycles, where their high performance characteristics can be used. [5]

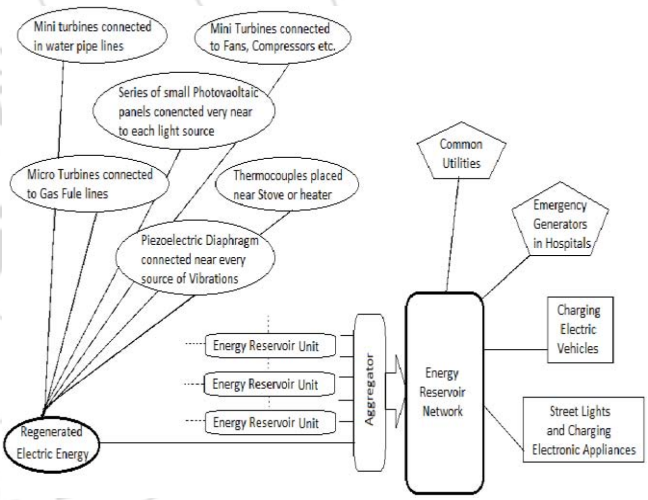

Figure 3: Schematic for Implementation of Energy Regeneration and Energy Reservoir Network

Above schematic gives the idea about how we can connect all regeneration units to energy reservoir and further connect all of them in a network. Such network is comprised of individual energy reservoirs connected using aggregator to the main network. This network can be used for all desired purpose like common utilities for public, running emergency generators in hospitals, charging electric vehicles, for street lights and charging electronic appliances. In case of power failures, this system can be very much useful. By implementing the Energy Reservoir Network, it is also possible to supply recycled energy to remote interior places of the states in the country where there is a shortage of electric energy.

5. Recommendations for Future Implementation

- Mechanical Energy of Elevators can largely be converted into Electrical Energy. Elevators move bidirectional. To run the turbines connected to the elevators in particular direction, ratchets can be used.
- Micro rollers in playing slides and ratchets with swings can be placed in Children Park. These rollers and ratchets can be converted to mini generators to regenerate electrical energy from kinetic and mechanical energy.
- Excess energy produced by heavy vehicles converting kinetic energy into electric energy by regenerative brakes can be stored at charging stations.

6. Advantages of Energy Reservoir Network

- Dependence on fossil fuels and other conventional energy sources will be decreased.
- Extravagance in Energy Sector will be reduced; hence overall economic growth will be increased.
- The techniques we described, use noncombustible technology; hence Co_2 emission will be reduced and it will decrease pollution and climate change.
- People will have to spend less money to get more energy. In comparison to initial investment to setup this network, the outcome is considerably beneficial.

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