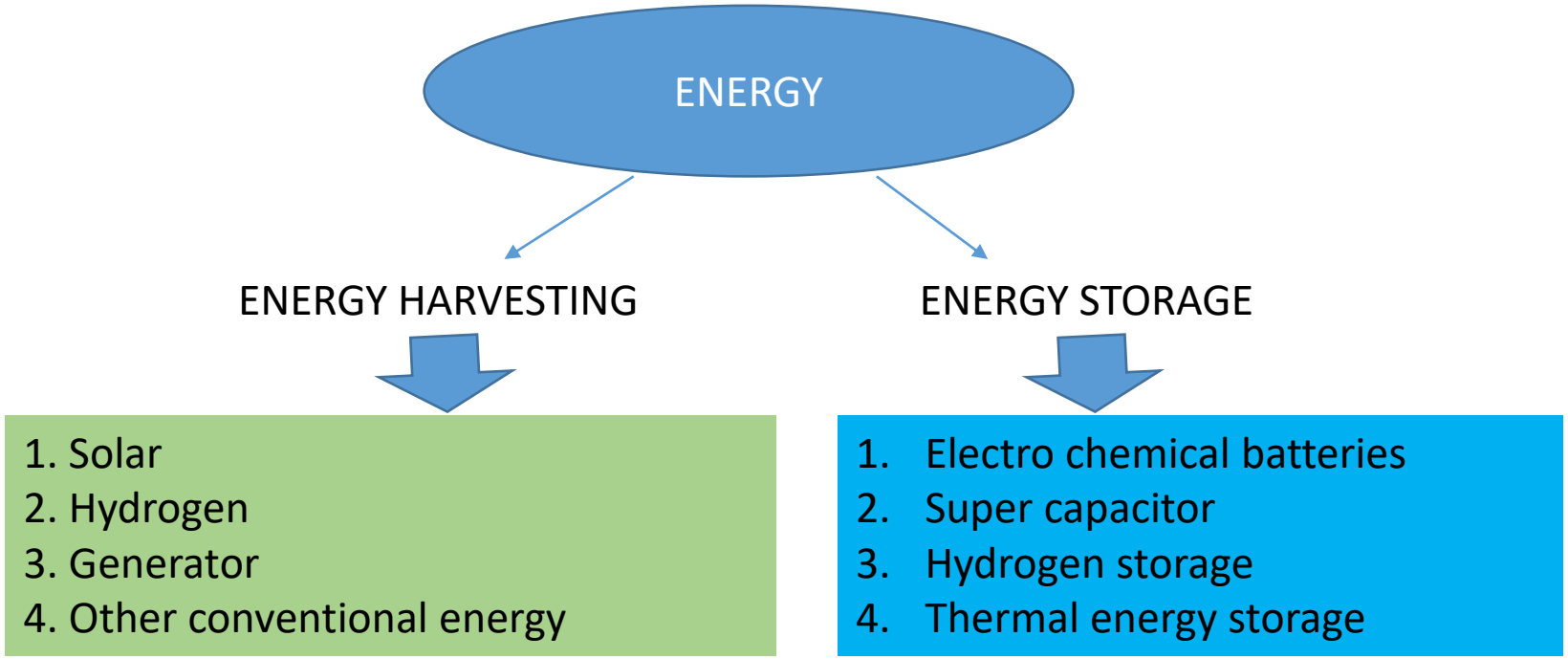
# Energy materials

# What is energy ??

- Energy/Power derived from the utilization of physical or chemical resources to provide light and heat or to work machines.
- It neither be created nor be destroyed and can be transfer from one system to another system.



# Energy harvesting

- Also known as power harvesting or energy scavenging.
- It is a process that capture small amount of energy, That would otherwise lost as heat, light sound, vibration and stored for small wireless autonomous devices.
- Typically generates several microwatts to several miliwatts.

Advantages:

- ✓ Self sustainable
- ✓ Unlimited usage
- ✓ Mobility and promote truly autonomous
- ✓ Environmental friendliness

Applications:

- ✓ Charging of electronic devices
- ✓ Remote area sensing
- ✓ Industrial automations
- ✓ Lifestyle managements
- ✓ Structural health monitoring
- ✓ Autonomous Network
- ✓ Eco management

# Solar energy harvesting

- The amount of energy in the form of heat and light supplied by the sun to the earth in a single day is sufficient to total energy needs of the earth for one year.
- This process is used to capture and store solar energy,
- Solar energy is use to convert into electrical energy.

**Materials used in SHE**

1) Silicon,
2) Solar thermal (Cu-Ni-Mn Spinel composite)
3) Die sensitized solar cell, Perovskites

# Hydrogen energy harvesting

- Hydrogen is most abundant element in the earth. Hydrogen is not available in free form but bounded with water and natural gas.
- also in Bio mass, fossils fuels, and other hydrogen containing compounds.(in lower concentration)
- A fuel cell converts chemical energy into electrical energy and heat.
- A fuel cell combines hydrogen and oxygen to produce electricity.

**Materials used**

natural gas, oil, coal, and electrolysis; which account for 48%, 30%, 18% and 4% of the world's hydrogen production respectively. Fossil fuels are the dominant source of industrial hydrogen.

# Electric generators

It converts Thermal/ Mechanical energy into electricity.

**Type of generators:**

1) Piezoelectric generators: **Ceramics are commonly used as piezoelectric elements**.
Some examples include Zinc Oxide, Barium titanate, and Lead zirconate titanate.
2) Triboelectric generators : **polymers, metals, and inorganic materials**. The most commonly used materials are dielectric polymers such as PTFE, FEP, PDMS, and Kapton.
3) Pyroelectric generators: **polycrystalline thin film on silicon (MEMS),** $PbTiO_3$, (001) thin-film epitaxy on Pt/MgO
4) Thermoelectric generators: **bismuth (Bi2Te3) telluride, lead telluride (PbTe) and Silicon germanium (SiGe)**.
5) Electromagnetic generators: **magnetic steels and copper** for wirings in electromagnet generators or steels, copper, boron, neodymium

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| A triboelectric nanogenerator is an energy harvesting device that converts the external mechanical energy into electricity by a conjunction of triboelectric effect and electrostatic induction. | A pyroelectric generators (PEG) was fabricated using nanocomposite. | A thermoelectric generator, also called a Seebeck generator, is a solid state device that converts heat flux directly into electrical energy through a phenomenon called the Seebeck effect. | In electricity generation, a generator is a device that converts motive power into electric power for use in an external circuit | A piezoelectric generator converts mechanical energy into electricity and is used in energy harvesting devices. |

# Other energy harvesting system

**Wind energy:** wind is caused by the uneven heating of the atmosphere by the sun, variation in the earth surface And rotation in the earth.
Wind flow influenced by mountains and vegetation. Wind turbine converts wind energy into electricity,
**Materials used:**
steel (66-79% of total turbine mass); fiberglass, resin or plastic (11-16%); iron or cast iron (5-17%);
copper (1%); and aluminum (0-2%).

**Tidal energy:** moving water to spin turbine and produce electricity
Tidal rise and fall due to the gravitational pull of the sun and moon, it is consider as renewable.
**Materials used:**
Anti corrosive coting on turbine blade and rotor like, WC/Co etc.

Geothermal energy: (renewable resources → Independent of weather and always active)
two source of energy a) radioactive decay in the earth crust b) heat trickling through the mantle from the earth's core.
Materials used: Hot water can be released through **geysers, hot springs, steam vents, underwater hydrothermal vents, and mud pots**. These are all sources of geothermal energy.

Thermal power plant energy: this process generating electricity from heat. Heat energy can be produced by
Burning fuel, wood, oil, gas, coal etc. these materials produce heat energy and it is used to create steam steam
Drives the steam turbine which is connected with generator.
Materials used :
Inorganic salt ($LiClO_3 \cdot 3H_2O$), Polyglycol E400 (organic), Paraffin $C_{15}$–$C_{16}$ (organic)

# *Energy storage*

In simplest terms, energy storage enables electricity to be saved for a later, when and where it is most needed o the capture of energy produced at one time for use at a later time. A device which store energy is called accumulator or battery.

Ultimately, storage is an enabling technology. It can save consumers money, improve reliability and resilience, integrate generation sources, and help reduce environmental impacts.

***Method used for energy storage:***

- ***Super capacitors,***
- ***Batteries,***
- ***Flywheel energy storage,***
- ***Thermal energy storage,***
- ***Hydrogen storage.***

# *Benefits of energy storage*

❑ **Save money :**

Energy storage can save…….

- operational costs in powering the grid,
- money for electricity consumers who install energy storage in their homes and businesses.
- reduce the cost to provide frequency regulation and spinning reserve services,
- offset the costs to consumers by storing low-cost energy and using it later, during peak periods at higher electricity rates.
- By using energy storage during brief outages, businesses can avoid costly disruptions and continue normal operations.
- Residents can save themselves the inconvenience of not having electricity.
- And there is an option for both businesses and residential consumers to participate in demand response programs when available.

## *Improve Reliability & Resilience*

Energy storage can provide backup power during disruptions. The same concept that applies to backup power for an individual device (e.g., a smoke alarm that plugs into a home but also has battery backup), can be scaled up to an entire building or even the grid at large.

Storage provides flexibility for the grid, to ensure uninterrupted power to consumers, whenever and wherever they need it. This flexibility is critical to both reliability and resilience. As the cost of outages continues to rise, the value of enhanced reliability and improvements in resilience also increases.

## *Integrate Diverse Resources*

Energy storage can smooth out the delivery of variable or intermittent resources such as wind and solar, by storing excess energy when the wind is blowing and the sun is shining, and delivering it when the opposite is happening.

But storage can also support the efficient delivery of electricity for inflexible, baseload resources. When demand changes quickly, and flexibility is required, energy storage can inject or extract electricity as needed to exactly match load – wherever, and whenever it's needed.

## *Reduce Environmental Impacts*

In simplest terms, energy storage enables electricity to be saved for a later, when and where it is most needed. This creates efficiencies and capabilities for the electric grid—including the ability to reduce greenhouse gas (GHG) emissions.

By introducing more flexibility into the grid, energy storage can help integrate more solar, wind and distributed energy resources. It can also improve the efficiency of the grid – increasing the capacity factor of existing resources – and offset the need for building new pollution-emitting peak power plants.