*https://www.sciencedirect.com/science/article/pii/S0360544221030504*

Energy is one of the keys supporting economic development and playing an essential in our daily life. It is the sector that contributes significantly to various sustainability issues, such as GHG (Greenhouse Gases) emissions, air pollutants, water use and poverty. At the same time, the energy sector has prevalent room for improvement and is the target solution in various sustainability-related policies.

As nations bind together to tackle global climate change, one of the urgent needs is the energy sector's transition from fossil-fuel reliant to a more sustainable carbon-free solution. Recent progress shows that advancement in energy efficiency modelling of components and energy systems has greatly facilitated the development of more complex and efficient energy systems. The scope of energy system modelling can be based on temporal, spatial and technical resolutions. The emergence of novel materials such as [MXene](https://www.sciencedirect.com/topics/engineering/mxene), metal-organic framework and flexible [phase change materials](https://www.sciencedirect.com/topics/engineering/phase-change-material) have shown promising [energy conversion efficiency](https://www.sciencedirect.com/topics/engineering/energy-conversion-efficiency). The integration of the [internet of things](https://www.sciencedirect.com/topics/engineering/internet-of-things) (IoT) with an [energy storage system](https://www.sciencedirect.com/topics/engineering/energy-storage-system) and renewable energy supplies has led to the development of a smart energy system that effectively connects the power producer and end-users, thereby allowing more efficient management of energy flow and consumption. The future smart energy system has been redefined to include all energy sectors via a cross-sectoral integration approach, paving the way for the greater utilization of renewable energy.

Table 1. The sustainability-related performance of different energy sources.

| **Energy** | **EROI [****[22](https://www.sciencedirect.com/science/article/pii/S0360544221030504" \l "bib22)]** | **LCOE [****[23](https://www.sciencedirect.com/science/article/pii/S0360544221030504" \l "bib23)] [USD/MWh]** | **Carbon Footprint [**[**27**](https://www.sciencedirect.com/science/article/pii/S0360544221030504#bib27)**] [kg/MWh]** | **Water Footprint [**[**27**](https://www.sciencedirect.com/science/article/pii/S0360544221030504#bib27)**] [L/MWh]** | **NOx [**[**27**](https://www.sciencedirect.com/science/article/pii/S0360544221030504#bib27)**] [kg/MWh]** | **SO2 [**[**27**](https://www.sciencedirect.com/science/article/pii/S0360544221030504#bib27)**] [kg/MWh]** | **Land use/biodiversity losses [****[28](https://www.sciencedirect.com/science/article/pii/S0360544221030504" \l "bib28)] [acres/GWh/y]** | **Risk [****[29](https://www.sciencedirect.com/science/article/pii/S0360544221030504" \l "bib29)] [death rate/TWh]** | **End of Life Management - reclamation** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Fossil Fuel (Coal) | 10.7–39.1 | 65-159 (45 in average) | 855 | 2220 | 2.1 | 3.365 | 11.11 (once) | 24.62 |  |
| Solar (PV) | 1.0–16.1 | 29–227 | 101.5 | 330 | 0.275 | 0.205 | 8.33 (perpetual) | 0.02 | Electronic waste [[30](https://www.sciencedirect.com/science/article/pii/S0360544221030504" \l "bib30)], Solution [[31](https://www.sciencedirect.com/science/article/pii/S0360544221030504" \l "bib31)]. |
| Wind | 10.3–32.4 | 26–54 | 22 | 43 | 0.275 | 0.205 | 26 (perpetual) | 0.04 | Blade waste [[32](https://www.sciencedirect.com/science/article/pii/S0360544221030504" \l "bib32)], Solution [[33](https://www.sciencedirect.com/science/article/pii/S0360544221030504" \l "bib33)]. |
| Hydro | 5.0–66.4 | 44 (in average) [[34](https://www.sciencedirect.com/science/article/pii/S0360544221030504" \l "bib34)] | 11 | 4,961 | 0.032 | 0.016 | 30 (perpetual) | 0.02 |  |
| Biomass | 3.5 [[35](https://www.sciencedirect.com/science/article/pii/S0360544221030504" \l "bib35)] | 76 (in average) [[34](https://www.sciencedirect.com/science/article/pii/S0360544221030504#bib34)] | 69.25 | 85,100 | 0.89 | 0.485 | 188 (perpetual) | 4.63 |  |
| Nuclear | 69.6–96.2 | 129–198 | 19 | 2,290 | 0.025 | 0.021 | 16.66 (only once) | 0.07 | Radioactive waste [[36](https://www.sciencedirect.com/science/article/pii/S0360544221030504" \l "bib36)] Solution: e.g. TP [[37](https://www.sciencedirect.com/science/article/pii/S0360544221030504" \l "bib37)], Bio-T [[38](https://www.sciencedirect.com/science/article/pii/S0360544221030504" \l "bib38)] |

In the thermal sector, the development of 4th generation district heating (4GDH) is envisioned to meet the demand for more energy-efficient buildings and integrate district heating and renewable energy sources into a smart energy system. The [4GDH system](https://www.sciencedirect.com/topics/engineering/district-heating-system) is defined as a smart thermal grid that integrates the supply of heat to low-energy buildings with low grid losses, utilizing low-temperature heat sources that is integrated into the operation of smart energy systems, by considering the planning, cost and incentive structures to ensure the sustainability of the systems.

*https://www.pnas.org/doi/full/10.1073/pnas.1004581107*

Substantial changes in population size, age structure, and urbanization are expected in many parts of the world this century. Although such changes can affect energy use and greenhouse gas emissions, emissions scenario analyses have either left them out or treated them in a fragmentary or overly simplified manner. We carry out a comprehensive assessment of the implications of demographic change for global emissions of carbon dioxide. Using an energy–economic growth model that accounts for a range of demographic dynamics, we show that slowing population growth could provide 16–29% of the emissions reductions suggested to be necessary by 2050 to avoid dangerous climate change. We also find that aging and urbanization can substantially influence emissions in particular world regions.

Statistical analyses of historical data suggest that population growth has been one driver of emissions growth over the past several decades and that urbanization, aging, and changes in household size can also affect energy use and emissions. Demographers expect major changes in these dimensions of populations over the coming decades. Global population could grow by more than 3 billion by mid-century, with most of that difference accounted for by growing urban populations.

More recently, a large emissions scenario literature has developed that informs a wide range of climate change analysis and related policy discussions. Model sophistication and scope has increased substantially over time. Scenarios typically span timescales of decades to centuries, include emissions of multiple gases and aerosols from a range of sectors, including land use, and consider a wide range of emissions drivers.

HEAT TRANSFER

*https://www.sciencedirect.com/science/article/pii/S0017931010004229*

The temperature of battery modules in electric vehicles (EVs) must be controlled adequately to remain within a specified range for optimum performance.

The performance, lifespan, durability and cost of electric vehicles are highly dependent on the battery packs. Battery temperature is a crucial parameter for the battery performance. Most batteries can only charge or discharge efficiently and safely in a certain temperature range. High temperatures above the defined operating range can significantly reduce the lifetime and even damage the battery. Battery temperatures below the defined operating temperature range (especially below 0 °C) lead to a decrease in voltage and charge of the battery. In both cases, the performance and lifetime of the battery are reduced, resulting in higher costs and decreased reliability of the electric vehicles. It is therefore crucial to keep the battery modules within a defined temperature range. This requires an effective thermal management system.

A good thermal management system must maintain the batteries in a defined temperature range, when the vehicles operate in both hot and cold climates. Most batteries generate a significant amount of heat during discharge, which must be dissipated by adequate cooling from the thermal management system. Also, heating is necessary when the vehicles operate in cold winter climates. The thermal management system should be able to maintain a uniform temperature among all battery cells in the entire battery pack. Previous studies have found that temperature gradients between modules reduce the overall battery pack capacity. Temperature uniformity within a battery pack is important to ensure all battery cells operate as close as possible within the defined temperature range, to maintain high performance and lifetime of the whole pack. Thus, good thermal management is crucial for reducing the life-cycle costs of EVs.

[*https://www.sciencedirect.com/science/article/pii/S001793101400009X*](https://www.sciencedirect.com/science/article/pii/S001793101400009X)

When higher current is extracted from the Li-ion cells, heat is generated due to the ohmic law. Therefore, it is vital to design a successful thermal management system (TMS) to prevent excessive temperature increase and temperature excursion in the battery pack. During the [phase change process](https://www.sciencedirect.com/topics/engineering/phase-change-process), PCMs absorb heat and create a cooling effect. In the discharging (solidification) process, stored heat is released and it creates a heating effect

Despite the small peripheral surface of the prismatic cell, the orthotropic property of Li-ion cells improves the planar heat transfer and effectiveness of the PCM around the cell. A numerical study is conducted using a finite volume-based method. The results show that the maximum temperature and temperature excursion in the cell are reduced when PCM is employed. The PCM with 12 mm thickness decreases the temperature by 3.0 K. Furthermore, the effect of the PCM on the cell temperature is more pronounced when the cooling system is under transient conditions. When a 3 mm-thick PCM is employed for the Li-ion cell, the temperature distribution becomes about 10% more uniform which is an important result in thermal management systems in electric vehicles.