






Review Article

Developments in Nanoparticles Enhanced Biofuels and Solar Energy in Malaysian Perspective: A Review of State of the Art

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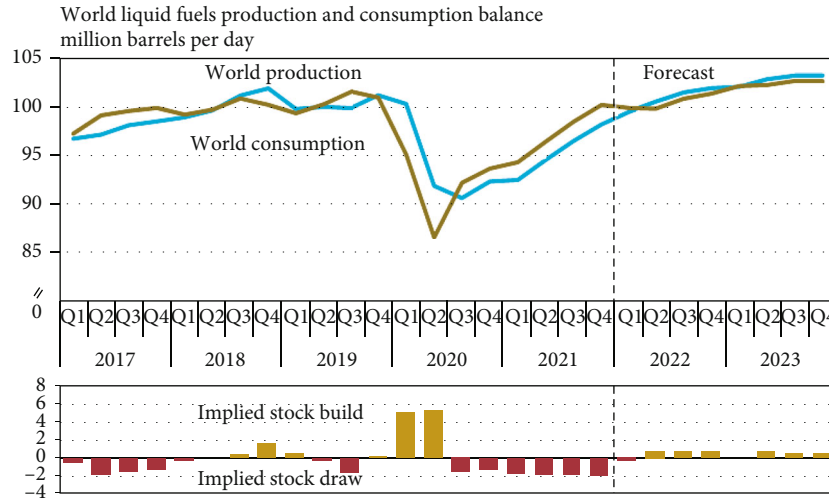
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The rapid rise in global oil prices, the scarcity of petroleum sources, and environmental concerns have all created severe issues. As a result of the country's rapid expansion and financial affluence, Malaysia's energy consumption has skyrocketed. Biodiesel and solar power are currently two of the most popular alternatives to fossil fuels in Malaysia. These two types of renewable energy sources appear to be viable options because of their abundant availability together with environmental and performance competence to highly polluting and fast depleting fossil fuels. The purpose of adopting renewable technology is to expand the nation's accessibility to a reliable and secure power supply. The current review article investigates nonconventional energy sources added with nanosized metal particles called as nanomaterials including biodiesel and solar, as well as readily available renewable energy options. Concerning the nation's energy policy agenda, the sources of energy demand are also investigated. The article evaluates Malaysia's existing position in renewable energy industries, such as biodiesel and solar, as well as the impact of nanomaterials. This review article discusses biodiesel production, applications, and government policies in Malaysia, as well as biodiesel consumption and recent developments in the bioenergy sector, such as biodiesel property modifications utilizing nanoparticle additions. In addition, the current review study examines the scope of solar energy, different photovoltaic concentrators, types of solar energy harvesting systems, photovoltaic electricity potential in Malaysia, and the experimental setup of solar flat plate collectors (FPC) with nanotechnology.

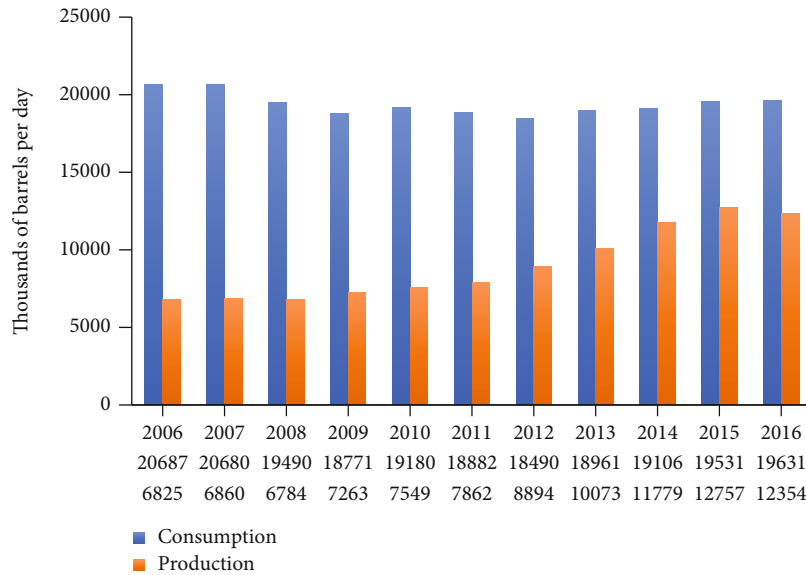
1. Introduction

Climate change is among the most pressing environmental issues of the day. The only way to avoid or mitigate this crisis is to limit greenhouse gas (GHG) emissions [1]. Several solu-

tions have indeed been implemented across the world to control GHG emissions and hence mitigate environmental impacts. The world's usage of oil resources is equivalent to emptying an Olympic-sized swimming pool each 15 s [2, 3]. The use of petroleum-based products to generate electricity



(a)



(b)

FIGURE 1: (a) World liquid fuel production and consumption [6]. (b) The United States oil production and consumption per day [7].

results in the release of a substantial concentration of CO₂, which contributes to global warming. The utilization of non-conventional sources is merely one approach for taking care of the environment and is devoid of pollution [4, 5].

According to EIA short-term energy outlooks, the worldwide consumption of liquid fuels reaches 100.6 million b/d in 2022, up 3.1 mil. b/d from 2021. Usage is expected to rise by 1.9 mil. b/d in 2023 to a mean of 102.6 mil. b/d illustrated in Figure 1(a). Figure 1(b) depicts the daily production and consumption of oil in the US for each subsequent year. Petroleum (gasoline and diesel) accounts for 93 percent of all transportation fuels in the United States. In 2010, the US spent an average of 19,180 barrels of crude oil and crude petroleum distillates every day. Usage progressively grew, and by 2016, the utilization had climbed by 500 barrels per day. Crude oil is used to produce a variety of goods, the most important

of which are petrol and diesel, which together provide and meet approximately 93 percent of our transportation demands. Throughout 1970 and 2008, crude oil production fell every single year. In 2009, the pattern shifted and started production to increase as a result of more affordable exploration and completion machinery, as well as innovation production lift. However, due to decreased crude oil prices in 2016, production fell compared to the previous year [7, 8]. Figure 2 illustrates the CO₂ emissions by region.

Figure 3 depicts the top 10 CO₂-generating nations in the world. The overall global CO₂ emissions are 32.3 Gt of CO₂, with the top CO₂ generating nations producing 21.7 Gt of CO₂.

Figure 4 illustrates the CO₂ emission trends by sector-wise and fuel type globally; the five leading energy-consuming commercial and economic areas responsible for

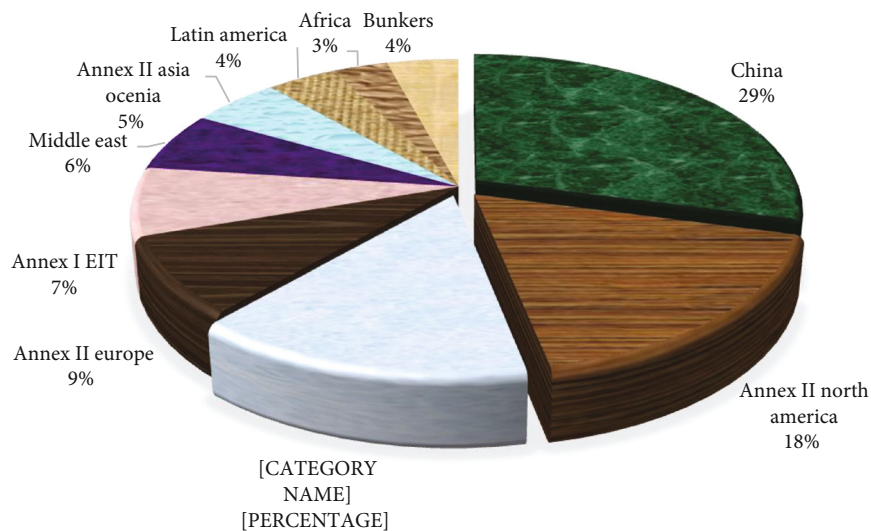


FIGURE 2: CO₂ emissions by region [9]

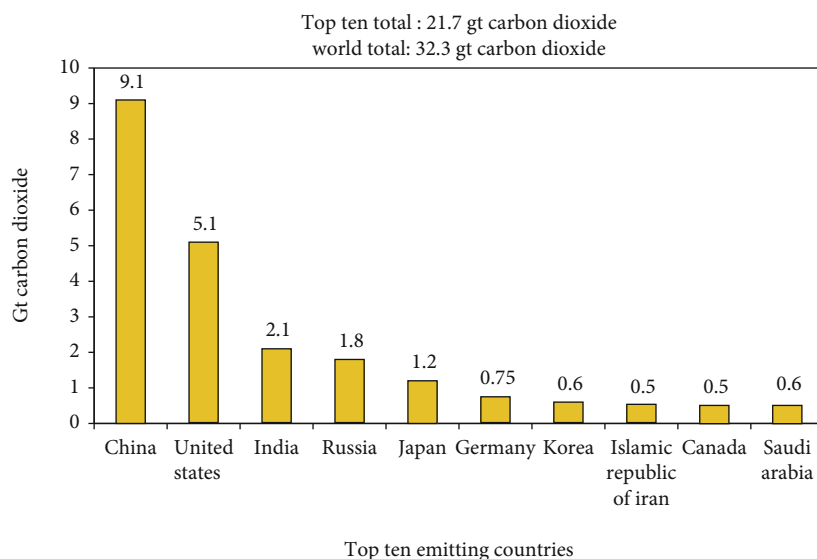


FIGURE 3: Top ten CO₂ emitting countries [10]

CO₂ release from fossil fuel burning are industrial, electric power, transportation, commercial, and residential [11]. The transportation sector is the primary CO₂ emitting sector using petroleum fuel, followed by the industrial sector. The world's 23% of energy related CO₂ is generated by a transportation sector [12]. The transportation sector is assumed to be responsible for nearly 60% of the world oil demand and will be the uppermost demand sector soon. Coal is generally used in the power generation sector, and it produces the highest CO₂ from coal. Furthermore, natural gas is used for residential, generation of electric power, commercial, and industrial purposes, respectively [7, 8]. The CO₂ generated by using natural gas is 29.7%. The overall trend shows that around half of the CO₂ generated comes from the usage of petroleum-based fuels. The demand growth is generally based across all main sectors, with the industrial sector consuming around half of the overall increase. The transport

sector demand drops in comparison to the past scenario because of higher vehicle efficiency [13, 14]. Several nations have adopted different steps to reduce CO₂ emissions at a sustainable rate [15, 16].

Nonconventional energies are the energy reserves that are provided constantly by the environment and are sourced straight from the sun. Some of the nonconventional energies are wind, hydel, tidal, biofuel, and biomass sourced indirectly from the sun. The direct sun energy sources are photochemical and electric and thermal [17–20]. The latest technologies convert these environmentally friendly energies into useable forms of energy such as heat, power, fuels, and electricity. The MPIA (Malaysian Photovoltaic Industry Association) President Chin Soo Mau said that Malaysia is aiming to achieve 20% energy generation through nonconventional energy sources [21–23]. Figure 5 shows an overview of Malaysia's renewable energy from 2012 to 2019.

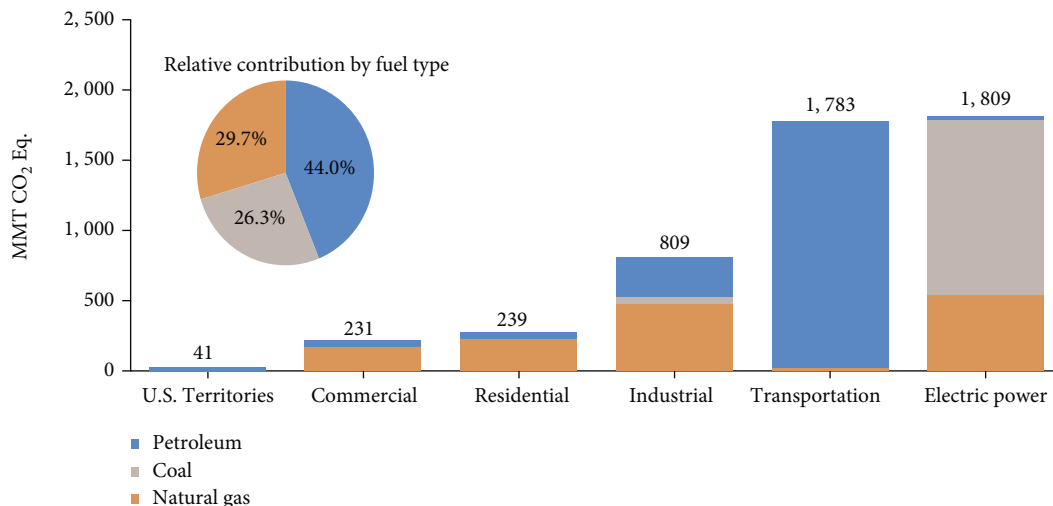


FIGURE 4: Carbon dioxide (CO₂) release from fossil fuel-burning sector-wise and fuel-type [11].

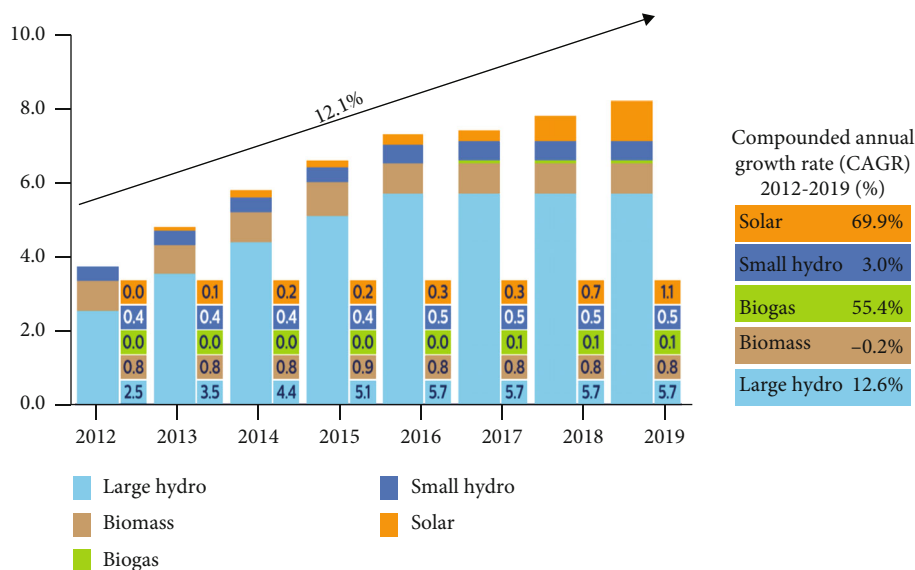


FIGURE 5: Overview of Malaysia's renewable energy 2012-2019 [24]

In its landmark research, IEA (International Energy Agency) projected that there is a significant implementable perspective for renewable energy in Asia nations, totaling 1028 TWh, which includes wind, tidal, solar, biomass, biogas, small hydro, geothermal, and wave energies [25, 26]. ASEAN-6 nations (China, Japan, Korea, India, Australia, and New Zealand) together meet well over 95 percent of Southeast Asia's energy needs. Because of growing industrialization and urbanization, energy usage is predicted to double. While having a significant potential for deploying renewable energy technology, financing and skills are still short in the absence of effective renewable energy legislation. Until 2013, the ASEAN region's electricity is produced by nonconventional energy sources, particularly big hydroelectric energy facilities, at a rate of roughly 21%, or 169.34 TWh. Rise in awareness, supporting government reg-

ulations, and the advent of dependable and economical renewable energy technologies could increase renewable energy output in these countries, allowing for more affordable renewable power [25, 27]. Various tools have been implemented to improve the climate's investors more inviting. Among these would be the net energy metering system among other major projects aimed at boosting the expansion of the renewable industry. Presently, just 8% of Malaysian energy is provided from renewable sources, to reach 20% by 2025 [21, 24]. Currently, fuel additive findings have suggested that nanoparticles (metallic, nonmetallic, organic, and combination) blended with diesel-BD (biodiesel) blend and solar applications improve the overall performance [28]. The obtained results showed an improvement in thermophysical characteristics, an increase in the rate of heat transfer, and fuel blend stability [29-32]. BD drawbacks

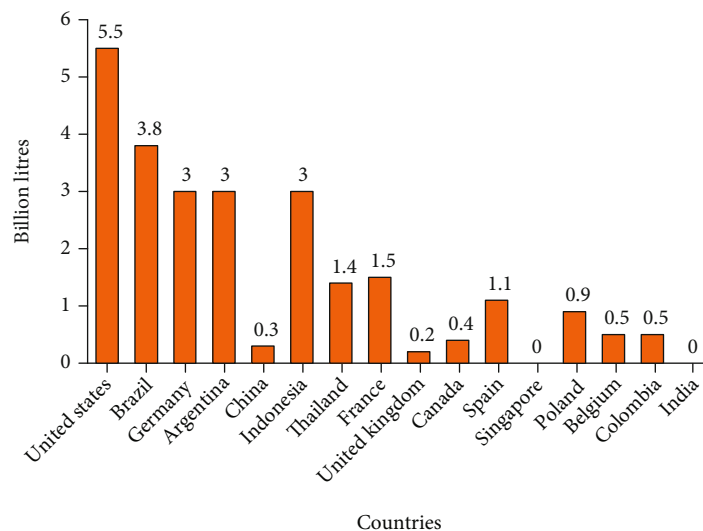


FIGURE 6: Biodiesel worldwide production, top 16 countries, 2016 [50]

TABLE 1: Properties of diesel and various biodiesel fuels.

Ref.	Properties fuel name	Calorific value (kJ/kg)	Density (kg/m ³)	Iodine value (IV)	Cetane number	Kinematic viscosity at mm ² /s		O ₂ content (% weight)
						27 ^o C	40 ^o C	
[62–64]	Diesel fuel	43,350	815	—	47	4.3	—	—
[65]	ROME	41,550	857-914	94-120	37.6-54.4	—	4.6–6.7	10.9
[66]	WOME	40,055	870	—	56	—	—	11.3
[65, 67]	CSOME	40,580	874	90-140	41.8-51.2	11	4–6.1	10.49
[65, 68, 69]	SME	39,760	872	117-143	38-46.2	11	4.08	10.92
[64, 70]	SOME	40,579	878	110-143	37.5-51	10	4.22	10.89
[64, 67, 68]	COME	41,140	873-913	103-140	37.6	—	3.62	10.96
[65, 71]	POME	41,240	867	44-54	42-62	—	5–6	11.27
[72]	KOME	38,300	875	81	81	—	3.99–4.2	11
[64, 67]	JME	38,450	880	109.5	109.5	—	4.75–5.65	—

SME: soybean oil; JME: Jatropha oil; SOME: sunflower oil; WOME: waste cooking oil; CNOME: coconut oil; ROME: rapeseed oil; POME: *Pongamia pinnata* Oil; KOME: Karanja oil.

can be solved by modifying fuel quality using highly energetic concentration nanoadditions. Several investigators have researched the influence of nanoaddition in biofuels and discovered a remarkable increase in the quality of the working fluids. The inclusion of NPs in biofuels lead to partially burning fuel, which boosts catalytic performance and decreases emissions [28, 33–38].

The minireview deals with the production of biodiesel, usage, and government policies of biodiesel in Malaysia, biodiesel utilization, and new developments in the biodiesel field such as property modification of biodiesel using nanoparticle additives. Moreover, the scope of solar energy, different photovoltaics concentrators, types of solar energy harvesting system, photovoltaic electricity potential in

Malaysia, and the experimental setup of solar FPC with nanotechnology are studied in the current review article.

2. Biodiesel

Biodiesel (BD) is a sustainable, recyclable fuel produced from plant oils (soybean, palm, rapeseed, Jatropha, etc.), animal fats (beef tallow, waste chicken fat, lard, etc.), or recyclable restaurant grease and waste cooking oil [39–41]. Biodiesel is highly considered a sustainable renewable fuel, being used in the transport sector to partially replace fossil fuels where it plays a major role in abating the global warming and resulting climate change [42]. Because of its complete miscibility, there can be a direct or blended use of

TABLE 2: Fatty acid composition of edible and nonedible feedstocks.

Fatty acid Scientific name Carbohydrate- double bond ratio	Lauric "Dodecanoic" (12:0)	Myristic "Tetradecanoic" (14:0)	Palmitic "Hexadecanoic" (16:0)	Stearic "Octadecanoic" (18:0)	Oleic "cis-9- Octadecenoic" (18:1)	Linoleic "cis-9-cis-12- Octadecadienoic" (18:2)	Linolenic "cis-9- cis-12" (18:3)	Arachidic Eicosanoic (20:0)	Behenic Docosanoic (22:0)	Lignoceric Tetracosanoic (24:0)	Reference
<i>Edible feedstock</i>											
Sunflower	0.50	0.20	4.9–6.8	2.3–3.26	16.93–32.6	59.4–73.73	0.00	0.40	—	—	[68, 73–75]
Rapeseed	—	—	3.49–5.2	0.85–1.4	64.4–66	18.9–22.3	5.6–8.23	1.90	—	—	[75–77]
Soybean	—	0.10	11.7–11.7	3.15–3.97	21.27–23.26	53.7–55.53	6.31–8.12	1.23	0.10	—	[59, 75, 78]
Peanut	—	—	17.20	2.70	40.50	36.60	0.50	0.90	—	—	[75, 79]
Corn	—	—	11.40	1.30	27.10	60.20	—	—	—	—	[58, 67]
Palm	—	1.00	49.80	2.90	38.60	6.60	—	—	—	—	[67, 80]
Palm kernel	—	—	11.50	1.40	15.90	1.80	—	—	—	—	[67, 80, 81]
Coconut	46.50	19.20	9.80	3.00	6.90	—	2.20	—	0.30	—	[82, 83]
Rice bran	—	0.30	12.50	2.10	47.50	35.40	1.10	0.60	—	0.20	[84, 85]
Tallow	—	—	23.30	19.30	42.40	2.90	0.90	—	—	—	[71, 86]
Lard	—	1–2	28–30	12–18	4–50	7–13	—	—	—	—	[86, 87]
<i>Nonedible and waste-based feedstocks</i>											
Jatropha	0.10	0.10	13.23–16	5.40–7	41.62–49.39	33–36.99	0.2240.80	0.20	—	—	[88–90]
Honge	—	—	10.50	5.56	49.39	20.37	3.66	1.36	—	—	[91, 92]
Karanja	—	—	3.7–11.65	2.4–8.9	44.5–71.3	10.8–18.3	—	—	—	—	[93, 94]
Mahua	—	—	16–28.2	14–25.1	41–51	8.9–17.9	—	0–3.3	—	—	[67, 95]
Cottonseed	—	—	11.67	0.89	13.27	57.51	0.00	—	—	—	[67]
Rubber seed	—	—	10.20	8.70	24.60	39.60	16.30	—	—	—	[73, 96]
Waste fried sources	—	—	27.30	4.90	36.10	25.70	1.90	—	—	—	[97, 98]
<i>C. inophyllum</i>	—	—	17.90	18.50	42.70	13.70	2.10	—	—	2.60	[99]
Neem	—	0.2–0.26	14.90	20.60	43.90	17.90	0.40	1.90	—	0.30	[100, 101]
Algae	—	0.60	6.90	3.00	75.20	12.40	1.20	0.40	0.10	—	[102]
Poultry fat	—	1.00	19.60	7.50	36.80	28.40	2.00	—	0.10	—	[103, 104]
Evening primrose	—	—	6.00	1.80	6.60	76.30	9.00	0.30	—	—	[58, 67]

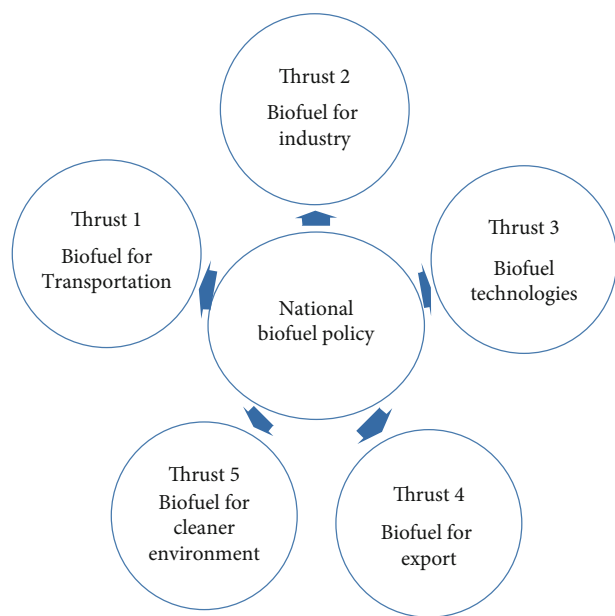


FIGURE 7: Five strategic factors in promoting biodiesel [106].

biodiesel with petroleum products. In its pure, unblended state, BD is known as B100 or plain BD [43–46]. Some of the major advantages are safer to handle, nonflammable with low toxicity, higher combustion efficiency, and low emissions like CO_2 , CO , and SO_2 , whereas some of the advantages are higher pour and cloud point fuel and corrosive to copper and brass together with degrading plastic and natural rubber gaskets [47].

Malaysia's Parliament passed Malaysia's Biofuel Industry Policy (MBIP) in 2006-07 to promote its use of ecologically sustainable forms of energy. This initiative was aimed at consolidating and improving palm oil prices, in addition to minimizing the dependency on diminishing fossil resources. By the National Biofuel Policy, the Ministry of Plantation Industries and Commodities (MPIC) launched a biofuel program that includes the adoption and marketing of biofuels in public transit and manufacturing companies [48]. Biodiesel is usually produced using the transesterification reaction (TE); it is a cyclical reaction that occurs by combining the reacting species—fatty acids, OH^- , and catalysts. Crude biofuel and crude glycerin are the byproducts of the TE [17, 34, 38, 44, 49].

Figure 6 represents the production of biodiesel globally. In the year 2015, the United States observed a 56% increase in sales in biodiesel production. In 2016, worldwide biodiesel production improved by about 9% in comparison with the year 2015, with significant increases in the US and Indonesia. In Indonesia, biodiesel production continued to grow, a significant increase was seen in the year 2016, and the palm oil-based biodiesel segment saw a hiring level of 60% and created around 154,000 jobs in Indonesia. In the United States, 18% of biodiesel was produced in the year 2016, while Brazil produced 12%, and Argentina, Germany, and Indonesia separately produced 10%, respectively. The year 2016 saw an increase of 7.5% (30.8 billion liters) biodiesel produced

compared to 6.5% (28.7 billion liters) for the year 2015. The growth was primarily due to restored production levels in Indonesia and Argentina and substantial growth in North America.

The physicochemical properties of biodiesel are near to diesel fuels, and therefore, biodiesel has become the best alternative for diesel fuels. The transformation of triglycerides into esters of methane or ethane through the transesterification process decreases the viscosity by a factor of around eight, the viscosity is close to diesel fuel, and the molecular weight to one-third that of triglyceride and increases the volatility slightly—The properties of diesel and various biodiesel fuel Table 1. The combustion is enhanced compared to diesel fuel due to the higher oxygen content of the esters, around 10–11% oxygen by weight, and generally, the cetane number is around 50. In cold conditions, the volatility increases slightly. The tertiary fatty amines and amides in biodiesel can be useful in reducing the ignition delay of the blended fuel without a negative effect on the cold flow properties. The volumetric heating values are less compared to the diesel fuel; however, they have a high cetane number and ash point [51, 52].

The fatty acids generally originating from vegetable oils, WCO, and fats are palmitic, oleic, linoleic, stearic, myristic (tetradecanoic), linolenic, arachidic, palmitoleic, and octadecatetraenoic [53–57]. Babassu, bay, laurel leaf, coconut, and Luphea consist of the lauric fatty acid. The camelina, poultry fat, beef tallow, and yellow grease consist of Myristoleic and economic fatty acids. The crambe and peanut kernel contain behenic and lignoceric fatty acids. Fatty acid compositions are used to calculate the quality of fatty acid methyl esters of oil to be utilized as biodiesel. Table 2 summarizes the fatty acid composition of edible and nonedible feedstocks. FAME of oils such as *Jatropha curcas*, *Calophyllum inophyllum*, *Azadirachta indica*, and *Pongamia pinnata* was found most appropriate for use as biodiesel, and they meet the significant specification of biodiesel standards of ASTM and EN [58–61].

Malaysian industries collected approximately 19.5 Mt of crude palm oil out of its 5.8 M hectares of palm oil plantations in 2018. The nation's economic sales were 16.7 Mt, worth 67.5 billion Ringgit to Malaysia's economy [105, 106]. Malaysia's policy for biofuel scheme execution is unambiguous. In 2019, the B10 transport project (a combination of 10% palm BD fuel and 90% diesel) and the B7 industry plan were adopted.

The key elements of this plan are 5 strategic factors in promoting (Figure 7), which encompass transportation, industry, exports, technology, and bioenergy for a sustainable future [106]. On February 20, 2020, the B20 transport scheme was inaugurated. The adoption was carried out in stages, beginning with Langkawi and Labuan on January 1 and 15, in the year 2020, consecutively, and then moving on to Sarawak on September 1, 2020. As a result, the B20 project is tentatively planned to launch in Sabah in June 2021 and Peninsular Malaysia in Dec 2021, according to the report from MPOB. However, the target is postponed to early 2022 due to the ongoing COVID-19 pandemic. The clean fuel, which is composed of 20% palm

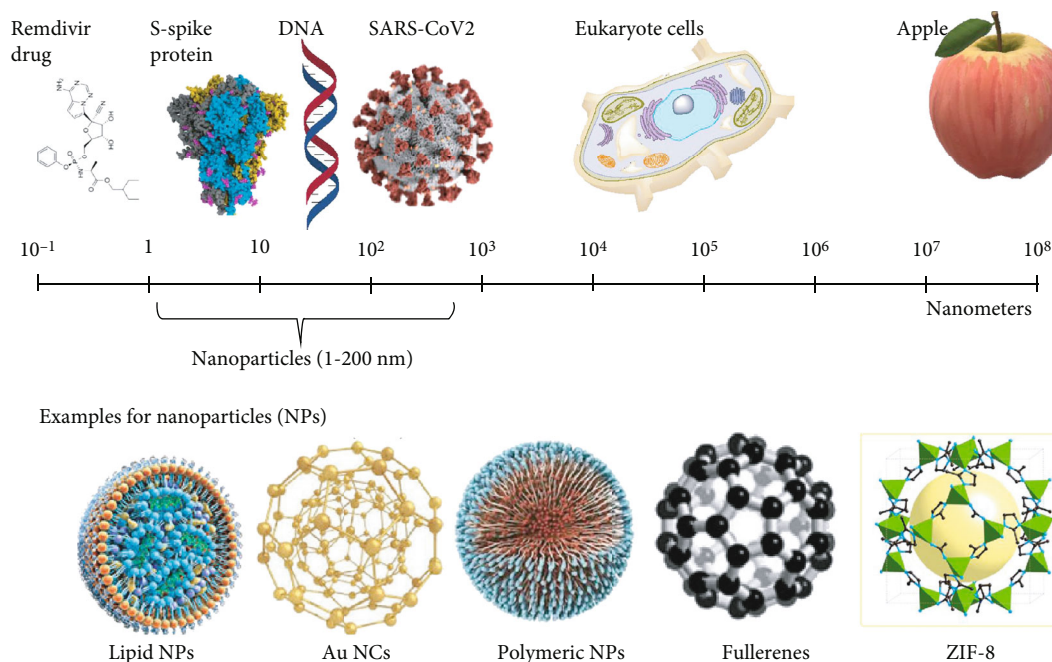


FIGURE 8: The scale of various nanomaterials [114]

BD and 80% conventional diesel, will ultimately replace B10 at almost 3,400 pumps countrywide, except for Cameron and Genting Highlands in Pahang and Kundasang in Sabah, wherein B7 will remain to be utilized [107, 108].

2.1. Nanoadditives in Biodiesel. The word “nanoparticles” relates to particles with sizes varying from 1 to 100 nm. NPs are commonly employed by combining them with a base fluid to create nanofluids [109, 110]. The nanofuel additives have been used to improve the performance of the fuel. NPs also work as a catalyst to boost the reaction rate, provide further O_2 for full fuel combustion, and so improve the engine characteristics. Similarly, the actions of NPs may be thought of as catalysis effects [111–113]. From the number of studies in the preceding publications, it is advised that metal oxide-based and/or carbon-based NPs be blended with diesel and/or D-BD mixes since metal oxide and carbon-based NPs have typically shown good potential effects in terms of environmental factors. Figure 8 shows the scale of various materials compared to carbon nanotubes.

Gavhane et al. [38] showed the effect of zinc oxide NPs and soybean BD (B25/SBME25) on CI engine performance. Figures 9(a) and 9(b) illustrates the complete processes involved in nanofuel preparation. The addition of 50 ppm of ZnO NPs in SBME25 improved the overall CI engine characteristics. The authors reported an enhancement in the BTE by 20.59% at CR 21.5, while the BSFC reduced by 20.37%. The emissions such as CO reduced by 41.08%, while the NOx slightly increased due to CC, temperature, and HC, and smoke reduced by 30.83% and 22.54%.

Soudagar et al. [115] observed that adding 40 ppm of GO NPs to a dairy scum oil BD blend (B20) boosted the BTE by 11–12% while decreasing fuel economy by 8%. Additionally,

CO and HC pollutants were decreased by 38–39% and 21–22%. Nevertheless, scientists discovered a 5–6% rise in NOx emissions.

Also, Soudagar et al. [46] studied the effect of Sr@ZnO NPs on the *Ricinus communis* BD (RCME20), 90 ppm of Sr@ZnO NPs and CTAB surfactant in RCME20 results in overall enhancement in the performance and reductions in emissions. Figure 10(a) shows the CO emissions at CR 17.5 and 19.5, and Figure 10(b) illustrates the BTE at CR 17.5 and 19.5. CR 19.5 was observed to be better compared to CR 17.5. At CR 19.5, the BTE increased by 20.88%, emissions such as CO, HC, and CO_2 lowered by 47.63%, 26.81%, and 34.9%. While the combustion characteristics such as HRR increased by 24.35%, the cylinder pressure was enhanced by 9.55%, and the ignition delay period was reduced by 20.64%. Hence, the authors concluded that the addition of NPs in biodiesel improved the overall engine attributes.

3. Solar Energy

The utilization of nonconventional energy as an electric power source is among the most successful strategies undertaken by the power sector among all areas across the globe [116–119]. The major challenges of almost any RE plan that must be considered are as follows: highlighting existing market breakdowns, assigning long-term sustainable development; designed to encourage startups; and understanding the importance of the ecosystem as an economic expansion’s participant, advancing HRD in research innovation and technology, and improving the continuity of existing policy [120–124]. The Nation’s RE vision policy’s objectives, goals, and strategic plan aid in the development and progress of any sector are shown in Figure 11.

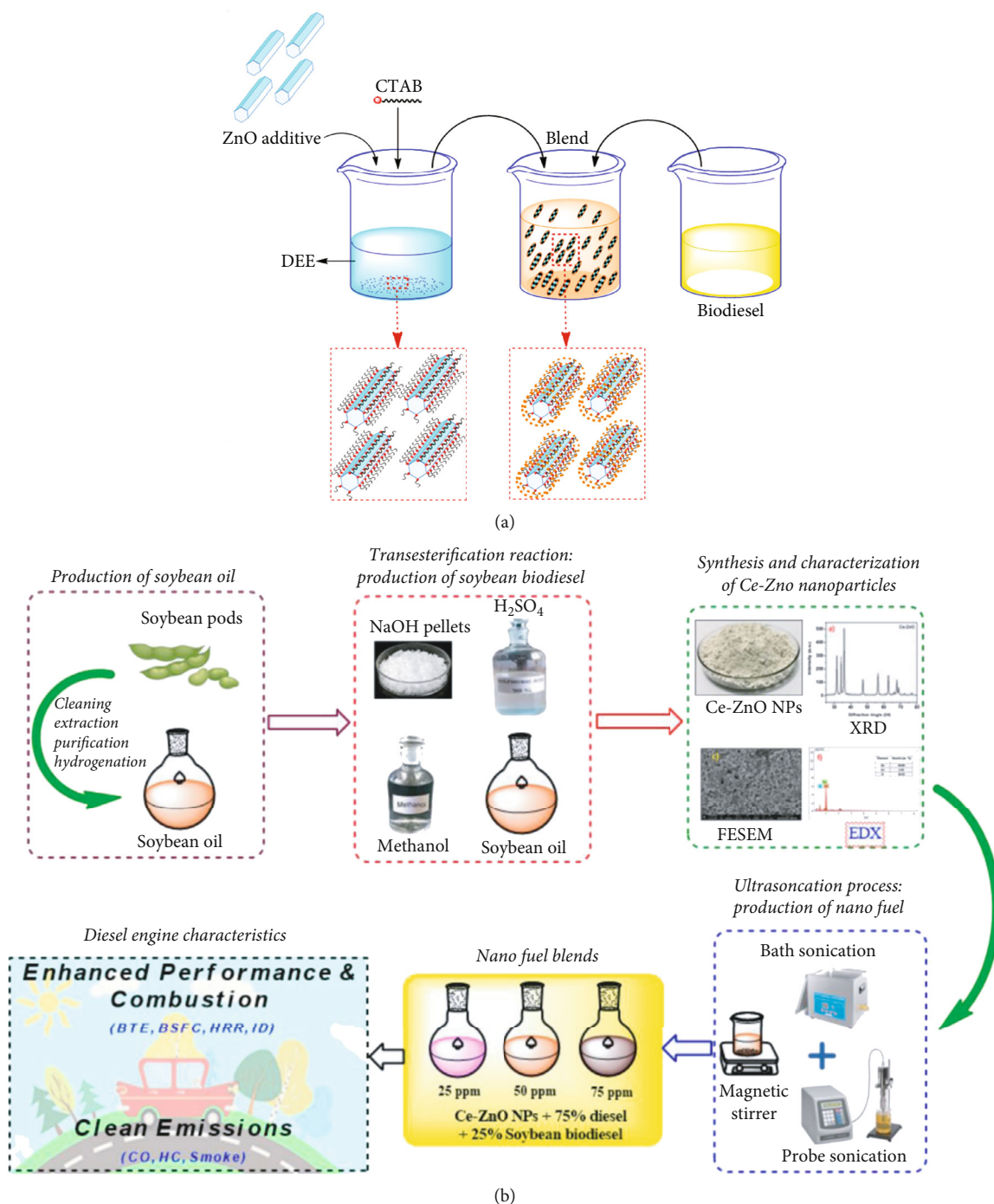
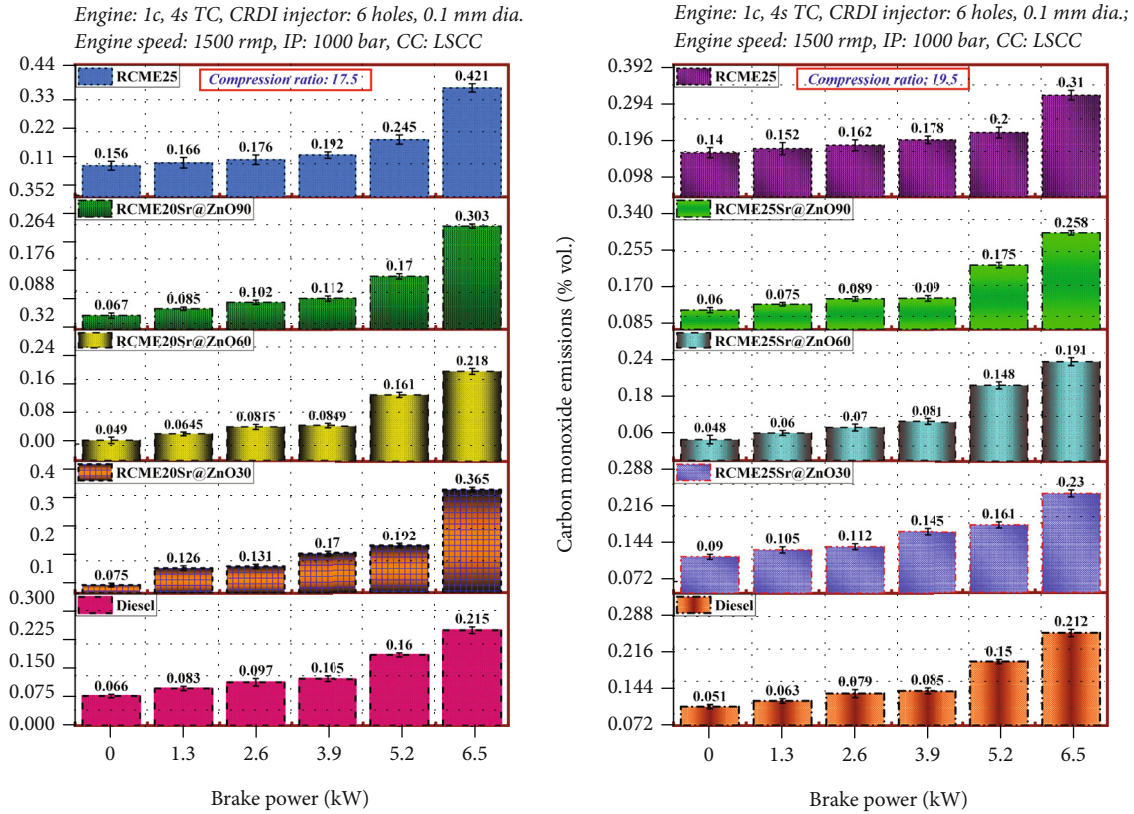


FIGURE 9: (a) Steps involved in the preparation of nano fuel [111]; (b) comprehensive steps involved in preparation of Ce-ZnO NP-blended soybean biodiesel [34].

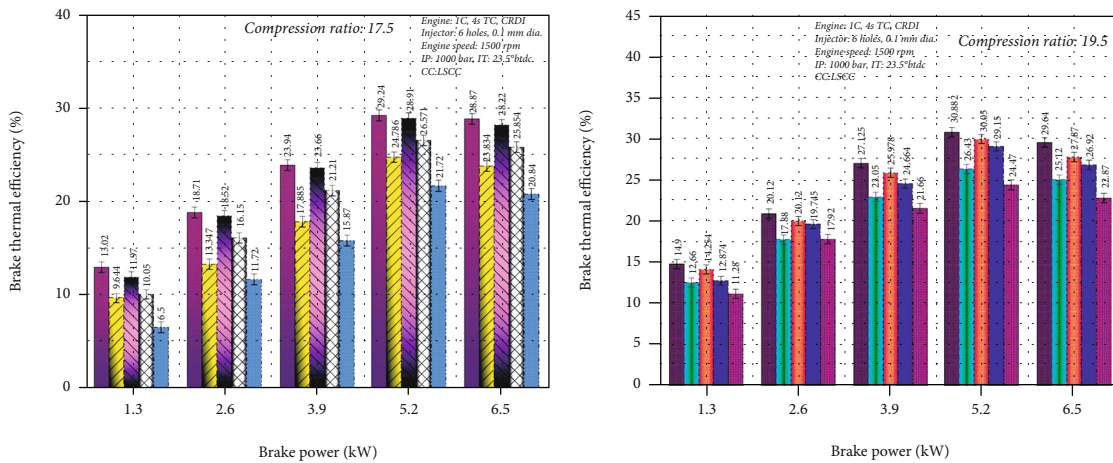
Solar is an economically and technically feasible nonconventional energy resource, as well as one of the major sources of energy in the renewable energy field [125–127]. Solar energy (SE) is an abundant resource that, in theory, could meet the globe’s energy requirements.

As seen in Figure 12, the techniques for harvesting SE may be classified into two parts: photovoltaic (PV) technology and thermal devices. Sun’s radiation is converted into heat energy by thermal systems, while the sun’s radiation is

converted into electrical power by PV systems. Thermal devices may capture more than 95 percent of direct sun energy [128, 129]. The sun typically emits radiation at 3.9×10^{26} W, whereas the energy acquired by the world’s outer atmosphere is 1368W/m^2 , because of fluctuations in the Earth-Sun distance; this number fluctuates by ± 1.7 percent [130, 131]. Some agencies also anticipate that solar energy will be the leading source of power, with most solar projects taking place in China and India [132]. SE technologies such



(a) Carbon monoxide emissions



(b) Brake thermal efficiency

FIGURE 10: (a) CO emissions at compression ratio CR 17.5 and 19.5; (b) BTE at compression ratio CR 17.5 and 19.5 [46].

as solar heating, PV cells, solar thermal power, and solar buildings can make a substantial contribution to alleviating several of the globe’s most pressing power concerns [133].

According to IRENA, worldwide solar photovoltaic jobs were at 3.6 mil. in 2018 (Figure 13(a)). Eight of the top ten

nations in Figure 13(b) are in Asia (Turkey is included in Asia for the aim of this study). Altogether, Asia employs about 3 million solar PV workers (85 percent of the world total), followed by North America (6.4 percent), Africa (3.9 percent), and Europe (3.2 percent). The global total for this

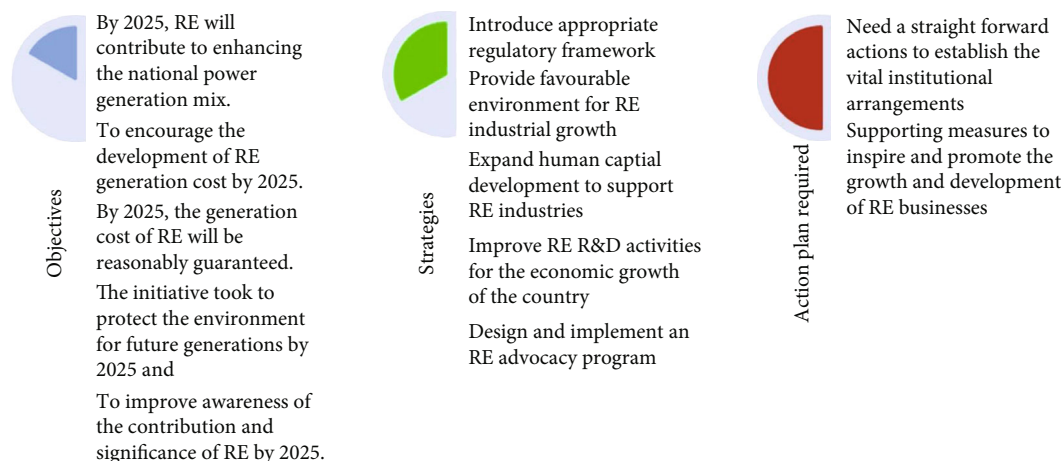


FIGURE 11: The objectives, strategies, and action plans adopted by the Malaysian govt. for implementation of RE [120].

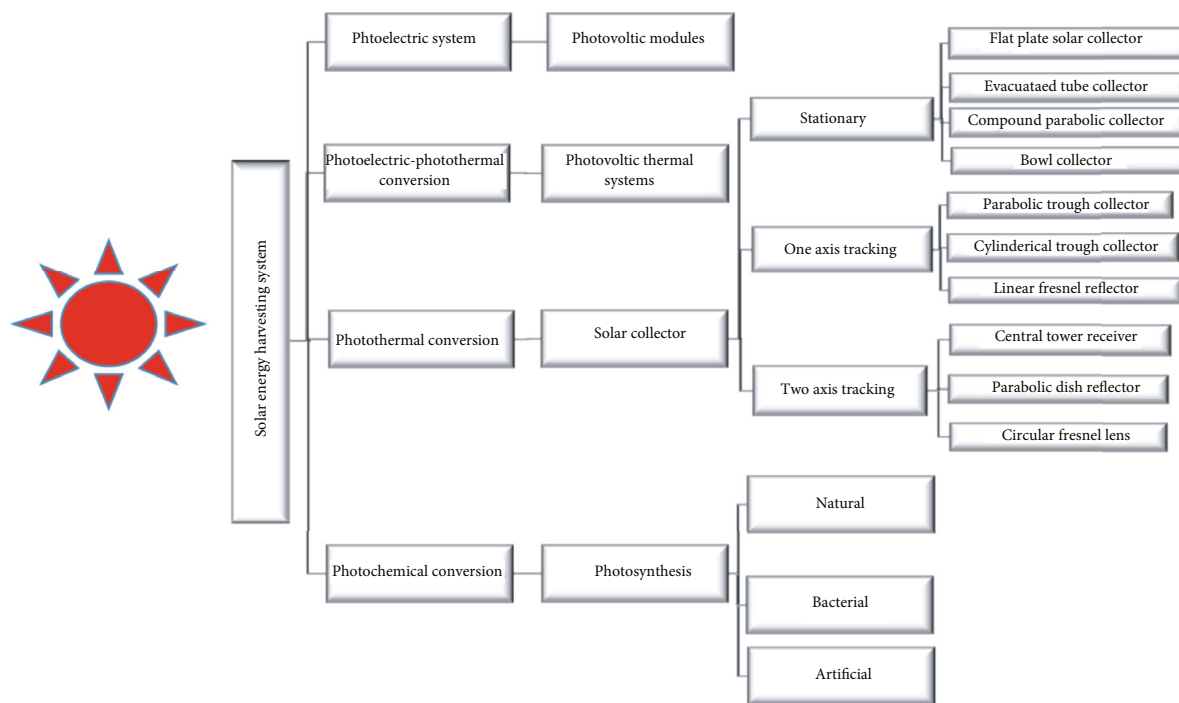
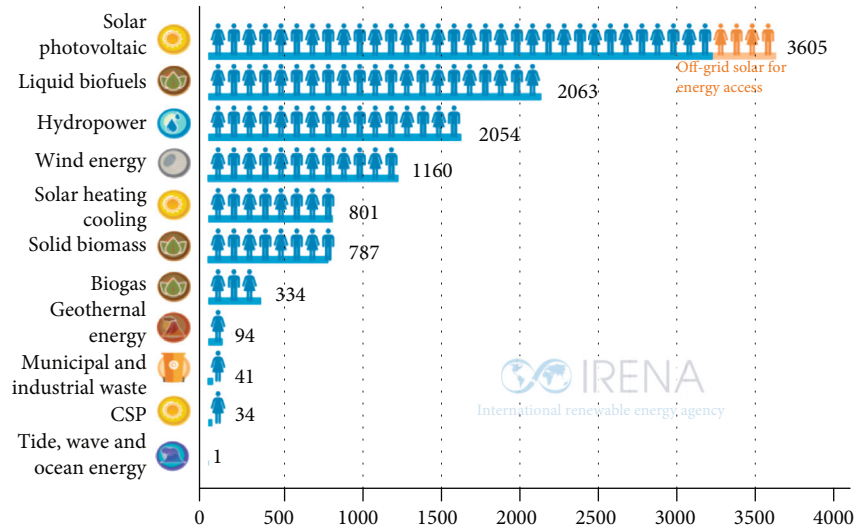


FIGURE 12: Types of solar energy harvesting systems [30].

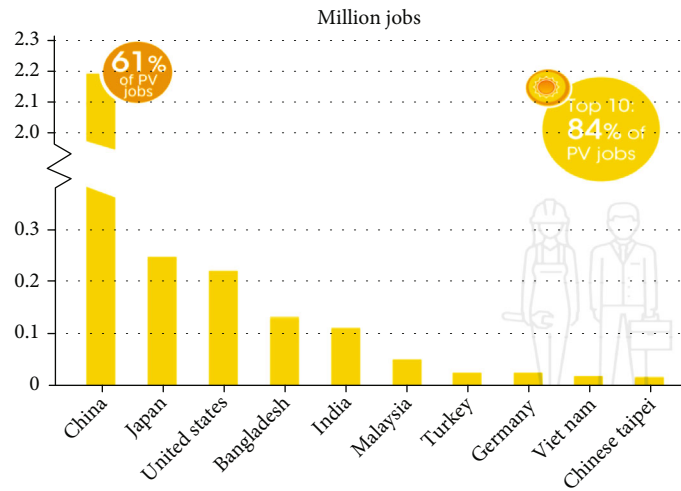
year is not directly comparable to the sum provided in the last year’s edition. It estimates 3.72×10^3 off-grid jobs for South Asia and portions of Africa [134]. Malaysia has one of the maximum solar absorption potentials due to its strategic location in the equatorial region. Malaysia, a tropical country, is normally humid throughout the year. With a mean of 12 hours of sunlight each day, the yearly solar energy collected ranges around $1400\text{-}1900 \text{ kWh/m}^2$ [130]. Malaysia’s monthly sun irradiance is predicted to be $400\text{-}600 \text{ MJ/m}^2$ [135]. Malaysia, in particular, has a significant potential for solar energy due to its warm and sunny climate throughout the year. The projected potential for solar power is 6500 MW [130, 135, 136]. According to the Malaysian Govt. Data, it is projected that the utilization of solar PV

cells to produce free and nonconventional sun energy can power four million buildings in Malaysia [137]. Table 3 shows the solar energy roadmap of Malaysia.

The benefit of the PV device is that it has no shifting components or emits any form of pollution while in operation. The fundamental appeal of PV technology is its minimum maintenance and absence of pollution, which has positioned PV as the selected energy alternative for plenty of remote applications in each space and on the ground. Due to the numerous benefits of the PV device, photovoltaic (PV) technology is anticipated to be the main technology in resolving energy and worldwide environmental challenges. PV cells produce power by collecting solar energy and converting it into electricity. Each solar panel has numerous



(a)



(b)

FIGURE 13: (a) Renewable energy job database; (b) top 10 countries in solar PV employment [134].

photovoltaic cells, and the electric charge generated by many cells significantly contributes to enough power to run several industries, hospitals, schools, etc. Figure 14 illustrates the PV electricity potential in Malaysia.

3.1. Types of Photovoltaic Concentrator. As illustrated in Figure 15, the primary types of concentrators include compound parabolic, parabolic dish, Fresnel lens, nonimaging dish, concentrators, quantum dot, and parabolic trough, which are briefly reviewed. Kamath et al. [140] performed a case study to determine the PV concentrator’s perspective in India. India has a large supply of sunlight; however, the majority of it is lost. PV technology could efficiently harness solar energy. PV technique has shown the best potential, particularly in areas with high DNI and low aerosol content. Pune and Jaipur were discovered to have high DNI and low aerosol levels. The results demonstrated that by employing different effective solar cells and optical devices, the overall efficiency of more than 30% is attainable. Ahmadi et al. [141] analyzed the perfor-

TABLE 3: Solar energy roadmap of Malaysia [138].

Year	Solar power capacity cum. (MW)	Ren. energy capacity cum. (MW)	Ren. energy capacity mix (%)
2011	20	219	1
2015	295	1275	7
2020	1250	3140	14
2030	3100	7088	25

mance and exergetic of solar chimneys in 3 distinct sites around Iran, an Arab World nation. Bandar Abbas, Semnan, and Tehran were selected to conduct economic and thermophysical analyses. For many cities, several optimum collection and chimney works have been developed. A stack length of 733.242m and a collector dia. of 1070.740 were employed for the Tehran. A chimney length

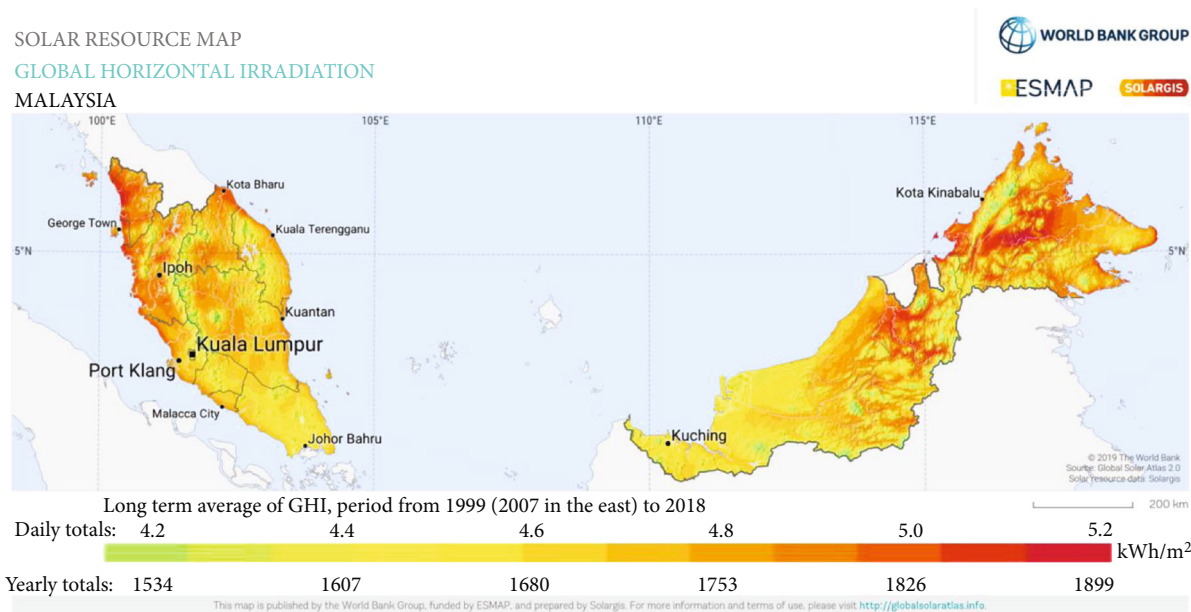


FIGURE 14: Photovoltaic electricity potential in Malaysia [139]

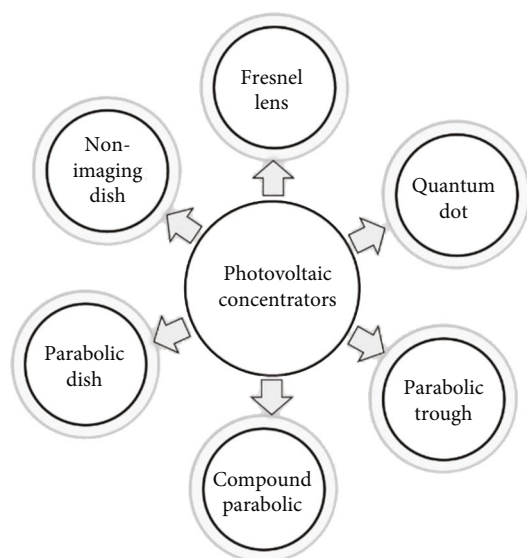


FIGURE 15: Different photovoltaics concentrators [143].

of 807.343 m and a collector dia. of 1281.196 were utilized in the town of Semnan, although a chimney distance of 823.353 m and a collector dia. of 1544.823 were chosen for the town of Bandar Abbas. According to findings, Bandar Abbas is the first, followed by Semnan and Tehran in suitable plant efficiency and both physical and economic difficulties. Venkatachalam and Cheralathan [142] tested the thermal efficiency of conical absorber plates with varied ratios of 0.8, 1.0, and 1.2 as parabolic dish concentrators. On completely bright days with energy over 600 W/m², the receivers of various proportions were tested. The researchers noted that when the increase of proportion, the thermal efficiency of the receiver decreases, and the device performs best at 0.8.

Figures 16(a)–16(e) show the schematics of different photovoltaics concentrators. Fresnel lenses, which employ a jagged form to focus solar rays on a solar panel, are perhaps the most promising lens utilized for PV applications. Its operation is similar to that of a standard lens in that light is redirected and focused to a single point [149]. Among the most common concentrators utilized in CPV systems is the parabolic dish concentrator. This kind of solar concentrate features a two-axis tracker that directs the sun's radiation to a limited region of solar panels [150]. To increase the output, optical devices are used to focus the sun's radiation on a narrow band of a solar panel. The quantum dot concentrate was developed to replace a wide area of solar cells, lowering the system's cost [151].

3.2. Nanoparticles in Solar Applications. Among the numerous strategies for improving collector performance, replacing the base fluid with such fluid with a higher convective h_t factor is perhaps highly successful.

Figure 17 illustrates the experimental setup of solar FPC with nanotechnology. Sharafeldin et al. [152] carried out research employing the test equipment depicted in Figure 17. The thermal performance of 2.009 × 1.009 m² FPSC was determined using WO₃/H₂O nanofluids as the operating fluid. The FPC thermal performance was found to be 71.87 percent at a nanoparticle vol. of 0.0666 volume percent and a mass flow of 0.0195 kgs⁻¹. According to Sundar et al. [153], Al₂O₃/H₂O nanoemulsion was employed. The collector's efficiency rose as the m_f rate and vol concentration of NPs increased. According to the findings of Akram et al. [29], the thermal efficiency of a solar panel improves with increasing m_c and m_f and declines with increasing lowered temperature factor. At m_c 0.1 mass percent and m_f 0.0260 kgs⁻¹m⁻², the best thermal efficiency of

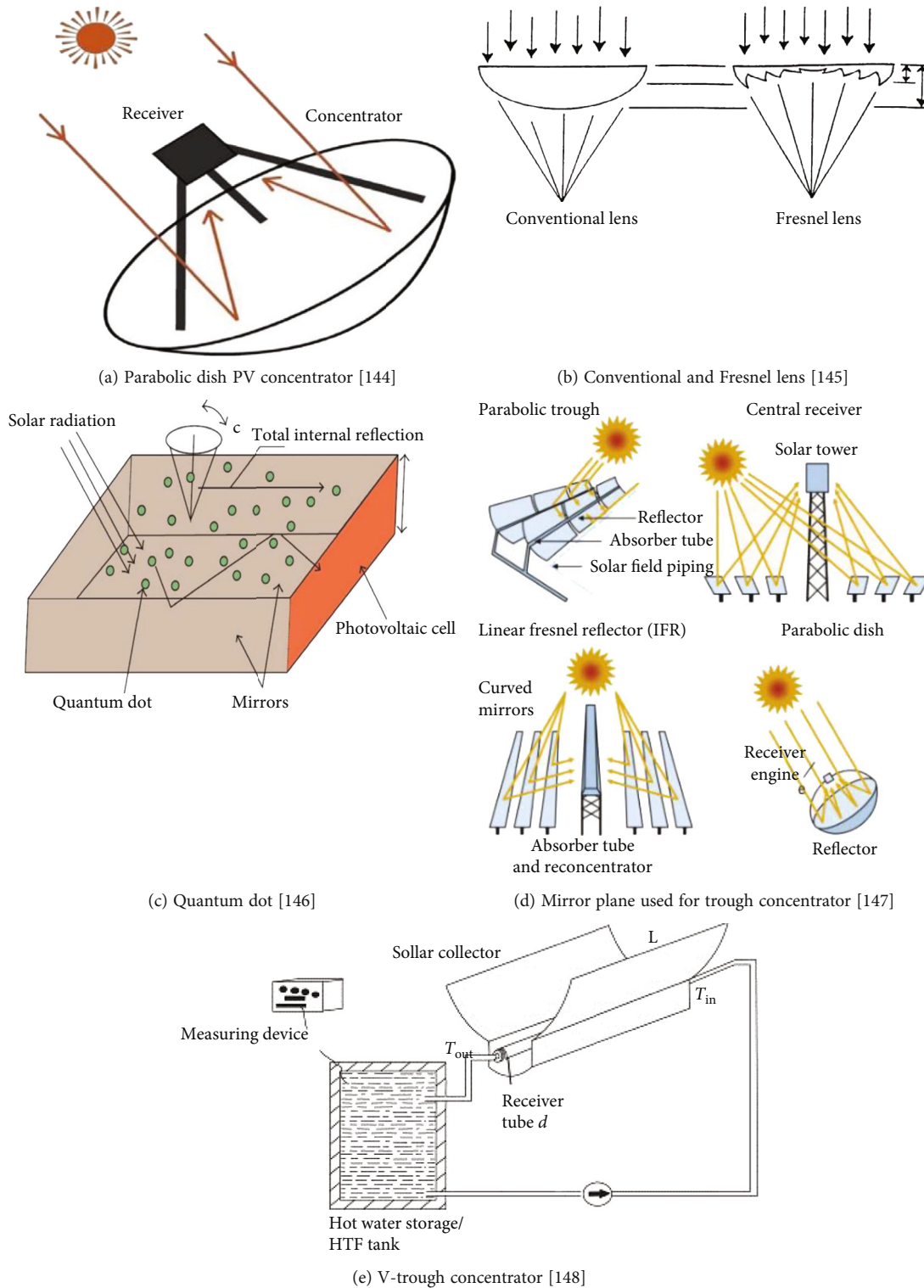


FIGURE 16: Schematics of different photovoltaics concentrators.

a solar concentrator achieved 78 percent, which is 18.2 times larger compared with water at similar flow rate circumstances.

Furthermore, nanoparticles are also widely used in other solar energy technologies such as solar stills, solar thermal photovoltaics, solar-assisted refrigeration, and

dye-sensitized solar cells [154], to enhance their efficiency. Whether it is solar mechanical system or solar cells of different types, the wide use of nanoparticles is being investigated where researchers have found notable difference in energy efficiency of these solar technologies [155]. Many other related works are reported in [156–167].

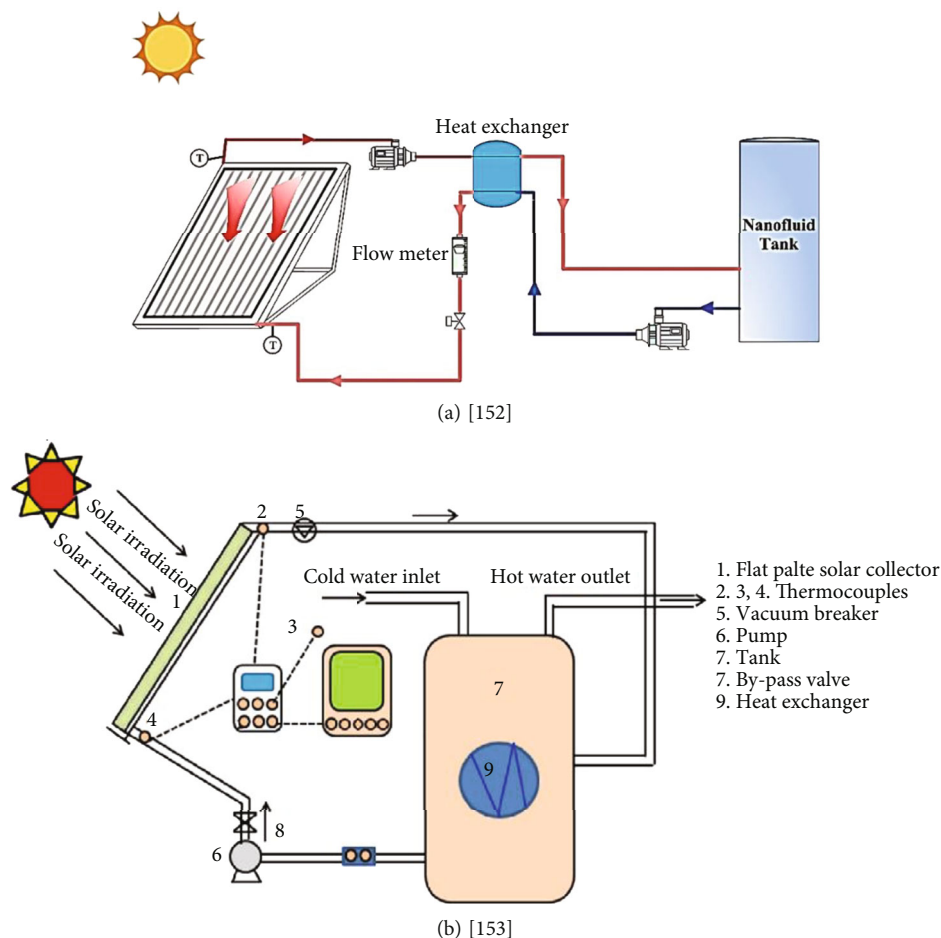


FIGURE 17: Experimental setup of solar FPC with nanotechnology.

4. Summary and Future Recommendations

COVID-19 is regarded among the key issues which not just Malaysia, as well as most nations worldwide, have yet to conquer. Nevertheless, Malaysia's attempts to execute the MCO rule have resulted in the closure of most towns and cities, economic and entertainment sites, and a ban. The adoption of this legislation has led to lower concentrations of pollutants and carbon footprints. The Malaysian government is on track to cut GHG by 40 percent in the next year, 45 percent by the year 2030, and completely nonpolluting by 2050 to provide greener earth for a future generation [120]. The potential and demand for biodiesel in Malaysia are rising due to the enormous availability of edible and nonedible feedstocks. According to the United Nations Food and Agriculture Organization, 62.3 percent of Malaysia, or around 82782.49 sq. km are covered with forests. To boost RE, the govt. has taken several steps to attract FDI. It has aided in this by strengthening economic growth, preserving economic stability, and delivering a range of financial advantages. The govt. has suggested several positive policies, which include tax breaks for the establishment of large multi sites for solar panels, Li storage batteries, EVs, and charging stations.

- (1) A well-developed biofuel sector may undoubtedly be economically successful, environmentally friendly, and useful to society. Palm oil (PO) biodiesel is used in Malaysia in the transport sector and industries. Malaysian state prioritizes investing in PO production research, biodiesel enhancement, obtaining more effective combustion quality, power conversion, and environmental concerns
- (2) The Malaysian government has passed several norms to commercialize B20 biodiesel fuel blends in the transport sector and offered subsidies on the setup of biodiesel plants
- (3) Due to its tropical spot, Malaysia offers enormous potential for significant solar thermal deployment in industry and commercial buildings. Moreover, solar energy is an excellent choice for the PO sector because of its constant supply of sunshine, lack of moving parts, independence from fuel sources, and environmental friendliness
- (4) The inclusion of metal and carbon-based NPs in the biofuel mixture reduces the flashpoint while increasing the oxygen content and calorific value. The NPs

assist in promoting oxygen atoms and act as catalysts improving the microexplosion phenomenon

- (5) SE production is a sustainable option that leads to significant reductions in CO₂ emissions while requiring no fuel throughout the operation. Long-term goals should include the deployment of grid-ready off-grid network systems for the township and isolated locations, as well as the adoption of grid-connected by-laws for grid structures that are “Roof-top ready”
- (6) Energy-saving policies and sustainable heat should be regulated, and a committee has been formed to ensure that excess heat is minimized. The government should focus on developing EVs operated by solar and charging stations powered by biodiesel and solar energy

The following are the barriers and solution:

- (1) The stability of nanoparticles is lower in the base fluid due to Van der Waals motion. The stability of the nanoparticles in the base fluids can be enhanced by lowering the surface tension between nanoparticles and the fluid molecules
- (2) The addition of surfactant lowers the nanoparticle interaction and reduces the agglomeration of nanoparticles in the base fluids. Several researchers are investigating the methods to increase the shelf life of the nanoparticles in the base fluids through high ultrasonication methods, addition of different surfactants, and increasing the Brownian motion of the nanoparticles
- (3) Few researchers reported that the nanoparticle additives in diesel-biodiesel fuel blends may cause environmental pollution. However, the recent investigations suggest there are minimal emissions due to complete burning of H-C fuels, although very insignificant quantity of nanoparticles are found in the fuel filters after combustion of fuels
- (4) The cost of commercially available nanoparticles is high; however, the cost of nanoadditives can be significantly reduced by chemical synthesis in laboratories using methods such as CVD, sol-gel, laser ablation, microemulsion, precipitation, and sputtering

Nomenclature

D/D100:	Diesel
BD/B100:	Biodiesel/100% biodiesel
ASTM:	American Society of Testing and Materials
EN:	European Norms
MPIA:	Malaysian Photovoltaic Industry Association
IEA:	International Energy Agency
IRENA:	International Renewable Energy Agency
GHG:	Greenhouse gas

SE:	Solar energy
RE:	Renewable energy
TE:	Transesterification reaction
FDI:	Foreign direct investment
MCO:	Movement control order
B20/B25:	Biodiesel (20%)/(25%)
PO:	Palm oil
FAME:	Fatty acid methyl ester
NPs:	Nanoparticles
FPSC:	Flat plate solar collectors
PV:	Photovoltaics
EVs:	Electric vehicles
h_t :	Heat transfer
m_c :	Mass concentration
m_f :	Mass flow rate
CTAB:	Cetrimonium bromide
HRR:	Heat release rate
BTE:	Brake thermal efficiency
BSFC:	Brake specific fuel consumption
CO:	Carbon monoxide
CO ₂ :	Carbon dioxide
NOx:	Nitrogen oxide
CR:	Compression ratio
GO:	Graphene oxide
ZnO:	Zinc oxide.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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