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Fossil Fuel Alternatives: Renewable Energy and Nuclear

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Abstract

The use of fossil fuels (oil, gas, and coal) is still the mainstay of world energy for various reasons of its convenience. Although currently fossil fuels are also accused of being the main cause of climate change and global warming, it is not that easy to replace them with clean energy. There is still a transition period between dependence on fossil energy so that it can later be changed into green energy. Renewable energy is indeed planned to be the main energy source in the future because it will not run out. However, its management still experiences various obstacles such as costs or distribution. Some examples of renewable energy, for example solar, wind, bioenergy, tides, geothermal, water, nuclear, and others can be fully utilized for energy by changing its form to produce electricity or heat. Nuclear is also included in Indonesia's plan to start developing reactors so that they can be used commercially in the future. In the energy transition plan with its various obstacles, a combination of fossil fuels alongside renewable energy is used, which is called a hybrid system. This syst em can consist entirely of renewable energy or a combination of two or more fossil fuels and renewable energy. In addition to its better effectiveness, greenhouse gas emissions can also be reduced with this mechanism. That is why it is also important to develop hybrid systems and smart grids to support global energy security.

Keyword: Fossil Fuel, Renewable Energy, Nuclear.

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INTRODUCTION

The burning of fossil fuels has a significant impact on climate change and global warming, both from the transportation, industrial, and manufacturing sectors (Rehman et al., 2022)—for example, emissions from power plants that use coal as the main fuel. Coal has the highest CO2 emissions compared to other fossil fuels, making it the main cause of g—lo—b—al warming and climate change, one of which is the use of coal in steam power plants. Coal burning usually being largest contributor to climate change; the source of a global public health crisis; and be a largest contributor to global insecurity in all of the area (Burke & Fishel, 2020). In Indonesia, coal ranks first for fuel where half of the power plants in Indonesia still use coal, and the remaining one-third use natural gas. Now, Indonesia has 33 GW of coal capacities in development with the power plant, and being third country which is under China and India in while expanding of coal-fired power plants (Ordonez et al., 2022). That is why the government has a plan to kill coal power plants, but it has not been realized until now.

Natural gas is also one of the commodities to drive power plants even though its emissions are not as high as coal. However, the low intensity of carbon emissions from this energy will result in a decrease in environmental quality due to emission residues that accumulate on an ongoing basis. Uncontrolled consumption of natural gas will also cause environmental damage, especially air pollution. (Aimon et al., 2022). Natural gas has many benefits ranging from industrial, transportation, and household needs. That is why it is important to utilize natural gas in a more sustainable and environmentally friendly way so that it can reduce emissions. In the coming year, global demand for gas will mostly be needed in Asia Pacific countries. Its use is mostly for industry, power plants, residential and commercial. Russia as one of the largest gas producers is also still affected by geopolitics so its gas supply is more to the Asian region than the EU (IEA, 2023).

Crude oil is still the main need in the transportation sector. However, according to BP's 2018 Energy Outlook, renewable energy has been growing rapidly lately and could even reach 14% by 2040. And the need for oil continues to decline even though it has not yet reached peak demand. Drilling technology and hydrocarbon extraction costs are also not cheap, so there is a transition to replacing hydrocarbons with renewable energy (Pickl, 2019). In comparison with fossil powers, biofuels are a source of renewable vitality that can ensure the country's economy whereas protecting the normal climate. It shows up that as it were microalgae can supplant fossil powers as feedstock. It's common to develop microalgae in photo-bioreactors or colossal open lakes. The carbon dioxide created due to the combustion of biofuel is reused in photosynthesis for biodiesel generation. In coal co-firing, microalgae can create power to

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diminish nursery outflows and lower coal utilization. Besides, bioethanol and biodiesel can supplant two essential fossil fills (gasoline and diesel) utilized within the transportation division (Malla et al., 2023).

Natural gas, oil, and coal are improving to reduce greenhouse gas emissions that can threaten the environment. That is why renewable energy is present and has become one of the alternatives for energy transition and reducing emissions due to the combustion of fossil fuels. Currently, the consumption of non-fossil fuels is increasing due to the issue of climate change and emissions. Utilization of atomic and hydropower has been much more prominent than that of other non-fossil powers such as sun based, wind, etc. This means that nuclear is one of the alternative renewable energy sources for the world, although the aspects of acceptance and safety are still doubtful in Indonesia, it has been proven that nuclear energy sources are one of the largest contributors of renewable energy in the world (Chen et al., 2019). There are various types of renewable energy sources such as solar, wind, bioenergy, tides, geothermal, water, nuclear, and others that can be developed to meet the world's energy needs. Worldwide yearly renewable capacity augmentations expanded by nearly 50% to about 510 gigawatts (GW) in 2023. More over saw a step alter in renewable capacity increases, driven by China's sun- based PV showcase. In 2024, wind and sun- based PV together create more power than hydropower. In 2025, renewables outperform coal to ended up the biggest source of power era. Wind and sun- oriented PV each outperform atomic power era in 2025 and 2026 separately. In 2028, renewable vitality sources account for over 42% of worldwide power era, with the share of wind and sun powered PV multiplying to 25%. (IEA, 2024).

The comparison between fossil fuel and renewable energy can be compared from several aspects. The economic factor of fossil fuel materials is certainly cheaper than renewable energy. Fossil fuels such as coal when compared with renewable energy for conventional power plant fuels, of course coal will be much cheaper than solar energy. Even so, the price of renewable energy is predicted to continue to fall. The weighted normal fetched of power fell for utility-scale sun-oriented PV by 3 percent, for inland wind by 5 percent, for concentrating sun powered control by 2 percent, for bioenergy by 13 percent, and for geothermal by 22 percent (IRENA, 2023). Even so, the volatility of fossil fuel prices is often influenced by world geopolitics, so they often experience price instability, especially crude oil. The existence of renewable energy will support this so that energy price stability can be achieved. About environmental impacts, renewable energy does have a smaller impact than fossil fuels. Various studies have shown this so that the energy transition must be carried out immediately to achieve net zero emissions (NZE). Although the main weakness of renewable energy is the

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unstable availability of energy and is highly dependent on a particular location, so it is still difficult to produce on a large scale. Renewable energy is indeed suitable for remote areas with local energy potential because there no adequate infrastructure and very large costs.

Nuclear as a clean, environmentally friendly, low-carbon, and highly efficient technology has high potential in the future to be developed further. With the imaginative plan of progressed atomic vitality frameworks and the in-depth inquire about and improvement and comprehensive application of next-generation progressed atomic vitality innovations, the security of the atomic vitality framework will be made strides and the economy gets to be more competitive. There will be more prominent openings for the advancement of progressed atomic vitality innovations within the future. It'll be closer to clients, more secure, low-carbon green, and give an assortment of atomic nuclear vitality applications (Zhan et al., 2021).

Indonesia has planned to develop nuclear technology for various purposes, but it is not allowed to use it for weapons because it is bound by an international agreement. Various uses of nuclear such as for power plants, genetic engineering, and other benefits will certainly make this technology even better to be applied immediately. This nuclear technology has been planned to be developed for a power plant that is planned to operate in 2049 with a capacity of around 35 GW (. et al., 2023).

In addition to nuclear, hybrid power plant technology is also starting to be developed to increase the efficiency of energy use. This technology can use all renewable energy or a combination of renewable energy and fossil energy. The design of the dynamic energy process operation can produce electricity from one or more primary energy sources such as nuclear, renewable energy, and fossil fuels. The products produced are also diverse, such as heat, hydrogen, or various other derivative products that are useful for industry. This electricity network management system also requires a commitment model related to production costs, reliability evaluation, operational costs, and potential income from investments that have been made, to adjust to current market potential conditions. The hybrid system should also be connected to the smart grid and smart system so that it is easy to control and also to allocate for other facilities (Arent et al., 2021). The difficulty of having an IoT-based smart grid is ransomware, malware, or cyber security attacks that must be handled properly.

METHOD

The method used in this paper is a literature review. This research uses the Systematic Literature Review (SLR) method, a systematic research method that uses the method of collecting, synthesizing, evaluating, and presenting the results of previous research on a specific

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topic. By providing comprehensive evidence, SLR provides clear motivation to gain new insights and guide decision-making (Al-Zubidy & Carver, 2019). The SLR method uses a quantitative descriptive approach in its research. The research was conducted on secondary data in the form of research findings on the main themes. The research stages include data and information collection, analyzing and processing data, and drawing conclusions (Juandi, 2021). The collected data are the results of previous research published in national and international journal articles collected through electronic databases. Articles that are relevant and meet the inclusion criteria will proceed to the analysis stage.

RESULTS AND DISCUSSION

Role of Fossil Fuel to Energy Security

Fossil fuel is part of the energy that takes energy in one form and transforms it into another form. In the 20th century, since the development of the Industrial Revolution, energy began to be used on a large scale starting from the use of steam trains that convert coal power into rotary power with steam engines, or using firewood to be able to heat a room into a fireplace is also one form of energy transformation. Now, fossil energy has also been further transformed with manufacturing systems, transportation, electric power, and others. For example, coal and oil are mined in one place, refined, and undergo various further processes before combustion and energy utilization occur.

Energy utilization can be used for various purposes at various levels. There are several types of energy conversion types, namely:

- Essential energy. Crude fabric within the to begin with shape in which individuals get it: oil from a well, coal at the pithead, and so on. These fills may be utilized instantly, or after a few constrained handling (as coal and common gas frequently are), or may be changed over (changed) into other vitality carriers (coal or gas into power and/or warm, or oil in a refinery to oil items).
- Final energy. Energy within the shapes in which it is as a rule sold to clients (power, petrol or distinct heating) for assist transformation into useful energy.
- Valuable energy. Within the frame that a client needs it: warm for warming or cooking, light for lighting, the thought process control of a car, or mechanical vitality for fabricating.
- Energy services. The purposes for which individuals expend energy: keeping warm, being able to see after dull, communication, getting from put to put, or fabricating things. Energy conversion can also be in the form of fossil fuel or renewable energy. (Pirani,

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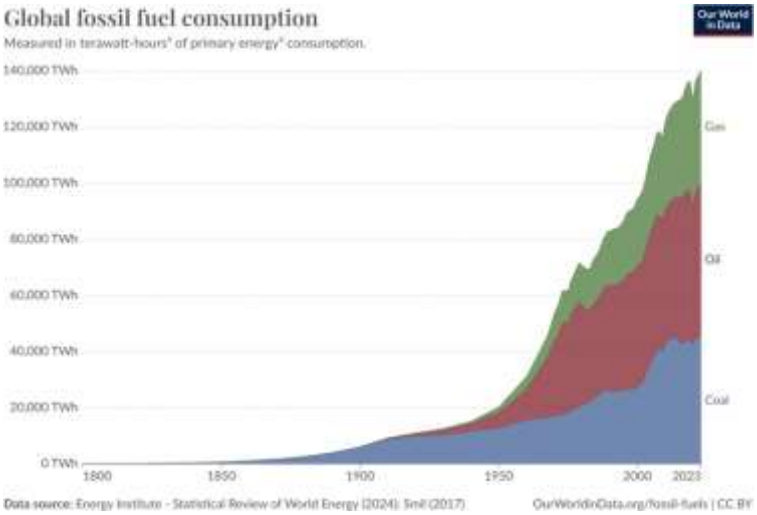


Fig. 1. Global fossil fuel consumption

Consumption of fossil fuels in the world still dominates where according to BP Energy Outlook 2023 data for the global oil mix, it is estimated to reach 31.6%, while natural gas is 23.5%. Meanwhile, coal is estimated to reach 26.7%, renewable energy is 14.2%, and finally nuclear reaches 4%. If calculated, around 70% of the world's energy sources come from fossil fuels.

Based on Fig. 1, it can be seen that the use of coal has begun to stagnate even though it is still used for around 45 thousand TWh (terra-watt hours). The claim that coal produces the most CO2 emissions has made it start to be abandoned or searching for other alternative resources that environmentally friendly, for example through co-firing with biomass in the power plant system. Meanwhile, oil still dominates the world market with around 54 thousand and TWh mostly for the transportation and manufacturing sectors. The use of oil has also begun to be reduced with the presence of electric vehicles to support the energy transition and clean energy. Natural gas as one of the least emission-producing energy sources still needs around 45 thousand TWh to fulfill the world's energy needs (Ritchie H. et.al, 2017). While the countries that use the most fossil fuels are of course China and the United States which use more than 20 thousand TWh of fossil fuels. Furthermore, it is dominated by Russia and India which use more than 5 thousand TWh, followed by Indonesia and several other countries in the world. The need for fossil fuels certainly continues to increase until peak conditions and will later affect the availability of fossil fuel supplies. Actually, there are many reserves that have not been studied and also discovered by various countries, for example, Saudi Arabia is one of the largest

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hydrocarbon producers in the world. Likewise, in Indonesia, various research and studies on other fossil fuel reserves still need to be carried out to achieve energy security.

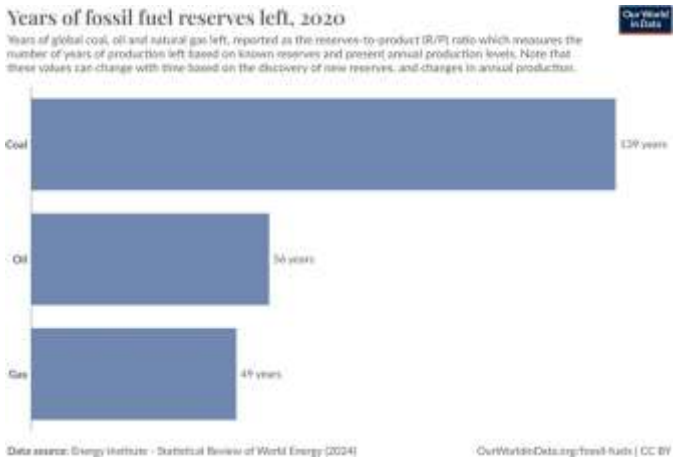


Fig. 2. Fossil fuel reserves

The world's fossil fuel reserves are predicted to last for hundreds of years. However, after this energy runs out, how will the world's people survive? That is why it is necessary to look for various other alternatives to find renewable energy sources to meet future energy needs.

Based on Fig. 2 on fossil fuel reserves, based on the Statistical Review of World Energy 2024, it was found that the world's coal reserves are still around 139 years and can still change depending on research and discoveries including coal reserves. Oil will run out around 56 years while technically boring for oil inconclusively, finding saves will gotten to be harder and harder the more profound burrow into the ground and the pricier, more complex, and less proficient. Gas forecasts shift and to a great extent depend on utilization rates, but specialists gauge that it'll be around 49 a long time some time recently we run out of natural gas. In fact, the world's natural gas reserves are still sufficient to meet needs for tens or even hundreds of years if further exploration is carried out. However, fossil fuel is a non-renewable energy so it is better to look for better possibilities to achieve energy security in the future.

Global demand for coal has indeed declined recently and in 2024 it is predicted to only increase by around 1%. China is the largest coal consumer country in the world, which is around 56% of the total demand in 2023. India as the second largest consumer country will increase its coal demand by around 10%. In addition, ASEAN countries also use a lot of coal for various industrial and power generation needs. Indonesia is the one that exports a lot of coal (512 Mt)

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to various countries, followed by Australia (353 Mt) and Russia (211 Mt). Meanwhile, oil exporters are still dominated by Middle Eastern countries that are members of OPEC such as Saudi Arabia and the United Arab Emirates. In addition, the United States also has a fairly good oil production capacity. The world's need for oil is still dominated by the United States, India, China, and also Indonesia. Currently, the need for oil is starting to decline due to the existence of electric vehicles that are transitioning from dirty energy to clean energy. In addition, biofuel technology has also begun to develop such as B35, B40, and others so that in the future the oil sector will be more sustainable and have minimal emissions. Natural gas production is still dominated by Russia as one of the largest natural gas producers in the world. The geopolitical tension between Russia and Ukraine has disrupted the supply of gas stability, especially in the European Union region, including in other regions and Indonesia. There are several results of natural gas extraction such as LPG, LNG, and so on. The largest product is LNG, the transportation of which is quite expensive.

The main geopolitical tension between Russia and Ukraine makes LNG prices very volatile. Indonesia has also entered into several contracts with foreign oil and gas contractors to conduct exploration in Indonesia. Currently, LNG contracts indicate long terms with destination fixed contracts so extraction is expected to be clearer. Countries that need gas mostly come from Asia and are likely to continue to increase demand to meet energy transition needs. As is known, emissions from natural gas are indeed the lowest compared to other fossil fuels. Low-emissions gases can play an important role in the decarbonization of long-haul, heavy-duty transport, where electrification so far has made slower progress compared to light-duty vehicles (IEA, 2024).

Challenges with Fossil Fuels Based on Economy and Environment

Fossil fuel has indeed been a primary energy source for hundreds of years. Its use has helped humans to develop various products and other needs. However, recently fossil fuels have been accused of being the main actor contributing to global warming and climate change so currently, the development of fossil fuels has begun to shift due to various factors.

1. **Fossil Fuel Reduction and their Impacts on Global Economy**

There are concerns that fossil fuels will run out in the next 300 years (1750-2050) with the current massive level of use. In 2030, it is feared that there will be a depletion of fossil fuels which will affect the global economy and also world political stability. Although British Petroleum also predicts that reserves of oil, natural gas, and coal can still be utilized in the next tens to hundreds of years. This also depends heavily on discoveries, extraction technology, the

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environment, and the development of renewable energy. If a breakthrough is not made immediately, the world's fossil fuel reserves may soon run out and drive the economic impact to the renewable energy transition which causes all negative economic impacts (Holechek J.L et.al, 2022).

2. Fossil Fuel Use and Impact on Climate Change

For the past 30 years, global warming and climate change have become widely discussed issues ranging from melting ice at both poles, rising sea levels, increasing heat in the ocean, increasing humidity, tornadoes, heat waves, and various other natural phenomena that damage human life and other living things in the world.

Fossil fuel is believed to be one of the factors causing climate change due to greenhouse gas (GHG) emissions. GHG consisting of CO2, CH4, NOX, SOX, and various other pollutants are the main factors of climate change. Over the final 40 a long time, the normal temperature increment per decade has been nearly 0.20◦C. Of incredible importance is that the rate of worldwide warming has been expanding. As authentication, 17 of the final 18 a long time have been the most-sultry on record, and the long time of 2014, 2015, and 2016 were characterized by progressive unused temperature highs. On the off chance that this rate of increment proceeds, the 1.5 ◦C limit which puts the world at hazard of catastrophe, will be come to by the early 2040s (Holechek J.L et.al, 2022).

That is why countries in the world are starting to be concerned about this and making various breakthroughs in the climate sector. The Paris Agreement at COP 21 in 2015 stated that its main objective is to keep the average global temperature below 20 Celsius and limit it to an increase of only 1.50 Celsius. In addition, it is also important to improve adaptation mechanisms and resilience and develop technology to reduce greenhouse gas (GHG) emissions. And the last is to allocate funds appropriately to achieve the previous goals. From these results, countries in the world finally set nationally determined contribution (NDC) targets to achieve net zero emission (NZE) conditions (Shana, H, 2019).

3. Who Does Not Believe in Climate Change

Climate change has become a theory that is believed by the whole world and proven by various recent research. Although in reality it is still a prediction for the coming years. However, the symptoms have indeed begun to appear. Even so, several groups of people do not believe in climate change so they see that climate change is just a normal phenomenon and is natural.

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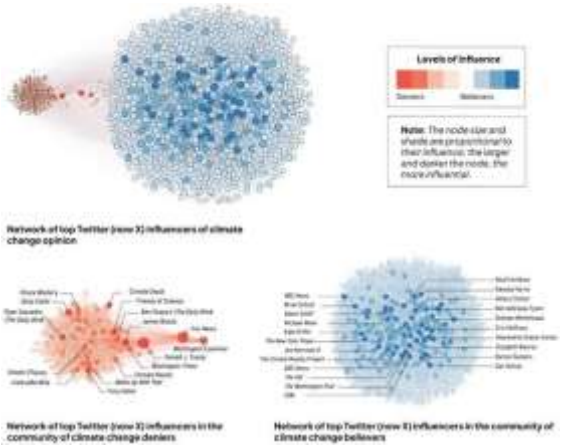


Fig. 3. Analysis of American people influence by media and influencers for climate change opinion in X

A study shows that research on the experience of a hot summer in 2023 is hotter than in previous years. This understanding is what causes climate change to be just a conspiracy theory. Research on respondents in the US and China found that temperature anomalies were not related to climate change. The existence of this issue is more about the theory spread by policymakers about the existence of a conspiracy from climate change (Chan A.W et.al, 2024). Another study in the US (Fig.3) that states that climate change is a hoax is research on various opinions on social media (Twitter/X) conveyed by influencers, national figures, presidents, and also local media about climate change. The results show that 2 groups on social media believe in climate change (blue) and also deny it (red).

Only about 14.3% of the total users who discuss climate change issues do not believe in this phenomenon. This means that the number is still very small. President Trump, who is also known to not believe in climate change, has the greatest influence on this group. The three groups that have the same understanding as Trump are blog news such as The Daily Wire, Daily Caller, Breitbart, and the Brad ford file; mis/disinformation websites that distribute deceiving and wrong claims around climate alter, counting Town Hall Media and Climate Depot; and right-wing makers, political commentators, and activists who disagree with the concept of climate change (Gounaridis D. et.al, 2024).

Role of Renewable Energy

Renewable energy is the energy of the future that is predicted to replace fossil fuels. This is because renewable energy is more environmentally friendly and produces relatively smaller emissions than fossil fuels. That is why the use of renewable energy is increasing from

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year to year. Solar energy and hydropower are two types of renewable energy that have the most popularity compared to other types.

Worldwide yearly renewable capacity augmentations expanded by nearly 50% to about 510 gigawatts (GW) in 2023. This year too saw a step alter in renewable capacity increments, driven by China's solar based PV showcase. In 2024, wind and solar oriented PV together produce more power than hydropower. In 2025, renewables outperform coal to ended up the biggest source of power era. Wind and sun powered PV each outperform atomic power era in 2025 and 2026 individually. In 2028, renewable vitality sources account for over 42% of worldwide power era, with the share of wind and solar based PV multiplying to 25% (IEA, 2024).

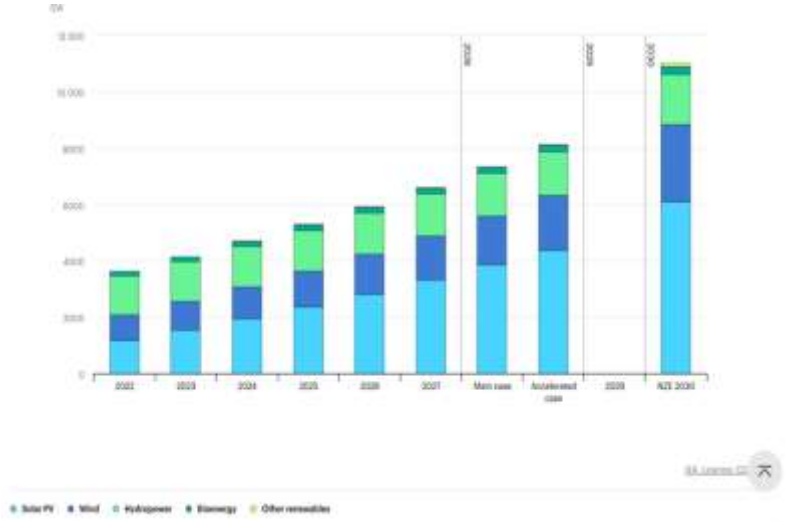


Fig. 4. Renewable electricity needs which is developed to reach Net Zero Scenarios until 2030 in G20 countries

Based on Fig. 4, it is predicted that in 2030 solar PV will still be the largest renewable energy source for the world. Wind energy will probably increase in balance with the use of hydropower as is currently widely used. Likewise, bioenergy and other renewable resources are very interesting to continue to be developed.

1. **Solar Energy**

   The use of solar energy is mostly applied to solar power plants often referred to as solar PV. This machine can convert sunlight to electricity so that it can be used for various needs. For example, as fuel for electric vehicles, turning on lights in buildings, desalination process on salty water, pump water in rural areas, and so on (Maka & Alabid, 2022).

2. **Hydropower**

   Hydropower is one of the leading sources of renewable energy up to 71% of this supply in

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2016. Many countries utilize hydropower to generate electricity starting from Europe, North America, the Mekong River Basin, Congo River Basin, the Amazon River Basin and various regions that have large rivers as their energy sources (Moran et al., 2018). In its technology, hydropower will dam the river and produce kinetic energy from the difference in water height so that the energy can drive the turbine and be used to generate electricity. This energy source is also interesting to be developed in Indonesia because the region has the potential for large rivers.

3. **Wind Energy**

   Wind harvesting is something interesting to develop because of its good potential in various regions of Indonesia. Choosing a site, of course, requires a hilly area that has a lot of wind flowing smoothly so that the power plant can operate optimally. Although the constraint is often unpredictable wind in terms of speed and directions. In general, this wind technology uses a wind turbine or rotor that supports capturing kinetic energy into mechanical energy and driving the turbine to generate electricity. Selecting the location for a wind energy framework plays a pivotal part within the specialized, financial, and usage potential. Another to location choice, agreeing to meteorological information, both appropriate advances and competitive costs, considering the limitations and motivations for wind capacity inside a certain time outline, ought to be assessed (Olabi et al., 2021).

4. **Nuclear Energy**

   Nuclear technology has developed widely in the world, although it has not been used commercially in Indonesia. Since the nuclear leak in Fukushima, calls for nuclear safety have become increasingly important in the future. There are several advanced nuclear technologies that will be developed in the future, namely to change over ripe fabric into fissile fabric to realize atomic fuel supportability. The strategy is to utilize quick reactors and thorium-based liquid salt reactors. This material is abundantly available throughout the world with reserves of more than 10 thousand years. The next is the focus on being able to implement comprehensive applications of progressed little reactors and the inventive application of progressed atomic vitality to construct an effective, low-carbon, and adaptable keen vitality framework. The final is to fortify fundamental inquire about and common innovation for investigate and advancement within the atomic field. Indonesia itself will make nuclear with a small module reactor type which can later be developed for various needs (Zhan et al., 2021).

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Hybrid Systems

Hybrid system in energy use is one way to obtain energy more efficiently and environmentally friendly. Several hybrid systems can be used, either renewable-renewable, renewable-fossil fuel, or consisting of 3 or more energy sources. That is why this method is one alternative to achieve net zero emissions. This system is also very suitable to be applied in Indonesia, especially for inaccessible and remote small medium island in Indonesia with the remote communities lack of along with power, heating, and cooling. There are several hybrid system models as follows

1. **Nuclear and Wind Power**

   Combination of nuclear and wind control hybridizes little secluded reactors with wind turbines for creating three valuable commodities (Fig.4), to be specific power, hydrogen, and hot water. The measured quality of such reactors presents vocal points like lower operational and support costs, lower outflows, and progressed efficiencies when compared to customary atomic reactors/SMRs. The calculated vitality efficiencies for the crossover polygeneration framework were 57.5%, separately; values much higher than the efficiencies of single and cogeneration plants. For this reason, the use of this hybrid system has various advantages besides nuclear being renewable energy also has quite good efficiency (Khalid F.et.al, 2019).

   Conventional nuclear power systems use a single- generation system that only produces output power. The heat generated can be reused to generate the system. Currently, the design of nuclear power needs to be hybridized so that it can produce hydrogen, electricity, and also hot water. SMR combined with wind energy network operations will be more stable and also carried out with better management.

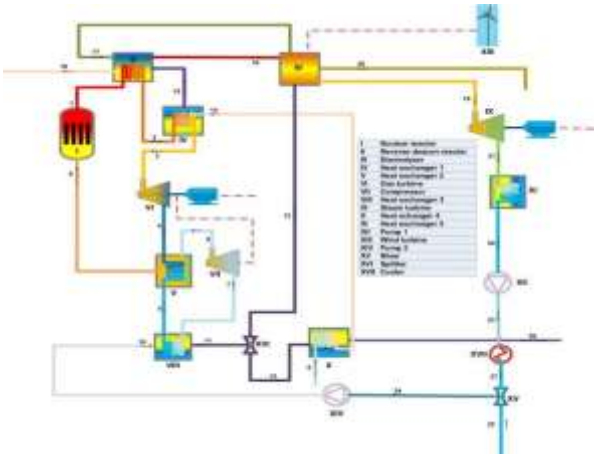


Fig. 5. Diagram of a hybrid nuclear plant and wind turbines

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2. **Natural Gas-Solar Energy in Residential**

Natural gas is a fossil fuel that has quite low emissions and is suitable for the development of various hybrid systems. The energy cost savings and emmitions of a vitality framework combining PV with a characteristic gas control era unit associated to the lattice to cover the power (3 kW), heat, and also cooling requests of a single domestic. This situation was found to produce more control and require less obtained control, driving to a day by day sparing of 28% - 40% when compared to the situation without the vehicle-to-grid choice or the request reaction program. (Brahman F. et al, 2015).

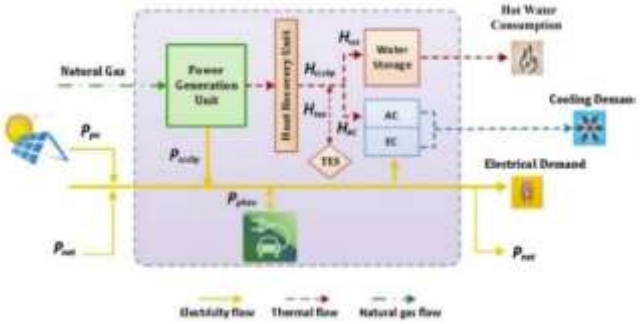


Fig. 6. Flow diagram of a hybrid plant in Anatural gas and solar PV using for hot water, cooling, electrical also for electric vehicles.

3. **Coal for Chemical Industry**

Cross breed energy framework is proposed as a way to relieve the carbon polution in coal-based chemical businesses.

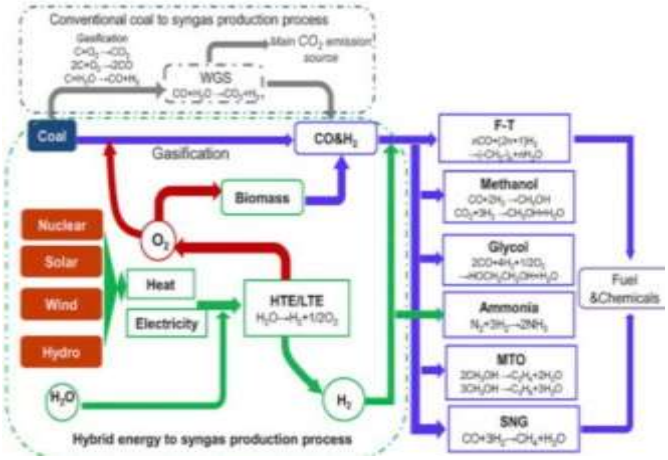


Fig. 7. Hybrid energy from coal and renewable energy resulting fuels and chemicals

Concurring to the International Energy Agency (IEA), 70% of CO2 pollution comes from

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fossil fuel combustion, in which coal involves more than 40%. Coal may be a basic enabler within the advanced world, giving 40% of the world's power, and is a fundamental crude fabric for 70% of the world's steel generation and 90% of cement generation (Qianqian Chen et al., 2018).

4. **Smart Energy System (SES)**

The most include of SES is the adaptability in utilizing the distinctive vitality sources and adjusting the fluctuating slant of renewable assets. Multilevel framework that interfaces businesses to person citizens and central control era to disseminated era, blending the power segment with the thermal one. SES must incorporate at slightest the taking after keen power lattices; savvy warm lattices (locale warming and cooling; DHC); and savvy gas networks. SES are done through the utilize of devoted computer program such as EnergyPLAN and Markal-Times and needs tall cyber security framework (Petrakopoulou, F. et.al, 2022).

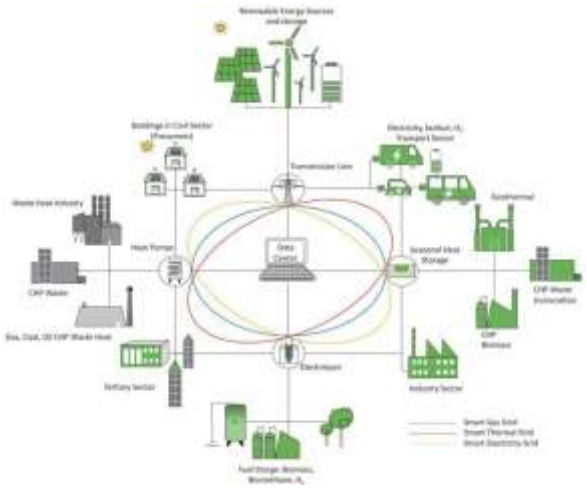


Fig. 8. Scheme of smart energy system

Smart energy systems can integrate all equipment in a system so that it can be connected to cyber security in one network. This is what makes it safe, easy to check and track, and easy to build networks with each other. This system can be used in an entire urban or rural design with one control system in the form of a smart grid. So that the connection between renewable energy, fossil fuel energy, and also various

CONCLUSION

Fossil fuel is an energy that has been used by humans since ancient times and still survives today. Although its reserves are dwindling, the need for fossil fuels is still quite high.

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The need for coal, oil, and natural gas continues to increase until it reaches its peak and is predicted to be replaced by renewable energy.

That is why the world is trying to find alternatives to fossil energy by using renewable energy. In addition, the issue of climate change and global warming produced by fossil fuels is one of the causes of global warming on Earth. Until now, the search for environmentally friendly alternative energy is still ongoing until appropriate energy is found and its efficiency is higher. There are several environmentally friendly energy alternatives such as solar energy, wind, hydropower, biofuel, and nuclear will be more environmentally friendly alternative energy for the future. The energy transition is also not easy because the comparison between fossil fuels and renewable energy is still very unequal in terms of price, cost, energy sources, technology, human resources, and other factors that must still be considered.

Nuclear technology is also being developed rapidly in the world, especially in Indonesia. In the next few years, Indonesia is expected to have commercial nuclear power-based energy that can be used for various needs. One of them is having a policy to build a Small Module Reactor (SMR).

In addition to renewable energy, of course, a hybrid system, namely a combination of two or more renewable energy and fossil energy or others, is expected to increase efficiency and also reduce the environmental impact of fossil energy use. For this reason, the existence of a hybrid system by combining these energy sources will be able to produce more diverse energy sources so that energy security can be achieved.

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