Renewable and Sustainable Energy Reviews 151 (2021) 111473

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Understanding the nexus of energy, environment and conflict: An overview

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ARTICLE INFO

Keywords:
Energy conflict
Climate conflict
Environment conflict
Conflict nexus
Energy environment
Public policy

ABSTRACT

Energy, environment, and conflict are each the subject of significant research efforts. However, their nexus has received relatively little attention, and even less when climatic shifts are considered. Here, we examine existing literature on these individual areas, their overlaps, and elucidate the fundamental gaps in understanding their nexus. Past work has shown that energy and the environment can both be the cause of conflict, or be used as tools in it. Importantly, while many databases have been developed to track conflict, these resources often fail to contain information on the root cause, or target of conflict events. It is also found that databases are not currently available which unify information on energy, environment and conflict. This makes the development of models for how energy, environment, and conflict couple difficult to formulate and test. Further work in this complex space could help inform decisionmakers working on reducing conflicts at the local, national, and regional levels.

1. Introduction

Conflict exists in a wide variety of forms and encompasses a broad array of possible interactions between participants. It can be violent, as in the case of wars, occur between national or subnational actors and can include violent protests and riots by civilians. However, conflict is not always synonymous with violence. It can also manifest as civil unrest, with peaceful protest or political upheaval, through diplomatic channels and take the form of trade disputes, embargoes, migratory disagreements, treaties, and the implementation or withholding of aid to foreign governments.

Conflict has a long history. The earliest known example of an injury from a weapon occurred ~50,000 years ago [1,2], while the earliest record of a battle dates from least 14,000–16,000 years old [3]. The argument has been made that at least some early conflicts were influenced by climatic conditions and resource scarcity [4–6]. The earliest hieroglyphic reference to conquest (i.e. 'captives') dates to at least the first Dynasty of Egypt while the earliest wars in China occurred in the period of the Yellow and Flame Emperors as described in Annals of the Five Emperors (written almost two millennia later) [7,8]. While battles are historically important, espionage also has a long been used to gain a strategic [9]. The use of spies is discussed in the Hebrew Bible's Book of Numbers [10] and Sun Tzu wrote of their importance in the 5th century BC [11]. Conflict, as a broad concept, is sometimes defined as a position where two or more groups (be they large or small, individual or institutional, etc.) have, or believe that they have, discordant needs, positions, or interests [12–16]. However, for the purposes of this review, conflict is defined to encompass only civil unrest (e.g. protests) and violent conflict (e.g. insurrection, terrorism, armed conflict).

Disagreements over environmental factors have led to the inclusion of environmental conflicts in modern peace studies. For the purpose of this review, climate is considered to be a subset of the environment and conflicts can manifest in a variety of ways. The environment can be a cause of a conflict (e.g. protesting logging, waste management, acceptable land use, etc.). It can be used as a tool in conflict (e.g. use of tunnels by Vietcong, caves in Afghanistan, or dense jungle obscuring drug trafficking operations in Colombia) [17–19]. The environment can also be an enabler of conflicts (e.g. through the generation of funds to support them).

Climate change is expected to cause shifts in temperature and rainfall which themselves could impact crop yields [20–22]. Food insecurity can influence conflict [23–25], which may be engendered through such crop changes. Furthermore, climate change may reduce our available space through sea-level rise [26]. Forced migration may occur due to climate change [27], which is correlated with conflict [28]. Environmental scarcities and resources may lead to conflict [29], and climate change is expected to change our access to such resources in some regions.

Energy systems have supply and transmission chains, which can be exploited in conflicts. Aggressors can disrupt a state by attacking supply

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https://doi.org/10.1016/j.rser.2021.111473
Received 11 May 2020; Received in revised form 12 May 2021; Accepted 6 July 2021
Available online 13 August 2021
1364-0321/

Abbreviations/Nomenclature

FARC	Revolutionary Armed Forces of Colombia
ISIS	Islamic State of Iraq and Syria
NASA	National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organization
OPEC	Organization of the Petroleum Exporting Countries
RAND	RAND corporation
UN	United Nations
US	United States of America
WWII	World War Two

lines [30–34], which can cripple vital infrastructure within a nation. The global interconnectedness of energy production, transport, and supply means that all nations have a vested interest in the role that energy plays in relation to conflict. Given the fundamental importance of energy in the modern world, there is a notable lack of studies explicitly examining its link to violence and the environment.

The ability to track violence around the globe, and distinguish its causes and targets, is essential if a true understanding of the interplay between conflict, energy and the environment is to be achieved. The present work reviews existing literature available to explore the ways in which violence can be tracked, the interplay of environment and climate on violence and conflict proclivity, and how energy affects the occurrence and intensity of conflict. The work reviewed here explores the interplay of environmental factors, energy systems, and conflict. This is a compelling area that justifies further research for peace efforts and conflict resolution studies, especially as growth in developing countries will operate within this nexus.

2. Methodology

For this review we consider multiple types of publications to determine past work that informs the nexus of energy, environment and conflict. Literature was found using Google Scholar, and databases were identified using both Google Scholar and Google's conventional search engine. Search terms are given in Appendix A. Inclusion criteria by publication category (book, journal article and database) are as follows:

1) Journal articles were excluded if they do not have at least 50 citations or the journal in which the paper was published is ranked in the top quartile of papers within that field as determined by the impact factor of the journal.
2) Book works and reports were excluded if they do not have at least 50 citations or if they were not published in academic press, or by a major institution (e.g. World Bank) or governmental organization. Writings of historical significance (e.g. the New Testament, writings of Caesar, Sun Tzu, etc.) were included as they are used for illustrative examples.
3) Databases were excluded if: The database was not provided directly by a government, government organization, government laboratory, or an inter-governmental alliance; The database was not provided by an accredited university; - The database was not provided by a non profit organization which the average person would consider reputable. No private corporation or paid subscription databases were included.

3. Environment, climate, and conflict

It has been proposed that the environment can be thought of as providing four *stabilizing and regulatory processes* [35]: 1) supply of air, water, and various processes with which the natural world may balance itself; 2) regeneration processes which includes decomposition of wastes, seed spreading from plants for re-vegetation, and soil renewal; 3) production of goods (food, energy and material resources necessary for survival); 4) Life-fulfilling functions that include natural beauty and aesthetics, wonder, and scientific discovery.

Natural resources, and the functions they provide are limited and competition for resources can lead to conflict [35–41]. However, environmental conflicts can also include disputes over land use, air and water rights, waste disposal, or resource management, and in general terms can be thought of as any dispute in which the environmental plays a central role [16,42–50]. An important distinction must be made between conflicts that arise because of environmental factors, and ones where the environment is used as tool or resource in conflict. As an example, disputes over Amazonian land use often revolve around different actors' views on the use and ownerships of the land, tribal rights, property rights, or water availability. This is an important distinction from conflict which has an environmental component but in which the environment is not the cause or primary factor. Diamond mining in Sierra Leone during the 1990's is an example. Here the resulting revenue stream was used to fund insurgencies and arms procuration for the Revolutionary United Front [51]. However, neither the mines, nor their environmental footprint were the focus or progenitor of violence.

Resource scarcity is often an environmental cause of conflict and water availability provides a good example. Water availability provides a good example. In 1967, the Six-Day War between Israel and its neighbors began over water [52]. More recently, control over dams and their water flow have played central roles in Islamic State's insurgencies in both Iraq and Syria [53]. It has also been shown that countries which share water resources are generally more prone to conflict [52].

Land availability provides another example of resource scarcity as a driver for conflict, and is even cited as a contributor to the genocide in Rwanda [54,55]. Moodley et al. (2010) argue that the population of Rwanda more than tripled in roughly a fifty-year time period. This population growth lead to several problems, including constraints on land availability and less land ownership [56]. People were incited to violence against the Tutsis in order to take possession of their land [57]. Here, there is a clear case of conflict over the environment where land (or lack of access to it) was the contested resource [58,59]. Conflicts over land are by no means confined to Africa and they have arisen in the Americas [60,61], Asia [62,63], the Middle East [64] and many more places. Environmental degradation can itself lead to conflict. Protests over pollution have been seen all around the world. Air pollution and environmental protests have been seen in China [65–69], India [70], and even London [71]. Protests over pollution have been observed in Bulgaria [72]. Protests over droughts have been observed from Bolivia to Indonesia [73,74].

Use of the environment as a tool in conflict has a long history. There is evidence for the Assyrian King Sennacherib's use of water to destroy Babylon in 689BC and of the Assyrians using water as a tool of war [75–77]. In his book on the Gallic Wars, Julius Caesar describes how he cut off water access to the citizens of Uxellodunum during his siege of the city [78]. During WWII, China destroyed a dike on the Yellow river, destroying cities, villages, crops and topsoil, to stop the Japanese advance [79]. Similar tactics were used by other countries during the same period [76,77]. In more recent times water supplies in the middle east have also been cut off for political and military reasons [80]. Water and sanitation systems were targets in the first Gulf war and played a role in the Syrian civil war [77,81].

Water is by no means the only environmental tool of war. Natural harbors have long been known to have strategic value for the movement of troops and supply chains. In the Gallic Wars, Julius Caesar also describes how he positioned his military resources around the easiest access points used by the citizens of Uxellodunum for getting water [78]. Highpoints were common locations for fortresses, both to limit access and to provide an outlook for enemies. The Vietcong used tunnel systems and the dense jungle to help fight [82]. Caves and mountainous

regions have been used for centuries to repel attacks in Afghanistan [83]. Dense jungles helped to hide the Revolutionary Armed Forces of Colombia (FARC) soldiers within Colombia [19].

Damage to the environment has also be used as a tool in conflict. Scorched earth tactics have been employed as a method of destroying anything useful to enemies. Ancient Greeks attacked farmlands including orchards and crops [84]. The Dutch destroyed dikes to protect their lands from invaders in the 16th-18th centuries [85]. The Purposeful destruction of crops and grazing land was seen in the 17th and 18th centuries in England during wartimes [86]. General Sherman burned plantations during his "March to the Sea" in Georgia during 1864 [87]. WWII also saw the use of crop burning as a tactic [87]. Crops have also been burned in protest to government regulations [88,89].

The environmental characteristics of an area can themselves lead toward the progression, escalation, or occurrence of conflict. As previously outlined, diamond mining in Africa helped to fund insurgencies. This is an example of the environment as a contributor to violence. The Council on Foreign relations has outlined various forms of terrorism financing with that trade in livestock, fish, and leather goods have all been used to fund terror organizations. The offices of Treasury of the United States also described environmental involvement in terror activities and the use of oil sales to fund the Islamic State of Iraq and Syria (ISIS) [90,91]. The Revolutionary Armed Forces of Colombia (FARC) used drug money to finance their activities [19]. Opium production has been a known source of funding for terror activities in Afganistan [92].

Environmental terrorism is also a form of conflict can be put into two broad groups: 1) terror attacks against the environment, and 2) terror attacks for the environment. One can define terror attacks against the environment as "purposeful destruction of a natural resource" [93]. A good example can be seen from Sadam Hussein's burning of oil fields in Kuwait during the Persian Gulf War. Terror groups can target water infrastructure directly, or contaminate it [94]. Beginning in 1991, the Iraqi government built a series of dams in order to prevent water from reaching the marshlands in southern Iraq as a form of environmental terrorism. The extent of the devastation was described by the UN Environment Program as "one of the world's greatest environmental disasters." Images from NASA showed around 90% of the wetlands were destroyed [95]. In the same year, Iraqi forces caused two intentional oil spills within the gulf waters and purposely detonated an estimated 1250 oil wells [96]. In addition to the draining of the marshes, the Iraqi government has burned villages within the marshlands, deployed chemical weapons against Kurds in the north, and expelled more than 120,000 people in the oil-rich Kirkuk region [97].

Terror attacks for the environment are seen with groups like the Earth Liberation Front which carried out 600 attacks from 1996 to 2002. These have been estimated to have caused $43 million in damages, targeting things such as research labs, logging companies, and multinational corporations [98,99]. The group Earth First has clashed with logging, oil, and electricity industries, including a 1989 attack on a nuclear facility's transmission lines [100].

Within the framework of this paper, climate change is a subcategory of environment. Climate change is poised to dramatically change the environmental landscape across the world. It is estimated that increasing global temperatures will result in sea level rise, increased severe weather events, increased drought severity and frequency, and changes in precipitation and annual rainfall, among other significant changes physically, ecologically, economically, and psychologically [101–124]. Climate change has the capacity to impact nations around the globe, and can be considered a security concern in affected regions [101,125].

While there is debate in the literature over the impacts of climate change, it has been estimated that climate change can increase conflict potential in specific cases [126] and this can occur through two major mechanisms. The first is through physical changes in the environment that result in economic and social strains in that a region. The second is through the subsequent destabilization of governmental institutions that can result. The weakening of state institutions can be influenced through economic losses engendered by changing climates and pressures to secure increasingly scarce resources, etc.

A major challenge in addressing the impact of climate change on conflict is that much of the work is focused on trying to predict what *will* happen. Several studies have looked to past cases of climatic shifts for a guide [101,125]. Past work has shown that food security is a concern that may manifest in conflict [127–132]. Migratory events can place a strain on receiving areas, which that can lead to conflict. If we use the past as a proxy, we can assume that reduced food security resulting from climate change will increase the likelihood of conflict. Forced migration events (driven by agricultural losses, rising sea level, or extreme weather events) could also increase the likelihood of conflict, especially as receiving regions become strained [127,133].

The agricultural sector is particularly susceptible to climatic shifts and this can have downstream impacts on labor. Of the total labor force in each region, agricultural workers comprise 58% of labor in Africa, 51% in Asia, 6% in North America, 14% in South America, 18% in Oceania, and 8.6% in Europe [127]. One in two workers in Africa and Asia may see increased competition or hardships as a result of climate change. Crop yields are expected to decline within Sub-Saharan Africa due to climate change [134,135].

Several studies have advanced the hypotheses that climate change was a catalyzing factor in the onset of the ongoing Syrian Civil War. During the mid-2000's, poor governmental policies and several major crop failures led to a surge in rural-to-urban migration, exacerbating existing social problems. In 2011, multiple droughts in key grain producing regions, including the US, Russia, and Australia, led to a surge in food prices. Regional impacts of climate and the acute food price combined to help tip Syria into a civil war [81,136].

Disruptions in annual rainfall amounts, increasing droughts, and changes in freshwater availability, thus has repercussions on the global agricultural sector, which may be especially vulnerable to climate change. Droughts have been found to have affected about 1.1 billion people in Asia, 222 million in Africa, 48 million in Latin America, 9 million in Oceania, 6 million in Europe, and 30,000 people in North America between 1975 and 2001 [127]. An important observation here is that conflict may not be directly related to the severity of an event, but rather, to the ability of the afflicted population to cope. If a population is unable to withstand the pressure placed on it, conflict results. It is then argued that developing countries, which are economically more dependent on stable environmental conditions than developed countries and often lack strong mitigating institutions, are at higher risk of suffering from climate change [127].

Underdeveloped or poor nations may be at increased risk of environmental conflict [137–140]. Kahl (2006) illustrated two mechanisms that could lead a state toward internal conflict: 'state failure' and 'state exploitation' [137]. The 'state failure' model posits that increasing resource scarcity can lead to rural-to-rural migration events, as people have less access to productive lands, or rural-to-urban migration. Rural to rural migration can lead to inter-ethnic conflict, and urbanization of a population tends to increase strain on government institutions responsible for housing and development, healthcare, and sanitation services. Institutions undergo more pressure as housing and development projects mount. Raleigh and Urdal (2007) state, "The weakening of the state is seen as an intermediate factor between resource scarcity and violent conflict" [141]. Weakened institutions are presented as opportunities to rebel groups who wish to challenge the government. Conflict results when, "the potential gains from a rebellion are higher than the costs that a state can inflict on the rebels" [141]. Climate change is expected to increase resource scarcity in some regions [142].

The 'state exploitation' model for conflict reveals another potential means that climate change can lead to conflict. 'State exploitation' reasons that a weakened state may rally groups to capture scarce resources in times of resource scarcity [141]. A state may initiate inter-ethnic conflicts to compete for scarce resources, as a sort of

diversion tactic, drawing attention away from the state's inability to provide. Kahl (2006) states that state exploitation "can occur at levels of state weakness far short of total collapse [137]." Weak states are also vulnerable to corruption which can itself cause social instability and upheaval.

Finally, sea level rise is expected to be a major effect of climate change with a rise of 0.26–0.77 m is expected to occur in the 21st century. This will be especially harmful to island and low-lying regions [143], and is expected to create forced migrations from regions fleeing the encroachment of ocean water [144–147]. This can be a driver, or contributor to state instability, and will certainly result in migratory pressure.

4. Energy and conflict

Energy systems, in combination with contextual social conditions, can increase the risk of conflict in an area [148]. Access to energy is vital for the security of a state, to run the military [149,150], and grow the economy [151]. However, energy resources are not uniformly spaced throughout the world and are often concentrated in specific geographic locations [152–154]. Infrastructure designed for the transport of energy can experience geographic bottlenecking [148,155]. Due to the inherent value of energy, actors may try to seize infrastructures (e.g. pipelines, transmission lines, production fields, etc.) in order to gain power or leverage. In the modern era, the First Gulf War was a global conflict primarily related to oil production. Iraq invaded Kuwait over disputes that Kuwait had over produced oil thus driving down its price and had stolen oil from the Rumaila oilfield. This threatened oil producers throughout the region, and ultimately culminated in an international from twenty eight countries with 700,000 troops sent to the area [156].

World War II saw major initiatives around energy. At that time, the US produced around two thirds of the world's oil, and Russia produced ~ ten percent [157]. By contrast, the Germans produced far less oil than they needed, and relied heavily on the importation of fuel prior to the war [158], and later coopted and captured oil fields in regions they had taken over [179]. The German tactic of Blitzkrieg, in which short engagements were fought with overwhelming technical superiority were attempted, was in-part born out of the need to conserve fuel resources [158]. The Germans attack Russia in 1941 with the objective of capturing Russian oil resources [158]. In an attempt to alleviate some of the oil concern, Germany built synthetic gas plants which produced fuel from coal, though the output of these was insufficient to meet demands [158]. The Russian southern front became an attractive region to the Germans due to the oil-rich resources, which would alleviate their fuel needs, and also deprive Allied forces of a fuel source [159]. Controlling these resources would have the added benefit of making Germany less vulnerable to air strikes on their synthetic fuel plants [159]. From 1940 to 1942, a main target of Royal Air force bombing runs was oil plants [160].

The German campaign in North Africa also centered on energy. The German army invaded North Africa in part to support Italy, but also set forth an offensive to gain control of the Suez Canal and access to vital Middle East oil fields [161–163]. One of the German objectives of the African offensive was to reduce Allied access to Middle Eastern oil, and instead secure its use for themselves [164]. Some of the heaviest fighting in this theater was in Egypt, where Britain had stationed a large number of troops for the purpose of protecting the Suez Canal to protect the British oil supply [163]. At the time, War Department analysts believed that if Hitler was successful, his new access to this oil would allow him to restation Wehrmacht divisions from the East to reinforce the West, and thus the war could last a decade [161,165].

Oil resources are not the only energy commodity of strategic importance. Uranium has been increasingly acquired by both China and Russia to fuel their nuclear fleets and as a leveraging tool in negotiations. China imported 80.1% of the total demand for Uranium in 2017 [166]. Russia has been buying companies from Canada to Kazakhstan or taking partial or controlling shares in Uranium companies since the beginning of the century the world over [167].

In contrast to situations in which energy is the object of conflict, energy can also be used as a tool in it. Disruptions of energy flow and supply can have rippling effects throughout the world. Because of the interconnectedness of nations and their dependence on existing energy systems, actors may intentionally manipulate energy in order to gain political leverage for objectives not directly related to it. Intentionally restricting, or altering, the flow of energy is sometimes referred to as the "energy weapon" [168]. The OPEC Oil Embargo of the 1970's, which was initiated in response to US support of Israel during the Yom Kippur War, is an example [169]. However, energy trade and vulnerability go both ways. Trade embargoes, or boycotts by importers, can be an effective means of political leverage [148]. A modern example of this is seen in the US trade sanctions against Iran, which were initiated in response to their suspected nuclear weapons program [170]. Russia has used gas pipelines running through Ukraine into Europe as a leveraging tool, cutting off gas flows to the region twice since 2005 [171,172].

Another type of energy conflict can occur when an energy flow disturbance is created by a third party. Such an action can be conducted with the objective of damaging the interests of the supplier, customer, or transit-route countries or populations. The interconnectedness of suppliers and consumers means that small disruptions may have cascade effects that have far reaching impacts. We see this, as an example, when radicals sabotage energy systems [173]. The selection of energy targets to attack is driven not only by the tangible amount of damage that can be done, but also by the political and social costs related to a disruption [174]. Energy systems can destabilize a society, or worsen existing tensions, and lead to conflict. Possession of natural resources may not be explicitly beneficial to a population, and even fund violence or be a point of conflict [175]. States with a wealth of natural resources may find themselves creating less diverse economies, opting instead to focus on one or few particular resources, creating a situation sometimes referred to as a "resource curse" [175]. Lack of economic development can weaken state institutions.

Energy and food prices are often related [176–178], and as the price of energy increases, so too can that of food. The relationship between energy price and food price affects the number of malnourished individuals around the world [179–181]. Energy can influence the price of food as modern, large scale agricultural endeavors need power to operate, and power is needed for the transportation and/or processing of foods [182]. If food becomes scare or too expensive to buy, populations will experience civil unrest, which results in conflict.

Energy systems are frequently the target of calculated attacks in order to harm a population. Radicals can attack electrical transmission lines, as was seen in the Phillipines in 2003 [174]. The US Air Force attacks electrical power systems as a 'critical target' since World War Two [183]. Criminals can steal oil, gaining resources or creating cash flows through its sale, as was seen in Iraq and Nigeria [184]. Power plants are obvious targets for attacks as they supply energy to large areas. NATO bombed five power plants across Serbia in 1999 [185]. In September 2019, an attack was launched against Saudi Arabia's oil facilities in Khurais and Abqaiq. The attack involved bombing these facilities with drones and cruise missiles and caused the largest single day disruption in Saudi Arabia's oil production [186]. Houthis in Yemen initially claimed responsibility for the attack, though the US Secretary of State asserted that Iran was responsible [187]. The possibility of such an attack were not altogether unforeseen. In a report from 2001, RAND noted that in Saudi Arabia "oil fields themselves—or the small number of critical and vulnerable processing sites—could suffer severe damage" if a conflict were to occur [188]. In the same report, they also state that "[Iran is] likely to make slow but steady progress over the next ten to fifteen years in improving their power projection capabilities." Such an attack, regardless of the culprit, exemplifies how attractive a vulnerable energy target may be. The single day attacks resulted in global oil supply dropping by about six percent [186].

5. Energy, environment and conflict tracking databases

In order to understand the nexus of energy, environment and conflict, data are needed that can connect all three. Due to its importance across various spheres of political and economic endeavors, the ability to track conflict, unrest, and violence has recieved considerable attention.

Various conflict tracking databases have been developed to help understand the progression or escalation of violence, and measure degrees of civil unrest or radicalism. These data often include the time, place, actors, number of injured and sometimes even what was targeted [189,189,190,190,191,191,192,192,193,193,194,194,195,195,196,196,197,197,198,198,199,199,200,200]. Appendix B summarizes specific conflict-related databases, exploring the capacities of the database, data sources, timeframes investigated, and methodology, where available. Although these conflict trackers use modern databases and user interfaces, some new technologies, like commercial earth observation through satellite imagery, have yet to become widespread in conflict trackers. None of the conflict trackers identified deal with conflict as it pertains to energy infrastructure, or contain explicit searchable data that can be used to identify it. Many conflict trackers include notes on conflicts, but it is left to the user to pour through the data to find instances of attacks on energy systems, their supply lines, or energy system disruptions.

A variety of databases exist to track current environmental indicators, such as air pollution or temperature, and resources, such as water, minerals, and biodiversity, along with our interactions and environmental policies [201–205]. Data is available in a variety of forms, from tables, to charts, to maps. Databases have been constructed that track current climate trends, historical climatic records, and future projections for a staggering amount of variables, often including a number of climate scenarios for the user to explore [206–216]. Appendix C contains environment and climate databases provided by government organizations or non-profits. A brief description of the capabilities or purposes of each database is provided within the appendix. However, with the exception of the Environmental Justice Atlas, none of the existing environmental databases identified for this work, climatological or otherwise, makes explicit connections conflict events.

Tracking the use of energy, the availability of energy infrastructure, and the abundance of energy resources is an important part of monitoring energy use trends and planning development for regions. A variety of databases can be found that examine energy use, production, trade, pollution, deployment, storage, heat, policy, or incentive [217–232]. Data is available in many forms from these databases. Charts, tables, time series, and maps can all be found depending on the need of the user. A summary of the energy and infrastructure databases found for this study can be found along with a brief description of the capabilities of each database. However, none of these make explicit connections to conflict or environmental factors that could drive it.

6. Results

Existing literature shows that environmental factors greatly affect the probability of conflict. Climate change is expected to aggravate current environmental issues such as land availability and crop yields which could in turn cause tensions that lead to conflict. The relationship between energy and climate change is complex, and though the argument of anthropogenically driven climate change is not discussed here, the role of carbon-based fuel sources in driving it is well established. Simply put, the use of fossil fuels will increase the speed of climate change, which will in turn increase environmental pressures that lead to conflict.

Existing literature shows that many regions where energy resources are found are also underdeveloped or developing. Energy resources can be a useful for raising funds, which can increase quality-of-life conditions in the regions they are found. However, many of these regions are susceptible to corruption and bribery in weak institutions. Funds can be diverted, and are hard to monitor in places where institutional transparency does not exist. This can create a greater inequality within a population, which is a major cause of civil unrest.

Climate change is expected to increase the probability of conflict. Forced migration events, precipitation deviations, worsening droughts and severe weather events are expected to put more severe strain on populations, which is likely to manifest through conflict. Climate change is also expected to weaken existing state institutions in poor and developing nations, which can lead to conflict events.

Energy also plays a role in the occurrence, onset, and duration of conflict incidents. Wars may be fought over control of energy or to secure production pathways. Energy can be used as a weapon to gain leverage over nations. Fragile infrastructure lends itself to be targeted by malicious groups. Investments in energy infrastructure can be diverted toward nefarious endeavors. Energy is interconnected with many facets of modern life, including food pricing. Sharp deviations in energy pricing may lead to conflict or increased food insecurity.

Energy infrastructure is often determined by natural resources in an area, and can be exploited with violent ends. Climate change is expected to increase environmental tensions. Energy production is estimated to have an effect on increasing global temperatures, increasing global climate change rates. Any discussion of conflict should include all three of these aspects: environment, climate, and energy. These three facets all contribute to the probability of conflict, and often play off of one another in a dynamic feedback loop. The literature reviewed here shows a clear and nontrivial interplay between environment, climate, and energy as they pertain to conflict. However, the databases identified here fail to unify data on energy, environment and conflict which makes quantifying the connections, and their geospatial dependence difficult.

7. Discussion

Throughout this work, it has been shown that relations have been studied between energy and conflict, and between environment and conflict. The 'energy weapon,' ecological conflicts, resource wars, forced migration, and more have all been studied. However, existing works often consider two areas in tandem, e.g. energy-conflict, environment-conflict, or energy-environment. The issue with these approaches is that they miss the nexus of energy, environment and conflict. Environment is clearly inter-related with energy (e.g. climate change, resource extraction, etc.) but also to conflict (e.g. environmental protest, environmental terrorism, fleeing from war, etc.). Energy is also related to conflict (wars for resources, the energy weapon, energy fuels the war machine, etc.). Conflict has impacts on both energy and environment. Given that all these factors are codependent, a change in one will affect the others. Conflict not only affects the environment in which it takes place, but also changes the energy sphere. Energy infrastructure can be the target of attacks. The supply lines of energy resources are vital to the war effort. Local conflicts, such as protests over a proposed power plant, are inherently an energy-environment-conflict event. Environmental factors affect both energy and conflict. An environment may make it attractive to resource extraction for energy production, more difficult to provide energy to, or a region that is highly contested for the energy resources within it. Any of these factors can lead to conflicts such as protests or battles. Energy infrastructure inherently changes the environment in which it is placed. When we examine only one or two of these areas, rather than all three in conjunction, we are missing the whole scope of the issue.

The interdependence of energy, environment and conflict was evident in the first Gulf War. In a clear example of environmental terrorism, more than a thousand oil wells were destroyed and set on fire within Kuwait. The smoke billowing from these torched wells obviously polluted the air, and the fires damaged energy infrastructure. However, the origins of the conflict and the infrastructure are important. Oil is vital to the energy needs of the world, and supplying oil is a source of cash revenue and stability. Oil wealth is related to increased regime

durability and lower rates of civil war or anti-state protest [233]. The invasion of Kuwait by Iraqi troops was due to border, oil, and debt disputes [234]. The invasion of Kuwaiti oilfields as an energy conflict (disputes over oil), that resulted quickly in the use of energy resources as a tool of environmental terrorism (burning the oil fields). During this time, they deliberately caused oil spills within the Persian Gulf, an example of an energy resource being used as a tool of terrorism. Similarly in 1991, immediately following the Gulf War, the Iraqis diverted and dammed the Tigris and Euphrates rivers to drain water from marshlands inhabited by ethnic groups. This draining of the marshland allowed troops to enter the region and terrorize inhabitants and burn villages, causing those left alive to flee. The purposeful destruction of the marshes was a clear act of environmental terrorism, destroying the land so that it was uninhabitable and allowing the perpetuation of genocide. Consequently, the marshlands just happen to contain some of the richest oil deposits within the country. Also in 1991, the Iraqi government leveraged its technological resources and used helicopters to fire on civilians and refugees [235]. Any examination of these events as an environmental conflict fails to see an underlying reason for the actions, energy. Conversely, any examination of the events as an energy conflict fails to see the deliberate destruction of the environment as a form of environmental terrorism. The lack of such a lens inhibits our ability to assess outcomes and rationales of conflicts, and prevents us from predicting future outcomes of similar events.

A major limitation in studying the nexus of energy, environment, conflict is the lack of data on how these three areas intersection. Current databases covering these three areas tend to focus on only individual parts of the nexus triad. Conflict databases exist that report instances of violence, warfare, and protest, often with a geographic visualization or ability to search for country-specific events. Energy databases may contain specific geographic information, but report energy infrastructure, use, or type, only. Similarly, climate or environmental databases may show a region, but detail how the area is physically changing, or show projections of how it will be impacted by various climate scenarios. The Environmental Justice Atlas is a rare database that examines social conflict through an environmental lens, showing environment-conflict predominantly. However, the data is available only by request, and currently the web service is slow and difficult to navigate. Energy infrastructure and climate projections are absent from this database. The database would benefit from an analysis of how close in proximity conflicts, especially those delineated as energy-related, are to energy infrastructure sites.

There are several limitations with the current overview. Each of the three areas for which literature was investigated is the subject of considerable research. As a result, the literature reviewed here must be considered to a representative sample of work in each area, instead of a comprehensive review. Only works in English, or translated into English, were considered even though relevant literature clearly exists in other languages. Conference papers were excluded because the quality of these works was often more difficult to determine. The same was true for papers, books and reports which failed to have the required number of citations or meet the journal or publishing house requirements. These criteria would filter out newer works, even though they could be of high quality and relevance. The criteria for inclusion of databases could similarly have excluded inclusion of some relevant sources.

8. Conclusions and further work

The literature reviewed shows that energy, environment, and conflict are inextricably linked with complex feedback mechanisms. Developing models for how they interact requires broad-based data that links conflict directly to energy systems, resources, pollution, and social factors. A thorough search of conflict trackers, as well as databases of environmental and energy information, was conducted for this review. The results show a multitude of databases that track conflict down to the individual day across the globe. However, no tracker or database was found that explicitly facilitates the analysis of the energy, environment, and conflict nexus. The development of such a resource is vitally important to understanding the manners in which conflicts begin, progress, and are resolved. It would be a useful tool to help researchers understand not only how conflicts came to be, but also how to mitigate their occurrence.

The energy-environment-conflict nexus must be investigated using empirical evidence and methodology could be created to form predictive models on the strength and typology of these interactions. Perhaps most important, preventative measures must be found and enacted in order to lessen future conflicts, environmental harms, and energy disruptions. Ostrom's work on the commons, which deals heavily with shared spaces, shared resource use, enforcement, and resolutions (as a primer see Refs. [236–240]) is especially important in this regard. As the energy-environment-conflict nexus is fundamentally a shared space, encompassing many actors, users, producers, and authorities, solutions must be robust regarding resource use and extraction, access, and jurisdiction. Preventative measures within the nexus will need to be international, national, and local.

Following on the work of Scheidel et al. [241] that studied effective mobilization strategies for environmental defenders, similar work could be usefully applied to the nexus of energy, environment and conflict. Once this is completed, energy-conflict and environment-conflict strategies should be compared and merged to find a unified theory to explain the interplay of energy, environment, and conflict.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

The authors would like to thank the support of the Colorado School of Mines and the Payne Institute of Public Policy for funding support. The authors would also like to acknowledge Dr. Amy Schweikert for her help in early proof reading of this work.

Appendix A. Literature Search Terms

Energy:

Energy and climate change.
Energy target of terrorism.
Food and energy price.
Supply chain attacks.
Oil burning in Gulf War.
Energy Weapon.

Environment:

Impact of climate change.
Climate change and migration.
Environmental terrorism.
Land scarcity.
Resource curse.
Climate change and food production.
Drug trafficking and environment.
Food insecurity.
Resource competition.
Conflict diamonds.
Environmental conflict examples.
Pollution protest.
Historical use of water in war.
Scorched Earth.
Climate and Security.
Climate and food.
Climate change and water.

Conflict:

Environmental conflict.
Environment and conflict.
Conflict and energy.
Climate conflict.
Resource conflict.
Crop burning.
Environmental protest.
Water conflict.
Food and conflict.
Migration conflict.
Energy conflict.
Violence and tourism.
Conflict and international investment.
Early environmental conflict.
Vietcong tunnels.
Violence and international relations.
Violence and investment.
Terrorist financing.
Earliest conflict.
Violence and investment risk.

Miscellaneous:

Early Geospatial analysis.
GIS history.
Databases were found using google.com and the following terms. As before, the area considered is underlined and italicized.

Energy:

Energy database.
Energy conflict database.
Infrastructure database.
Infrastructure project database.
Energy infrastructure database.
Energy infrastructure attack database.

Environment:

Environmental Database.
Climate database.
Climate change database.

Conflict:

Conflict database.
Environmental conflict database.
Climate conflict database.
Violence tracker.

Appendix B. Conflict Databases

Armed Conflict Location and Event Data Project [189]

The Armed Conflict Location and Event Data Project (ACLED), an independently operated non-governmental organization (NGO), provides a database focused on the geospatial tracking of political violence and protest. Through 2018, ACLED had identified and collated information for 420,000 conflict events. ACLED focuses primarily on Africa, South and Southeast Asia, and the Middle East. Current efforts are underway to expand data tracking further into Europe and Latin America.

Datasets presented by ACLED reveal information on the location and date of events, fatalities, which groups were involved, and if any changes in territorial control occurred. The aforementioned geographic regions have varying levels of data coverage. For the most part, Asian countries have data from 2010 to the present. African national conflict data aggregation goes back to 1997. Middle Eastern countries have been presented from 2016 to the present. Conflict activities in nations and regions are updated in near real-time.

ACLED aggregates data from research publications, government reports, local media, and humanitarian NGOs. Data is reported in a "who, what, when, where" style format. If a battle is ongoing for several days, a new report is generated for each day. Likewise, if two events occur on the same day in the same place, say aggression to civilian protests, then riots, both events will be recorded separately. Data is recorded regardless of fatality numbers.

Armed Conflict Database [190]

The Armed Conflict Database (ACD) shows conflict reports in a geospatial manner, particularly conflicts over time. These reports include things such as insurgency and non-state actor groups, human security, energy conflicts, civil unrest, and armed clashes/violent incidents. ACD is run by the International Institute for Strategic Studies (IISS). IISS analyzes every conflict from three separate views. These lenses are political, military/security, and humanitarian. ACD allows the user to not only visualize conflict across a region, it also includes comparisons for refugee numbers, displaced persons due to conflict, and fatalities. ACD contains data tracking conflict over decades.

Uppsala Conflict Data Program [191]

The Uppsala Conflict Data Program (UCDP), run by the Department of Peace and Conflict Research at Uppsala University in Sweden, began recording conflict in the 1970s to facilitate ongoing research in peace and conflict arenas. UCDP originally tracked armed conflicts, which it defined as conflicts resulting in at least 25 battlefield deaths, where at least one side was a government. Now, in addition to these clashes, UCDP contains data on "non-state conflicts," where no state is involved, and "one-sided violence," where attacks are directed toward unarmed civilian populations. UCDP contains the Armed Conflict Dataset, supported with the cooperation of the Peace Research Institute Oslo (PRIO). Data covers 1946–2008. UCDP publishes its data annually within the SIPRI Yearbook and the Journal of Peace Research. Data is publicly accessible through their webpage.

Sexual Violence and Armed Conflict Dataset [192]

The Sexual Violence and Armed Conflict Dataset (SVAC) was developed by the Peace Research Institute Oslo (PRIO). It contains geospatial information on the locations of conflicts as well as the intensity of sexual violence. Publicly accessible data is available from 1989 to 2009. SVAC tracks violence committed by state forces, pro-government militias, and rebel groups. Data includes prevalence, perpetrators, victims, forms, timings, and locations of sexual violence reports perpetrated by armed forces. SVAC obtains its information through the United States State Department, Amnesty International, and Human Rights Watch.

Data on Armed Conflict and Security [193]

Data collected by the Event Data on Conflict and Security (EDACS) is presented within the Data on Armed Conflict and Security (DACS) in a spatial and temporal manner, and is available for download. DACS only presents conflicts spanning from 1990 to 2009 within sub-Saharan Africa. DACS also contains the Consolidated List of War (CoLoW), which lists wars from 1946 to 2006, classified into four categories. These include inter-state wars (between at least two sovereign states), extra-state wars (State and non-state actors outside of the states boundaries), intra-state wars (government and non-state actors inside the state), and sub-state wars (between non-state actors). DACS also contains the Private Security Database (PSD), which tracks data on the prevalence of private military and security companies (PMSCs). This includes information on who uses PMSCs, what kind they use, where, and for how long. Data spans 1990–2007. PSD is part of the Collaborative Research Center Berlin.

Global Terrorism Database [194]

The Global Terrorism Database (GTB) contains information from 1970 through 2017 on terrorist attacks around the world. GTD is maintained by the University of Maryland and the National Consortium for the Study of Terrorism and Responses to Terrorism (START). It contains information on terror attacks, including attacks of a domestic, transnational, and international nature. Data ranges from bombings, to kidnappings, to assassination, and includes more than 180,000 separate incident reports. Data includes location and date of the event, weapons employed, the target, casualty numbers, and group responsible. Recent events include more than 120 variables in the reporting of events.

Nonviolent and Violent Campaigns and Outcomes Data project [195]

The Nonviolent and Violent Campaigns and Outcomes (NAVCO) Data Project aggregates both violent and nonviolent resistance efforts from around the world. NAVCO covers from 1900 to 2013. NAVCO 1 includes aggregate-level data on resistance operations from 1900 through 2013. NAVCO 2 produces annual data on resistance efforts from 1946 to 2013. NAVCO 3 includes event data within 26 countries from 1991 to 2012. NAVCO 3 data includes type, sequence, and outcomes of events. The database is maintained through the University of Denver.

Conflict and Peace Data Bank [196]

The Conflict and Peace Data Bank (COPDAB) includes information regarding international and domestic events in an estimated 135 countries from 1948 to 1978. No newer data is currently available through this source. Data included contains nine variables, including date, instigator, target, information source, and description of the event, as well as type and scale of the incident. COPDAB is provided by the Inter-University Consortium for Political Science and Research.

Center for Preventative Action's Global Conflict Tracker [197]

The Center for Preventative Action supplies a Global Conflict Tracker which contains ongoing conflicts around the world that affect US interests. Currently, around 30 ongoing conflicts are being tracked, and include background information on the engagements, resources, and if the situation is improving, stagnant, or declining. The Global Conflict Tracker updates events daily.

RAND Database of Worldwide Terrorism Incidents [198]

The RAND Database of Worldwide Terrorism Incidents (RDWTI) covers instances of terror events from 1968 to 2009. Data contains information on date, location, classification, injuries, fatalities, as well as a description of the event itself. The database includes more than 40,000 incidents over the 40 years it covers.

Social Conflict Analysis Database [199]

The Social Conflict Analysis Database (SCAD) aims to cover events not traditionally covered by other violence trackers by focusing on social conflicts. It includes information on events such as riots, protests, violence from governments against civilian populations, strikes, and related occurrences. Data covers 1990–2017 for Africa, Central America, the Caribbean, and Mexico.

Seshat Global History Databank [200]

The Seshat Global History Databank contains information covering ten thousand years of history, focusing on social and ritual interactions, religions, and the expansion of society. The 'War, Peace, and the Evolution of Social Complexity' data set contains historical information on group formations, rituals, religions, with the aim to "investigate how changing patterns of ritual have contributed to inter-group competition and larger-scale systems of regulation throughout human history." This dataset covers from the Neolithic to early modern period, focus on the ruling polities of geographic areas.

Appendix C. Environment/Climate Databases

There is an abundance of climate change and environmental databases useful for the reader who wishes to further examine the effects of climate change. The variety and wealth of knowledge surrounding these databases is impressive. Here we include some of the best known climate databases that will familiarize the reader with types of data and concerns surrounding this issue. While extraneous databases may exist, this provides a solid starting point as an introduction to typical climate databases. The name of the database will be presented along with a short description of the work provided by the source on their website (shown in quotes) or a brief explanation when succinct descriptions are not available.

Climate Change Knowledge Portal [206]

"The Climate Change Knowledge Portal provides global data on historical and future climate, vulnerabilities, and impacts. Explore them via country, region, and watershed views. Access synthesized country profiles to gain deeper insights into climate risks and adaptation actions"
https://climateknowledgeportal.worldbank.org/

Climate Watch [207]

"Climate Watch offers open data, visualizations and analysis to help policymakers, researchers and other stakeholders gather insights on countries' climate progress."
https://www.climatewatchdata.org/

IRI/LDEO Climate Data Library [208]

"The IRI Data Library is a powerful and freely accessible online data repository and analysis tool that allows a user to view, analyze, and download hundreds of terabytes of climate-related data through a standard web browser.
It is a powerful tool that offers the following capabilities at no cost to the user:

- access any number of datasets;
- create analyses of data ranging from simple averaging to more advanced EOF analyses using the Ingrid Data Analysis Language;
- monitor present climate conditions with maps and analyses in the Maproom;
- create visual representations of data, including animations;
- download data in a variety of commonly-used formats, including GIS-compatible formats."

https://iridl.ldeo.columbia.edu/index.html?Set-Language=en.

OECD Environment Dataset [201]

The Organization for Economic Co-operation and Development (OECD) provides a database on environmental factors covering a range of topics including Air and climate, Biodiversity, Environmental Policy, Forest, Minerals, Waste, and Water.
https://data.oecd.org/environment.htm.

ORNL DAAC [209]

"The ORNL DAAC archives climate data sets that include measured and modeled values for variables such as temperature, precipitation, humidity, radiation, wind velocity, and cloud cover. The climate collection includes station measurement data as well as gridded mean values for the variables"
https://daac.ornl.gov/cgi-bin/dataset_lister.pl?p=5.

Socioeconomic Data and Applications Center (SEDAC) [202]

"SEDAC, the Socioeconomic Data and Applications Center, is one of the Distributed Active Archive Centers (DAACs) in the Earth Observing System Data and Information System (EOSDIS) of the U.S. National Aeronautics and Space Administration. Focusing on human interactions in the environment, SEDAC has as its mission to develop and operate applications that support the integration of socioeconomic and earth science data and to serve as an "Information Gateway" between earth sciences and social sciences."
https://sedac.ciesin.columbia.edu/

GeoNetwork [203]

"GEONETWORK'S PURPOSE IS:

- To improve access to and integrated use of spatial data and information
- To support decision making
- To promote multidisciplinary approaches to sustainable development
- To enhance understanding of the benefits of geographic information

GeoNetwork opensource allows to easily share geographically referenced thematic information between different organizations."
http://www.fao.org/geonetwork/srv/en/main.home.

U.S. Climate Resilience Toolkit [210]

Provides tools, data, and resilience information for the United States.
https://toolkit.climate.gov/

United Nations Environment Programme, Environmental Data Explorer [204]

"The Environmental Data Explorer is the authoritative source for data sets used by UNEP and its partners in the Global Environment Outlook (GEO) report and other integrated environment assessments. Its online database holds more than 500 different variables, as national, subregional, regional and global statistics or as geospatial data sets (maps), covering themes like Freshwater, Population, Forests, Emissions, Climate, Disasters, Health and GDP. Display them on-the-fly as maps, graphs, data tables or download the data in different formats."
https://geodata.grid.unep.ch/

Climate Data Dashboard of the ESA Climate Change Initiative [211]

Monitors, tracks, and provides observations on climate change, provided by the European Space Agency. Climate variables, satellite observations, satellite sensor arrays, and more can be selected.
https://climate.esa.int/en/odp/#/dashboard.

NASA Earth Observatory [205]

The Earth Observatory provides images and articles pertaining to a wide variety of climate and environment phenomenon including ice coverage, pollutants in the atmosphere, and more.
https://earthobservatory.nasa.gov/

Climate Data Online [212]

"Climate Data Online (CDO) provides free access to NCDC's archive of global historical weather and climate data in addition to station history information. These data include quality controlled daily, monthly, seasonal, and yearly measurements of temperature, precipitation, wind, and degree days as well as radar data and 30-year Climate Normals. Customers can also order most of these data as certified hard copies for legal use."
https://www.ncdc.noaa.gov/cdo-web/

Climate Data Guide [213]

"The Climate Data Guide provides concise and reliable information on the strengths and limitations of the key observational data sets, tools and methods used to evaluate Earth system models and to understand the climate system. Citable expert commentaries are authored by experienced data users and developers, enabling scientists to multiply the impacts of their work and the diverse user community to access and understand the essential data."
https://climatedataguide.ucar.edu/climate-data.

Climate Data Store [214]

"The Climate Data Store (CDS) is the cornerstone infrastructure which supports the implementation of the Copernicus Climate Change Service (C3S). It enables the provision of Essential Climate Variables (ECVs), climate analyses, reanalyses, projections and indicators at temporal and spatial scales relevant to adaptation and mitigation strategies for various sectoral and societal benefit areas."
https://cds.climate.copernicus.eu/#!/home.

Climate Data Services [215]

"NASA's Climate Data Services (CDS) provide a central location for publishing and accessing large, complex climate model data to benefit the climate science community as well as the broader public"

https://www.nccs.nasa.gov/services/climate-data-services.

Climate Change Litigation Databases [216]

"This site provides two databases of climate change caselaw. Cases in the databases are organized by type of claim and are searchable. In many cases, links are available to decisions, complaints, and other case documents."
http://climatecasechart.com/

Appendix D. Energy/Infrastructure Databases

A variety of databases exist which contain information regarding energy use, availability, investment, and more. Within this framework, we have also included several databases on infrastructure and infrastructure investment as frequently these types of projects will include energy aspects. We have decided not to include infrastructure investment databases that require a subscription, as the databases provided below should present the reader with an adequate place from which to begin learning about energy. While more databases exist, here we highlight several of the more prominent databases, along with a brief description of the database provided by the source on their website (shown in quotes) or a brief explanation when succinct descriptions are not available.

US Energy Information Agency [217]

The Energy Information Agency (EIA) has data on a staggering variety of energy statistics, uses, and more
https://www.eia.gov/

UN Energy Statistics Database [218]

"UNSD maintains the Energy Statistics Database, which provides annual statistics on production, trade, transformation and consumption (end-use) for solid, liquid, and gaseous fuels, electricity, and heat. The database contains data in their original units (e.g. metric tonnes, GWh) as well as calorific values to allow interfuel comparison in a common energy unit (terajoules). The Energy Statistics Database contains basic statistics for more than 230 countries/territories from 1950 year onwards and is updated annually."
https://unstats.un.org/unsd/energystats/data/

IRENA Data and Statistics [219]

"Detailed, accurate and timely data and statistics are essential for the monitoring and evaluation of renewable energy policies and deployment. IRENA helps analysts, policy makers and the public make informed decisions by providing access to comprehensive and up-to-date renewable energy data."
https://www.irena.org/Statistics.

IEA Data and statistics [220]

The International Energy Agency provides data on a wide variety of energy production and use statistics.
https://www.iea.org/data-and-statistics?country=WORLD&fuel=Energy%20supply&indicator=TPESbySource.

Database of State Incentives for Renewables and Efficiency (DSIRE) [221]

"DSIRE is the most comprehensive source of information on incentives and policies that support renewables and energy efficiency in the United

States."
https://www.dsireusa.org/

NREL Energy Analysis Data and Tools [222]

"Explore our free data and tools for assessing, analyzing, optimizing, and modeling renewable energy and energy efficiency technologies."
https://www.nrel.gov/analysis/data-tools.html.

Eurostat [223]

Eurostat is the statistical office of the European Union and produces statistics related to energy across the EU.
https://ec.europa.eu/eurostat/web/energy/data/database.

WHO Household Energy Database [224]

"The WHO Household energy database monitors household energy use for 157 countries. The database contains nationally representative data from surveys and censuses on cooking, heating and lighting fuels. … … The database is used to calculate national estimates for use of polluting fuels, such as wood, charcoal, animal dung, coal and kerosene - a proxy for exposure household air pollution"
https://www.who.int/airpollution/data/household-energy-database/en/

OECD Energy Data [225]

OECD visualizes data pertaining to energy use and supply.
https://data.oecd.org/energy.htm.

APEC Energy Database [226]

"The purpose of "the APEC Energy Database" is to establish a comprehensive and consistent energy database in the APEC region. This database provides useful information in identifying trends in energy supply and demand. The database consists of data collected from member economies"
https://www.egeda.ewg.apec.org/egeda/database_info/index.html.

DOE Global Energy Storage Database [227]

"The DOE Global Energy Storage Database is the go-to source for unbiased, accurate, and up-to-date information on energy-storage projects and policies. The database is publicly accessible and simple to use, providing an open-access resource for detailed energy-storage project and policy information, and allowing users to contribute data through a third-party vetting process."
https://www.sandia.gov/ess-ssl/doe-global-energy-storage-database/

The Chalmers Energy Infrastructure Database [228]

"In the Pathways research programme, the analysis of future developments in the European energy systems starts with a detailed description of the existing energy system. Each research group has been involved in creating databases regarding the present situation (in some cases also including historical developments and near-term plans). These databases have incorporated information obtained from different sources, including in-depth interviews, data and literature surveys, available statistics, and direct contacts with, for example, energy utility companies, energy plant owners, and international and national energy agencies. Also included is information from external databases that has been derived from official national and European statistics, EU-funded projects, research institutes, and private companies."
http://www.energy-pathways.org/infradb.htm.

World Bank Infrastructure Data [229]

The World Bank publishes a wealth of data related to infrastructure use, development, and investment.
https://data.worldbank.org/topic/9.

Nuclear Energy Infrastructure Database [Permission required for access] [230]

"Through the Nuclear Science User Facilities (NSUF) program, DOE launched the Nuclear Energy Infrastructure Database (NEID), which provides a catalog of existing nuclear energy-related infrastructure that can potentially be accessed through GAIN. NEID currently includes information on 963 research and development instruments in 465 facilities at 132 institutions in the United States and abroad. Nuclear technology developers can access the database to identify resources available to support development and implementation of their technology, as well as contacts, availability, and the process for accessing the capability."
Note that NEID is access controlled, and an account will have to be made
http://nsuf-infrastructure.inl.gov/

Private Participation in Infrastructure Database [231]

"The Private Participation in Infrastructure Projects Database is a product of the World Bank's Public Private Partnership Group. Its purpose is to identify and disseminate information on private participation in infrastructure projects in low- and middle-income countries. The database highlights

the contractual arrangements used to attract private investment, the sources and destination of investment flows, and information on the main investors."

https://ppi.worldbank.org/en/ppi.

National Infrastructure and Restoration Projects [232]

The Nature Conservancy tracks restoration projects across coastal areas of the United States
http://projects.tnc.org/coastal/

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