XL Insurance

Solar and wind power

Renewable Energy Environmental Exposures

An AXA XL environmental whitepaper

Contents

Concerns about greenhouse gas emissions and climate change have prompted the world to examine and take action to reduce our carbon footprint impacts.

Catastrophic weather events have become more frequent and severe and the insurance industry has seen increases in climate-related losses. Global warming is already impacting terrestrial and marine ecosystems and a multitude of other concerns have emerged ranging from potential sea-level rise to desertificaiton and drought.

Relative to fossil fuel power generation, there is little literature available on the potential environmental impacts from renewable energy sources. Although renewable energy options offer environmental benefits, development and operations can still be associated with some environmental exposures that should not be discounted. This paper provides an overview of renewable energy use, briefly discusses professional services and contracting risks, and outlines potential solar and wind energy environmental risks.

Background

Historic environmental impacts from production and use of traditional fossil fuel energy sources such as coal, natural gas, and oil are widely known.

In addition to air emissions, operational environmental risks include water consumption, effluent discharges, hazardous material spills, and hazardous waste disposal. Nuclear energy was once commonly considered to be the solution for low environmental impact and sustainable power generation because it does not generate greenhouse gas emissions and relies on uranium as an alternative, but nonrenewable fuel source. However, it presents concerns related to radioactive waste disposal, and nuclear plant support systems have many of the same environmental exposures found at fossil fuel power plants.

The world's attention is focused on greenhouse gas (GHG) air emissions, primarily carbon dioxide, from fossil fuel combustion that are driving climate change. Fortunately, this reality has collectively prompted individuals, companies, and governments to consider and accelerate sustainable, renewable energy sources rather than depend exclusively on fossil fuels. Renewable energy sources offer an increasingly attractive alternative in terms of cost effectiveness, output capacity and public acceptance.

Benefits of renewable energy use include enhanced energy security and independence, reduced air pollution, improvements in public health, and smarter reuse of distressed land. Renewable energy sources serve to enhance power generation diversification. They also provide local energy resilience from disruptive events that can impact the grid system and critical infrastructure.

Two key growth areas of renewable energy are solar power and wind power. AXA XL's research estimates that worldwide in 2020, on-shore and off-shore wind projects represented 43% of renewable energy investments, while solar projects represented 39%. These mature technologies are likely to drive future investment in the near term, while other forms of alternative energy such as geothermal, are projected to experience the most relative growth. The International Energy Agency (IEA) estimates that renewable energy sources are currently providing less than 25% of the world's electricity generation. In order to achieve net zero climate goals, it is estimated that renewable power sources would need to provide at least 60% of generation by 2030 with solar and wind energy contributing as much as 70% by 2050.

43%

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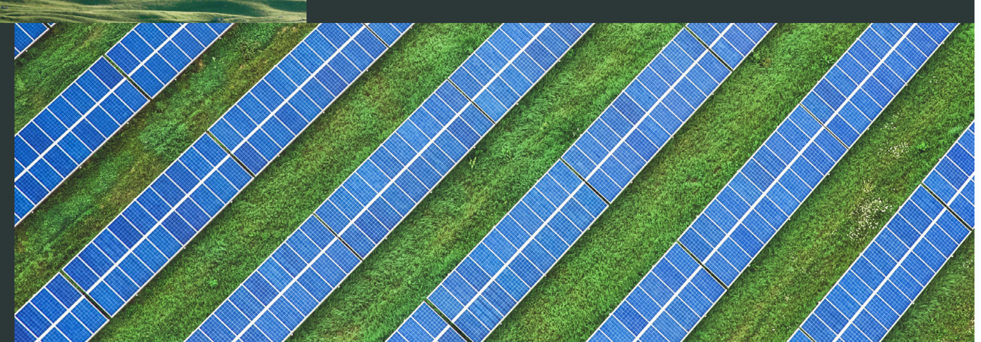

Renewable energy - what is it?

Renewable energy can be broadly defined as being collected from resources that are naturally replenished on a human timescale. This includes resources such as sunlight, wind, water, tides/waves, biomass and geothermal heat. They are considered virtually inexhaustible in duration but limited in the amount of energy available per unit of time.

In North America, the US Energy Information Administration (EIA) estimates that renewable energy sources comprise only 11% of the US energy consumption, while in Canada's it jumps to 28% due to hydroelectricity contributing 90% of renewable energy consumption. This limited generation and consumption history represents an enormous potential for renewable energy sources to subsidize, and perhaps someday supplant, conventional fossil fuel reliance.

While renewable energy sources are generally considered environmentally-friendly, some project sites present environmental concerns from historic site use, construction impacts, and operational issues. Siting and developing any kind of electrical generation project can present challenges. Concerns can include ecological impacts and natural resource damages that may involve threatened and endangered species. Projects can also encounter local community opposition due to pre-existing site contamination, potential impacts from construction and operation, view-shed aesthetic concerns, and social media misinformation. Renewable energy projects share most of these exposures.

Fortunately, many of the concerns associated with solar and wind energy projects can be effectively addressed via site planning, regulatory agency collaboration, operational risk management, and risk transfer programs such as pollution liability insurance coverage.

Professional services and construction exposures

Deciding to use and fund renewable energy sources for new power generation projects is a critical investment in our future and one that various economic incentives can influence.

Project viability and scope must be thoroughly evaluated and planned. However, siting considerations, design features, construction plans, and operations & maintenance details are important factors in long term success. Many types of professional service companies are needed to evaluate economic factors, create project specifications, solicit and evaluate bids, and retain contractors with appropriate experience. It is important to select qualified third parties to assist with these steps right from the start.

Projects often start by retaining consulting firms for pre-construction work such as preparing Phase I & II environmental site assessments and geotechnical studies. An environmental impact statement is typically needed if government funding is involved and/or if sensitive ecosystems and flora/fauna are present. Firms are needed to provide engineering design, general contractor services, subcontracted services, and other types of specialty support. For example, hiring a good public relations firm early in the process to evaluate opposition, educate local communities, counter misinformation, and propose mitigation efforts can pay big dividends in project approval and completion.

Design professionals and engineering firms should have a track record of successful projects involving the specific renewable technologies being proposed.

To this end, reputable firms must be selected with adequate design/build, engineering/construction, and project management related experience. Design professionals and engineering firms should have a track record of successful projects involving the specific renewable technologies being proposed. Competitive quotes are important, but less so than retaining firms that have the experience and project history to provide a realistic bid and project timeline. Due diligence is necessary to ensure that the selected bidders can actually perform the work in the planned time frames and that a high quality project will be completed without design flaws or construction defects. More importantly, this will ensure the project is economical, efficient, and produces the required energy output and return on investment. Retained firms should also have adequate professional and contractor pollution liability insurance coverage.

The long term success of a renewable energy project often rests on retaining an experienced asset manager responsible for operations and maintenance, including managing any subcontractor responsibilities. Operating requirements should be addressed during contract review and should be scrutinized similar to exposures during planning and construction phases. Construction punch lists, operating permits, startup period performance standards and handover requirements should be outlined in the operating contract. Quality checks and inspections will ensure the project being received is working as designed. If/when any performance issues are identified, they should already be addressed via equipment/hardware warranties and other performance guarantees.

In summary, project consultants and contractors must be evaluated to confirm qualifications; insurance requirements; indemnities; completion times; oversight (if appropriate); payments & change orders; dispute resolutions; and other associated standard contract terms are adequately addressed.

Historical environmental exposures

Instead of using undeveloped land for renewable energy projects, economic models can be positively impacted by development on cheaper, distressed lands.

In the United States, the Environmental Protection Agency's Re-Powering America's Land (RAL) initiative is focused on encouraging renewable energy development on current and former contaminated land, landfills, and mine sites. The RAL program purpose is to identify sites with the potential for renewable energy development and provide useful resources for communities, developers, industry, state, and local governments.

The RAL program covers a wide range of potential projects from smaller, non-grid connected sites, to community projects generating electricity for local area use, as well as commercial, multi-megawatt, utility-scale, projects supplying the electric grid. This includes sites with known or suspected contamination, brownfields sites, and sites undergoing corrective action and remediation under various federal and state environmental programs. Projects have included solar array construction on former landfills and wind farm development on abandoned industrial sites across the nation.

Construction of solar and wind power projects on former industrial brownfield sites may result in the need to manage historical fill and/or soil contaminated with a variety of pollutants such as: heavy metals, petroleum hydrocarbons, pesticides/herbicides, and volatile and semi-volatile organic compounds. Groundwater and stormwater from brownfield sites, landfills and mining sites may also be contaminated and require active treatment.

Some of the benefits of working with multiple stakeholders to locate a renewable energy project on contaminated land include:

- **Obtaining site identification and development support**
- **Creating a sustainable land development strategy and protecting open space**
- **Improving project economics with reduced land costs, tax incentives, and liability relief**
- **Leveraging existing support infrastructure**
- **Reducing project cycle times via streamlined zoning and permitting**
- **Providing low-cost clean power to communities**
- **Gaining community support**

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In the US, most states have a program that helps support the RAL initiative. EPA estimates that to date over 450 "re-powering" construction projects in 44 states have benefited from Federal and State financial and environmental collaboration. Solar energy projects have been a particular benefactor of these programs.

450+

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Solar power

Solar energy is generated by technologies that capture the radiant energy of the sun, which can be converted into heat or electricity. The amount of sunlight energy depends on the location and fluctuates daily, seasonally and with weather conditions.

Solar farms constructed on a commercial scale require acres of land, but solar energy can also be harnessed via rooftop and ground mounted arrays for individual businesses and homes. Solar renewable energy systems commonly include Solar Thermal Heat Collection (THC), Solar Photovoltaic (PV) Conversion, and Concentrating Solar Power (CSP).

Passive thermal heat collection techniques have been used in building designs for years, but there are also active commercial generation methods in use such as solar ponds. These operations capture solar radiation in brine solutions, which are pumped from the warmer bottom layers to create steam that can be used to power a turbine or heat another low-boiling point liquid.

PV conversion, or solar cells, are the most widely used and commonly associated with solar power generation. PV devices are used to convert sunlight directly into electricity but can be expensive to manufacture. Commercial photovoltaic power plants require large arrays that cover many acres to generate significant power. Individual commercial businesses and residential homes also use solar panels (i.e., photovoltaics) to generate electricity and these properties may or may not be connected to the electrical grid. Solar panel installation on residential and commercial roofs in the US is estimated to have grown more than 50% annually since 2010.

Utility-scale solar power generation most often relies upon CSP systems due to their common construction materials and lower costs. These technologies concentrate the sun's energy to a receiver to produce high pressure heat/steam that powers a turbine and generates electricity. Less commonly this approach can include the use of a Stirling engine (i.e., heat engine) that uses heated fluids or gases to move pistons and create mechanical power and electricity.

CSP systems generally include one of the two following concepts:

Trough systems

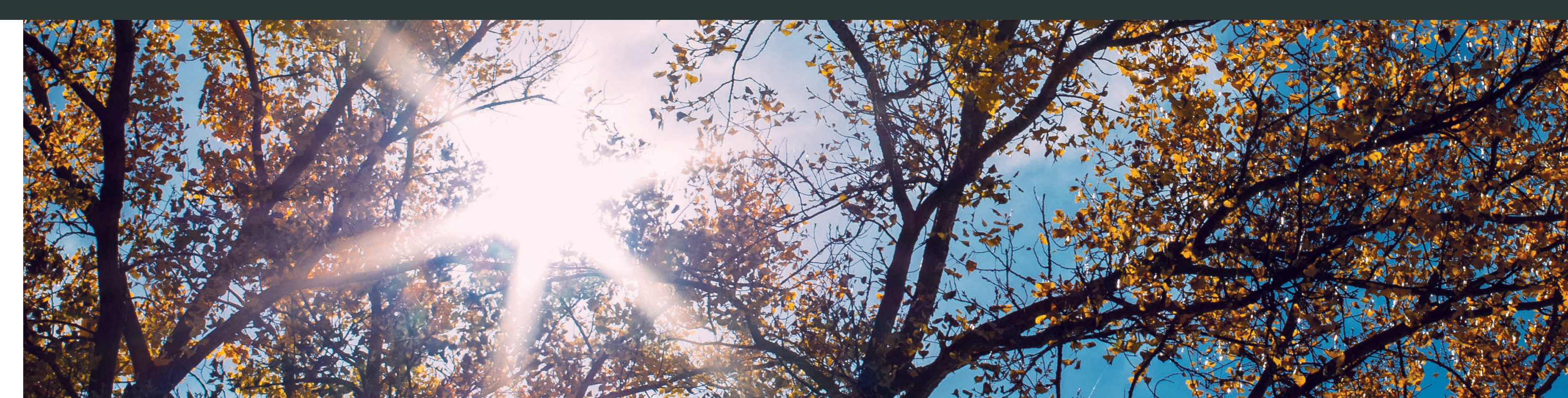
Use long rectangular curved (U-shaped) mirrors to concentrate sunlight on tubes that run the length of the mirrors. A fluid heated inside the tubes boils water to generate steam for a turbine.

Power tower systems

Use a large field of flat, sun-tracking mirrors (heliostats) or parabolic mirrors to concentrate sunlight onto a receiver on top of a tower. A fluid heated in the receiver is used to generate steam for a turbine.

Solar panel installation on residential and commercial roofs in the US is estimated to have grown more than 50% annually since 2010.

CSP mirror systems have a myriad of available designs including parabolic reflectors, point focus reflectors and Fresnel reflectors. Hybrid designs have also been used to employ Concentrator Photovoltaics (CPV) systems. This technology uses inexpensive mirrors, lenses, and glazed metals and plastics to concentrate energy on PV solar cells. These systems concentrate sunlight onto fewer and/or smaller solar cells thereby reducing capital costs and increasing power output per area. PV arrays can also be designed without the need for direct sunlight, be fixed in place, or capable of tracking the movement of the sun.



Solar energy environmental exposures

Most solar power environmental impacts have historically been associated with the manufacturing of solar panels and photovoltaic devices which rely on a variety of metals, acids, and solvents. As a renewable energy resource, solar power plants do not produce air pollution or greenhouse gases and generally have a lower environmental impact; however, there are pollution and environmental exposures that exist.

Environmental/ ecosystem impacts	Solar plants on public lands and those receiving public funding are subject to preparation of an environmental impact statement and evaluation process to review potential impacts to flora and fauna. Large tracts of land are typically required so this can include diverse habitats and natural features. Construction may introduce non-native, invasive plant species, which could be considered contaminants in sensitive environments. Mitigation plans and/or alterations to development/construction plans may be necessary to prevent environmental impacts.
Distressed land	Solar farms are increasingly being built on closed landfills and other distressed lands. Improper evaluation and placement/construction of solar panel supports through the landfill cover or cap can create problems. This could include the release of landfill gasses to the atmosphere, stormwater infiltration into waste fill, or instability in the supports thereby causing damage to the solar panel arrays.
Natural resource damages	Siting in sensitive desert and other ecosystems can result in impacts to flora and fauna. Large solar arrays can cause changes to microclimates and ecosystems. Development on federal or state lands may increase risks for trustee claims related to cultural or ecological value or recreational use.
Aesthetics/visibility	Large solar arrays can impact “viewsheds” and aesthetics may be considered in trustee Natural Resource Damage (NRD) claims.
Water consumption	Some solar plants may require water for cleaning solar collectors/concentrator or for cooling turbine generators. Using large volumes of surface water or groundwater, particularly in sunny, arid climates, can impact local ecosystems.
Heat transfer fluid releases	CSP technologies rely on molten salt solutions, most commonly sodium and potassium nitrate salts, to absorb and transfer heat. This material is present in piping and stored in tanks. Despite lower toxicity, salt releases can still result in environmental impacts to vegetation, soils, and groundwater. Temperature resistant hydrocarbon oils have also been used as heat transfer fluids but are less common because they tend to degrade over time.
Groundwater impacts	Breaches in liners of solar ponds may result in salt and dissolved solid contamination of aquifers. Biocides used to prevent pond algae growth may also cause impacts.
Stormwater	Disturbance and construction over large acreage tracts can result in stormwater sedimentation pollution. This can be an exposure when sites are not properly designed with appropriate stormwater conveyances and/or sedimentation/retention ponds.
Public relations/ opposition	Local and regional opposition increases the potential for third party claims and legal defense expense. An outreach program is often necessary to increase communication, combat misinformation, resolve complaints and minimize conflicts.

New and experimental solar technologies are also under development that could result in emerging environmental risks. These include concentrated photovoltaic systems, thermovoltaic systems, floating solar arrays, solar assisted heat pumps, artificial photosynthesis; algae fuels; solar updraft towers; and spaced based solar power. These exposures will continue to be studied to support larger scale use.

Wind power

Wind energy from onshore and offshore development has become the largest alternative energy source in the world.

Wind energy is captured by wind turbines with propeller-like blades mounted on a tower. The force of the wind causes the rotor to spin and the turning shaft spins a turbine to generate electricity. This may include utility-scale, community-scale (less acreage), or non-grid connected (smaller and fewer turbines to power a single property) operations.

Utility scale turbines most commonly have a horizontal axis design with two or three large blades. Larger and longer blades cover more surface area for wind energy capture resulting in greater power generation. Wind turbines are typically constructed in groups or rows comprising a “wind farm” to harvest energy in consistently windy spots.

A wind turbine is comprised of the tower, the blades, a rotor hub, and the box behind the hub, called the nacelle. The nacelle contains a gearbox that produces electricity via a generator. Hydraulic controls are used to consistently orient the blades into the wind and maximize output.

Operating a wind power system is more complex than simply erecting wind turbines in a windy area. Power plant developers and owners must carefully plan where to position wind turbines and understand how fast and frequent sustainable wind occurs at a site. Wind energy resources vary hourly and seasonally and significant planning is needed to match up generation capacity with nearby populations and seasonal demand.

When all the variables match up, finding an acceptable location for a proposed wind farm and related transmission corridors becomes critical. This includes off-shore projects, which are being proposed more frequently. On-shore, the reuse of contaminated land has expanded available siting options. Wind turbines require concrete pad foundations and construction of access roads for on-going maintenance. Construction activities can discover or result in environmental impacts that require mitigation.

Wind energy environmental exposures

As a renewable energy resource, wind power systems do not produce air pollution or greenhouse gases and generally have a lower environmental impact; however, there are pollution and environmental exposures that exist.

Environmental/ ecosystem impacts	Wind farms on public lands must undergo an environmental impact statement process to review potential impacts to flora and fauna. Mitigation plans and/or alterations to development/construction plans may be necessary.
Natural resource damages	Bird and bat mortality may result from propeller impacts, particularly from wind farms located in flyways of migrating birds or near wildlife refuges. As previously noted, development on federal or state lands may increase risks for trustee claims.
Electromagnetic fields (EMF)	Primarily a concern limited to off-shore windfarms from submarine cables and other electric infrastructure; however, perceived bodily injury concerns have also been raised in public meetings and litigation for on-shore facilities. There have also been concerns about the creation of EMF and interference with radar systems.
Aesthetics/visibility	This is the most common public relations issue associated with the siting of wind farms. Viewsheds can be permanently altered and environmental groups and local citizens may oppose certain siting options.
Transformers/ substations	A local substation is often needed to collect electricity from distributed wind turbines and transform/ convert it to high voltage prior to long distance transmission. Substations may contain oil-filled transformers and diesel-fired emergency power equipment that can result in releases to the environment.
Noise/visual nuisance	Blade noise can result in bodily injury or property damage claims due to impacts to humans and animals. Visual shadow flicker from propeller blades may also cause bodily injury as it has been linked to irritation, disorientation, and seizures in humans. These types of claims become more likely if there is inadequate buffer surrounding the facility.
Stormwater	Construction of towers, access roads, and transmission corridors can disturb soils and result in stormwater sedimentation pollution. Construction planning must incorporate erosion and sedimentation controls and fixed assets designed with appropriate stormwater conveyances and sedimentation/retention ponds.
Public relations/ opposition	As previously noted, adverse public sentiment increases the potential for third party claims and legal defense expense from individuals, communities, and nongovernmental organizations. A formal outreach plan is necessary to ensure good communication and minimize conflicts.

Conclusion

Renewable energy sources and projects provide a wide range of options and alternatives to fossil fuels for power generation and transportation.

Operational limitations, primarily due to scale and generation capacity, have resulted in limited contributions from renewable energy relative to fossil fuel sources. However, increasing awareness, use, research, problem solving, incentives, and public acceptance factors are making alternative energy sources increasingly viable in the battle to reduce greenhouse gases and minimize climate change.

Site developers, owners and operators should recognize the professional, construction, and operational risks associated with solar and wind energy projects. A primary concern is the location and siting of projects. Use of contaminated or distressed land for renewable energy projects increases siting options, but also presents some unique historical challenges that must be addressed. Obtaining buy-in from stakeholders and local communities for construction and operation of power generation and transmission assets is critical.

Solar and wind power projects have less obvious environmental risks, but there are some significant exposures that must be evaluated. These include potential ecosystem impacts, natural resource damages, aesthetics, and stormwater, soil, and groundwater risks. Ancillary operations and substations can also utilize various hazardous materials that can represent an environmental risk. On-going maintenance of solar-energy driven turbines/generators and wind-turbine machinery can generate oil and solvent wastes that must be properly managed and disposed.

Site assessments, stakeholder collaboration, contracts/indemnifications, and risk transfer programs that include pollution and professional liability insurance, can help minimize the exposures associated with solar and wind energy project construction and operation. Comprehensively implementing such controls is vital to successful long-term development and operation of renewable energy projects.

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