Charles Taylor Adjusting

Adjusters' Insight

Omar Mostafa, Executive Adjuster – Natural Resources and Engineering

Andrew Hodkinson, Regional Head – Australia & New Zealand, Executive Adjuster – Natural Resources and Engineering

Traditional Power and Renewable Energy – Who's got the Power?

Electrical Power can be generated from many sources. Historically it would be generated by a turbine and generator assembly that is fueled by diesel or gas or steam produced by burning coal. However as these fossil fuels become less accepted and prevalent, then power generation needs to turn to Renewables. This comes with its own challenges least of which is the requirement for energy storage such that intermittent power supply is avoided.

It is a very complex process running networks to provide the constant power required with sufficient reserve to provide power when demand quickly increases. This needs to be forecast well because it takes time for large power plants to increase output or for networks to draw from peaking stations which sit ready to respond to such situations.

The status quo has however changed in recent times, and is accelerating, with the advent of substantial renewable power being 'plugged' into the grid which tends to operate in synchronicity with mother nature thus being intermittent.

In this article Omar Mostafa, Executive Adjuster – Natural Resources and Engineering and Andrew Hodkinson, Regional Head – Australia & New Zealand, Executive Adjuster – Natural Resources and Engineering of Charles Taylor explore how traditional power generation and distribution systems now deal with an ever increasing renewable power input, and what this may look like in respect of future Insurance claims. Areas of focus in this article include:

- Thermal Power Plants
- Renewables
- How renewables interface with the existing networks
- Likely claims and emerging risks

How Is Power Generated?

The most common way of generating electricity is by applying Faraday's law of Electromagnetic Induction that involves movement of a conductor in a uniform magnetic field. The "movement" is the aspect that requires mechanical energy, and this is either achieved indirectly or directly:

- **Indirectly** – E.g. Gas is burned to generate thermal energy; the thermal energy is then used to generate steam under pressure which is used to rotate a turbine. The turbine is coupled to a rotor to convert the mechanical energy in a magnetic field into electrical energy.
- **Directly** – E.g. Wind is used to rotate a turbine. The turbine is coupled to a rotor to convert the mechanical energy in a magnetic field into electrical energy.

The two methods are demonstrated in Figure 1 below.

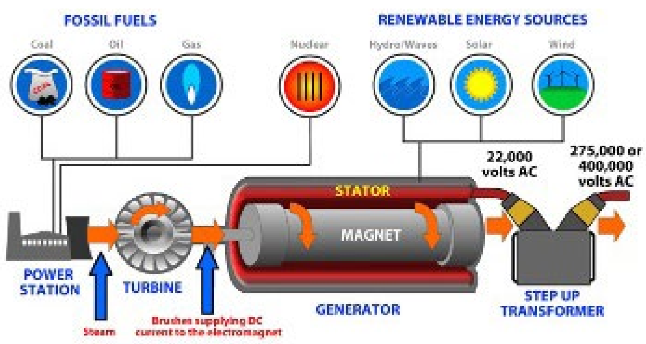

Fig. 1 (source: http://www.appliedscience.org.uk): Basics of electricity generation

This principle does not apply to Solar Photovoltaic power generation as the photons from the sun cause the movement of the electrons within the conducting cells of the photovoltaic panel which represent the produced electric current.

Baseload vs Intermittent Power

Baseload is the dispatchable bare minimum power that can be harnessed at any time to supply users, and is always available to the electrical grid. Baseload power is always running to provide the constant power required, and is often cheap fossil fuel based (coal or gas).

On the other hand, intermittent power is produced via inconsistent sources of energy such as wind, sun and tide/waves; this being particularly the case in Australia.

It is a common misconception to define all power generated by renewable energy as intermittent power. Examples such as geothermal and hydro are sources of renewable energy and are also defined as baseload power generation.

According to the International Energy Agency[1], Baseload generation from the conventional coal, gas and oil represent more than 60% of the global power generation. They remain large contributors due to their role in stabilising grids. Generators that spin in baseload power plants set the frequency (50 or 60 Hz) of the electrical grids, which is something that wind and solar do not currently achieve. Wind and solar use electrical inverters to match the already established grid frequency.

A typical baseload transmission arrangement is demonstrated in Figure 2 below.

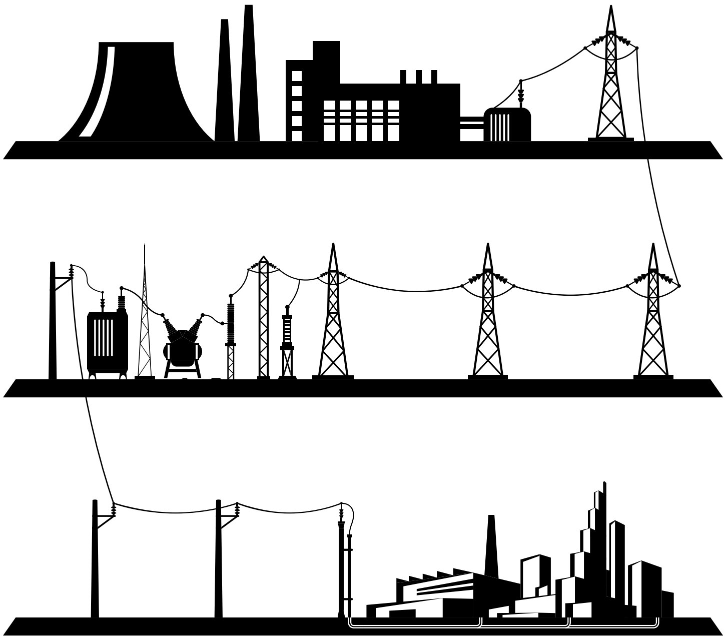

Fig. 2: Transmission of power from a baseload power plant to end users

Thermal Power Plants

Thermal (i.e. non-renewable) power generation involves power plants that are mainly run using coal, petroleum derivatives, nuclear fuel or gas. These fuels are burnt or processed in one way or another to produce thermal energy, which is in turn used to rotate coupled turbines and generators to produce electricity.

Each piece of equipment is critical to the operation of a power plant; however, we briefly discuss below the items that fail the most when the relevant factors are in place.

- **Boiler**: A boiler or a steam generator is most commonly found in power plants run by coal, oil or nuclear fuel. The boiler represents the platform of burning fuel and utilising the produced heat to transform water into high pressure superheated[2] steam. The steam is then introduced at high velocity to turbines coupled to generators to produce electricity.

  Boilers can suffer from weld cracking issues that can lead to steam leaks or worse. Water chemistry and other factors are important to their good working order.

- **Turbine**: The turbine is the key component that transmits mechanical energy to a generator to produce electricity. The designs and sizes vary significantly from one plant to the other, depending on the fluid used (steam, water, air-fuel mixture, etc.) and the efficiency sought. The fundamental is the same though. A rotor assembly that is made of a shaft and blade rows, and a fluid that is introduced to the rotor assembly to make it rotate. The most common types of turbines are:

  - Steam turbine: It is driven by steam and is classified into different types: Impulse turbine, Reaction turbine or Impulse-Reaction turbine.

  - Gas Turbine: It is driven by air-fuel mixture and operates using the principle of "suck, squeeze, bang and blow". Perfect for peaking power plants as it can be operated in minutes.

  Turbine blade liberation and failures can occur as a result of fatigue cracking which emanates from an inclusion or misuse.

[1] https://www.iea.org/data-and-statistics?country=WORLD&fuel=Energy%20supply&indicator=Total%20primary%20energy%20supply%20(TPES)%20by%20source

[2] The term superheated is used to describe the process involved in removing all droplets of water from the generated steam to prevent damage to downstream turbines and to also expand the volume of the steam and achieve higher energy. The temperature of the produced steam can be anywhere between 200°c and 700°c and the pressure can be anywhere between 10 to 300 bars.

Thermal Power Plants (continued)

- **Generator**: Simply put, the generator is made of a rotor (i.e. rotating component) and a stator (i.e. stationary component). Utilising the principle of Faraday's law, the generator receives the turbine's mechanical power and converts it to electricity. This is done through the movement of a conductor in a magnetic field.

  Generator losses often involve a breakdown of the winding insulation material due to a multitude of causes.

- **Transformer**: The transformer is a static piece of electrical equipment that transmits electricity from one coil to another coil without a conductive connection between the two coils, again using Faraday's law of induction, as long as they are wound around the same core.

  Varying the number of turns of each coil allows stepping up or stepping down the voltage depending on where the transformer is positioned in the grid. One of the main purposes of stepping up the voltage as soon as it leaves the power plant, is to reduce the transmission losses, and then it has to be stepped down again before distribution.

  Transformer losses can result from lightning strikes or winding failures due to age etc.

- **HRSG**: In some plants known as Combined Cycle Power Plants, the Heat Recovery Steam Generator (HRSG) represents the link between a gas turbine and a steam turbine. The HRSG functions as a boiler; however, it does not burn fuel to generate heat. It rather uses the heat from the exhaust gases from a gas turbine to generate steam to operate a steam turbine.

  These systems can suffer from similar failures to those noted in the preceding plants.

CTA has been involved in many Power Generation and Transmission losses over the years. These often involve catastrophic failure of rotating machinery or transformer explosion, some of which have led to business interruption in the millions of dollars.

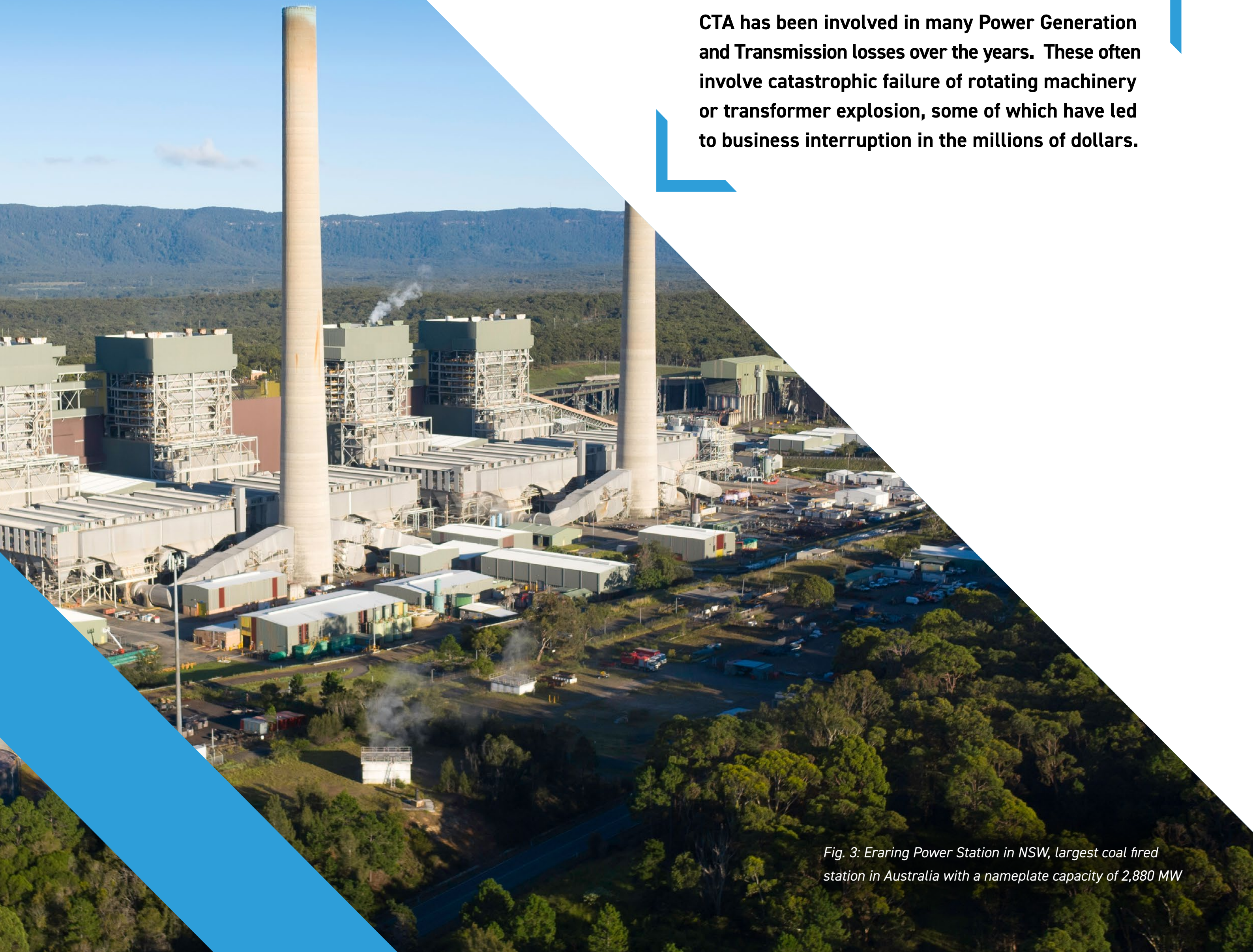

Fig. 3: Eraring Power Station in NSW, largest coal fired station in Australia with a nameplate capacity of 2,880 MW

Changes in Technology

As traditional power plants are only constructed every few years, the production cycles are long and the changes are slow. Nevertheless, if there is a change to design, technology or process, the driver would be mainly to achieve the highest possible heat rate from a power plant. In other words, minimising the fuel consumed and maximising the kilowatt-hour (kWh) generated.

Exceeding a 60% efficiency from a gas turbine in a combined cycle power plant was similar to the “space race”, between the Original Equipment Manufacturers (e.g. General Electric, Siemens, Mitsubishi Heavy Industries, etc.), which was broken in 2010.

A gross efficiency of a combined cycle plant operated by a gas turbine was recorded at 63.08% and achieved by General Electric at the Chubu Electric Nishi-Nagoya power plant. This was a world record as named by Guinness World Records in 2018. The race continues with manufacturers claiming new gas turbines that can achieve 64% and 65%.

This is a big deal given that it normally takes 10 years of research and development to raise a power plant's efficiency by 1%.

A gross efficiency of a **combined cycle plant** operated by a **gas turbine** was recorded at **63.08%**

This was a world record

Renewables

Massive investments are now pumped into renewable power generation all over the world due to concerns about climate change and the reduction in readily sourced fossil fuels. The reduced costs of construction and innovations are encouraging the investments into renewable energy and the initiatives to reduce the carbon footprint.

Wind

Harnessing wind and converting it into mechanical energy via rotating blades is centuries old.

Wind Turbines can be constructed onshore or offshore. The commonly known horizontal axis wind turbines as we know them mainly consist of

- the blades – that rotate when propelled by the wind
- rotor, shafts and gears – to transmit the movement (i.e. mechanical energy)
- generator – to convert the mechanical energy into power
- other components – nose cone, nacelle, brakes, yaw drive and motor, etc.

Changes in wind turbines over the recent years to make them more efficient included making the materials of the blades lighter and stronger (e.g. glass/carbon fibres with resin/epoxy).

Another rapid change in wind turbines is their size and accordingly the size of their blades to generate more power. Over the past years, the height and capacity of the wind turbine has progressively increased from 0.5 MW with a rotor diameter of 40 metres to approximately 10MW with a rotor diameter of 165 metres.

Offshore wind is a more consistent source of wind and is a novel frontier of exploration for some countries. On the other hand, the UK is a global leader in producing offshore renewable energy, with expectations that offshore wind will contribute to 10% or more of their power needs in the near future.

Most commonly, the wind turbines are installed with fixed bottom platforms, which is feasible for shallow foreshores with depths up to 60 metres. The direction is now towards going into deep waters, using floating platforms. An example is Hywind offshore wind farm in Scotland. This is the world's first commercial wind farm to use floating wind turbines and is located 29 kilometres off Peterhead, Scotland with depths in excess of 100 metres.

Figure 4 below is a typical offshore wind farm installation.

Fig. 4: Erection of an offshore wind turbine

At a local level in Australia, Star of the South is Australia's first offshore wind project proposed to be in the Bass Strait off Victoria. Another project is proposed by WA Offshore Windfarm, around 140km south of Perth, Western Australia.

In respect to Insurance claims involving wind farms, CTA has experience in matters concerning lightning strikes to blades, damage to interconnecting transmission equipment, coating failures, turbine failures and fires and even storm damage to the structures.

Solar Photovoltaic

Solar Photovoltaic power is a passive way of generating electricity, where semi-conductor cells (commonly made of crystalline silicon) absorb photons of light from the sun. The photons excite negatively charged electrons from one layer, forcing them to move in a single direction towards another layer, generating electricity.

To get meaningful power out of this process, the cells are grouped together to form a panel, and then panels are grouped in the hundreds, thousands and even millions like the Bhadla Solar Park in India that spans 57 km^2 and has a total capacity of 2,245 MW.

Similar to wind, solar panels are becoming more efficient and cheaper. Over the last 5 years, the efficiency has increased from 15% to 20%, where the standard size panel output increased from 250W to almost 350W.

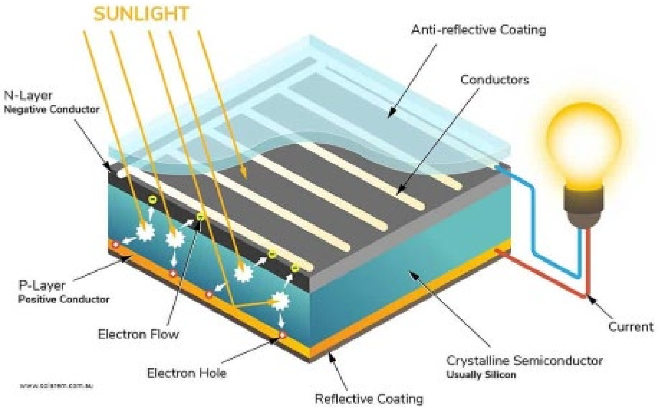

Fig. 5: How a solar panels works

Interestingly solar panels are designed to withstand most environmental elements including hail stones. Unfortunately, in countries like Australia, it is possible to have 'super cell' weather events that produce hail stones well in excess of the standard design size. Such circumstances can lead to catastrophic damage to solar farms, which will attach business interruption.

Renewables (continued)

Hydrogen

Using Hydrogen to generate electricity is currently receiving much attention due to its high potential in complementing intermittent sources of generation and being able to convert fossil fuelled turbines to Hydrogen fuelled.

There are two aspects to generating electricity using Hydrogen, how the Hydrogen itself is generated and the process used to generate electricity.

- Production of Hydrogen: processing of biomass sources[3] or electrolysis of water. The electrolysis of water has to be done via electricity already generated from wind or solar farms to be able to define the entire process as "Renewable"
- Using Hydrogen to generate electricity: Introducing Hydrogen and Oxygen to an electrolyte to produce electricity (i.e. Fuel Cell) or firing gas turbines using Hydrogen

Hydrogen is attractive because of its high energy content and its clean by-products when burnt (water!). With a high calorific value of 150 KJ/g (Kerosene oil is 48 KJ/g, wood is 17 KJ/g), it lends itself to be an obvious replacement to diesel. This being particularly useful when sites are remote and perhaps not having access to readily available renewable energy.

As hydrogen becomes more prevalent in use, CTA anticipates that we will likely see more traditional insurance claims such as plant fires and explosions still occur. This is because hydrogen has the ability to permeate metals and assist in crack development – not ideal.

Hydro

The principle has been around for centuries, which is utilising water's kinetic and potential energy (e.g. waterfall, pumped hydro storage, etc.) by running it through various types of impulse or reaction water turbines to be converted to mechanical energy and then into electricity.

Indeed, hydro power currently represents approximately 66% of renewable energy production as noted in the below graph.

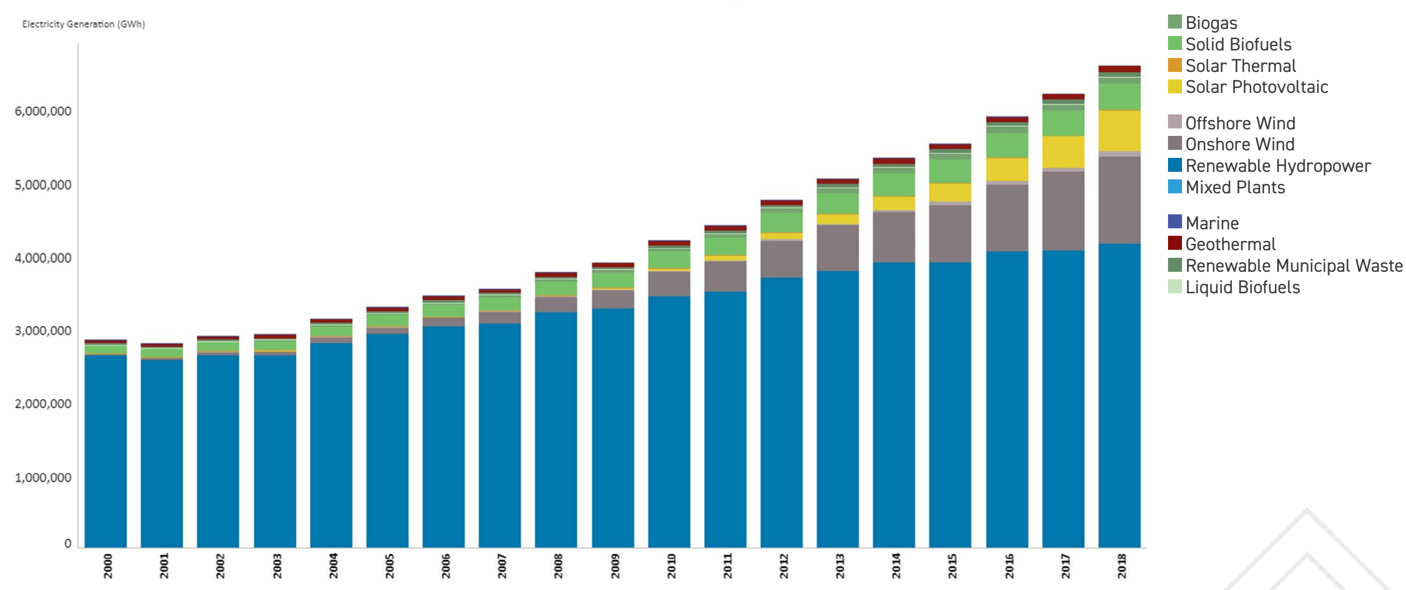

Fig. 6 (source: International Renewables Energy Agency): Percentage of hydro power in renewable energy production

[3] Processing of natural gas can also result in Hydrogen, but it would not fall under the "Renewables" umbrella.

Renewables (continued)

Geothermal

Geothermal plants use the same generation methods and components found in traditional power plants; however, the thermal energy required is harnessed from the Earth's renewable sustainable heat content via geothermal wells.

Concentrated Solar Power

The 'Concentrated Solar Power' method aims at harnessing the heat from the sun via heliostat mirrors. The harnessed heat is directed towards a tower with a working fluid generating thermal energy that operates the other components of the typical generation process.

The below schematic outlines the process in simplistic terms.

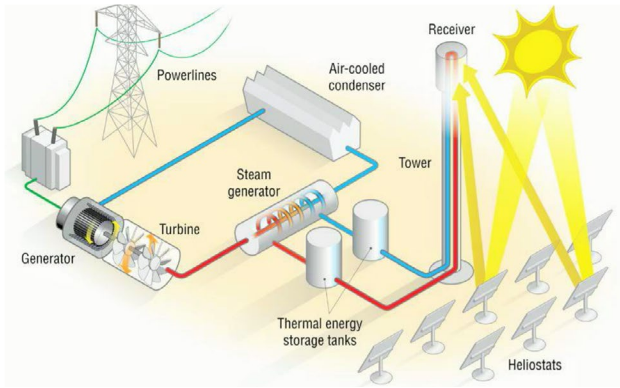

Fig. 7: Schematic of a Solar Thermal Plant

How Renewables Interface With the Existing

The ongoing controversy around the major and common sources of renewable energy (i.e. photovoltaic and wind) is that they are not able to entirely replace the baseload power. We discuss below some of the issues and how renewables can be uplifted to become more functional.

DC vs AC

Most of the aforementioned applications include generators, that spin and produce 3-phase Alternating Current (AC) at 50 or 60 Hz (cycles per second) depending on the region. This frequency has to be maintained to ensure the stability of the grid, where adding more power increases the frequency and drawing power slows down the frequency. This is achieved by generators that spin in the Baseload power plants and that by its nature sets the frequency.

Wind and solar photovoltaic do not currently take part in that equation.

The wind speed is not constant, and wind turbines cannot rotate at a constant rate, which requires additional mechanical and/or electrical controls to match the output with the grid.

As for the solar photovoltaic, it does not involve any rotation as explained earlier. The solar photovoltaics' power is Direct Current (DC), so Inverters are installed to convert the generated DC into AC before being connected to the grid.

Transition Pain Example

Because traditional power transmission systems are designed around constant power generation from fossil fuels, and as renewable power sources have progressively been added into the supply, this has led to old infrastructure 'struggling' with the integration.

An example of how the transition to renewables has had its 'pain' is the South Australian Network Collapse in September 2016. In this case two tornados struck electricity transmission infrastructure, which led to a cascading series of failures and outage, which affected renewable assets and 850,000 customers.

The South Australian state is powered by a mix of wind, thermal/gas and import from Victoria, however the storm damage led to a sequence of collapse and within 2 minutes there was a complete shutdown affecting most in the city of Adelaide!

There were several insurance claims arising from this incident and some points of interest include:

- Back-up diesel generators failed at Flinders Medical Centre leading to frozen embryos loss.
- Back-up diesel generators failed at the Port Pirie zinc smelter leading to smelter 'pot freeze'
- AEMO identified software settings in the wind farms that prevented repeated restarts once voltage or frequency events occurred too often. AEMO has suggested better fault ride-through capability for the wind farms.
- SA Government decided to purchase battery storage from Tesla.

Batteries/Hybrid Technologies

Storing electricity and harnessing it when needed is the focus of significant research, as it enables Renewables to be more reliable and compete with existing baseload powerplants. This can be done in many ways, some of them are briefly discussed as follows:

- Pumped Hydro: An extension to Hydro to store energy, where water is pumped from a lower- level reservoir to a higher-level reservoir when demand is low. When demand increases, the water flows back to the lower-level reservoir rotating the turbines using its potential energy. This is one of the oldest methods of storing energy and represents approximately 97% of the world's current storage capacity.
- Solar Thermal Storage: The harnessed heat from the sun at a Concentrated Solar Power plant would be directed to thermal storage tanks containing a fluid such as molten salt. The molten salt can be stored at temperatures in excess of 500°C for long periods, and with well insulated tanks, a daily temperature drop of 1°C would allow the molten salt to be stored for weeks and used to run the power plant when needed.
- Hydrogen Fuel Cells: A good example in Australia for complementing renewable energy with Hydrogen technology to make it as good as baseload generation is Project Neo in New South Wales. This project is proposed to have a capacity of 1000MW via combining 235 wind turbines and 1,250 hectares of land for solar photovoltaic panels. The generated electricity would assist in producing Hydrogen to be stored and introduced to Fuel Cells when solar/wind generation is low.
- Lithium-Ion Batteries: Tesla has put this concept in the public domain, a now common method nowadays to store energy and uplift wind and solar farms' availability. It involves a chemical reaction where Lithium ions move from one electrode to the other through an electrolyte. They move in one direction when being charged and the other directions during discharge.

  A good example is the Tesla large scale battery storage system, with an output capacity of 150MW attached to the Hornsdale Wind Farm in South Australia. Another large scale battery storage system is the 700MW battery proposed to be built at the Eraring Power station in New South Wales.

Challenges, Risks And Likely Claims

Challenges and Risks

Offshore Wind

The benefit of constructing offshore wind turbines in deep waters is to obtain reliable and stronger winds, which if combined with increasing the size of the turbines, would lead to increased and continuous power production. This of course, comes with the complexities during construction and operational risks.

The effects of higher centre of gravity and forces of the blades alongside the impact of severe weather and waves are yet to be measured in respect of long term fatigue and performance. This is considering that the turbine has to have at least a lifetime of 20 years to be economical, which comes with a lot uncertainty regarding the impacts of weather and wave patterns with the accelerating climate change observed.

Most claims however handled by CTA in the offshore wind space in fact relate to the subsea cables which interconnect the wind turbine towers. All of these matters include exotic materials and offshore vessels, making for some expensive claims.

Overseas Suppliers

Power generation, whether traditional or renewable, has always been featured by the monopoly manufacturers of the major components. This makes the supply chain volatile, especially with global events such as COVID19 taking place. This in turn has its impact leading to unpredicted lead times, inability of overseas manufacturers' representatives to travel and shutdown of factories.

New Technologies

Inevitably as mass production of new technology takes place to satisfy the customers' demands, this can lead to widespread defect issues and 'prototype' designs which are yet to be proven. Often in such cases Insurers will be potentially picking up the bill as a pseudo Research and Development bunny for the manufacturers.

Challenges, Risks And Likely Claims (continued)

Likely Claims

Failure/Machinery Breakdown

Machinery breakdown is the most common peril that impacts a typical power plant, mostly happening in the power plant's large rotating equipment (e.g. turbine).

The failure could be the result of a change in one or the contribution of:

- Material characteristics (e.g. oxidation, corrosion, fatigue, etc.)
- Operational characteristics (e.g. frequent start-ups/shut downs, overspeed, etc.)
- Environmental characteristics (e.g. temperature, vibrations, etc.)

These could lead to common modes of failure such as blade failures and the liberation of blades (unlike the liberation of an entire turbine-generator assembly similar to what happened in the Sayano-Shushenskaya hydro-electric power station in 2009).

Fig.8: Wind farm in the path of a bushfire

Foreign Object Damage is another common mode of failure in turbines (steam or gas), which could be in the form of maintenance leftovers and impurities in fuel, air or stream, resulting in significant downstream damage.

As for Renewables, failure in Wind farms' turbines would be the most common. The causes of failures vary between overspeed, wear of bearings/gears, lack of lubrication amongst others.

Failure can also be electrical/electronic due to underlying manufacturing, design and workmanship issues. This can be encountered in malfunctioning inverters in solar and wind farms as well as cascading thermal runaways in batteries due to internal cell defects.

Marine/Transit

Renewable Energy is more prone to the risk of damage occurring during transit since wind and solar farms involve sending multiple similar items (e.g. wind turbine blade) to the site to be erected.

A thermal power plant is usually made of 2-3 turbines, whilst a wind farm can be made of hundreds of turbines and generators, each having 2-3 blades, and each wind turbine blade can now be in excess of 100 metres long.

Getting from the supplier's overseas plant to the location of the wind farm involves risks associated with Inland transit in country of manufacture, ship loading and unloading and inland transit to the wind farm, which could be hundred kilometres away from port.

Weather

Damage caused by weather events is more common in renewable energy due to the wind turbines and solar panels being in the open air. This makes them susceptible to lightning strikes, cyclones, hail, floods, bushfires, etc. which are all common sources of claims within that sector.

Defects

Inevitably construction claims involve damage to contract works often from a variety of causes.

The more challenging construction claims involve workmanship, material and design defects. This gives rise to a variety of Policy clauses such as serial losses, microcracking and LEG exclusions.

Conclusion

In conclusion, power losses whether baseload or intermittent during operation or construction are most likely to be complex due to constant change in technologies, potential impact to thousands of customers, dynamics of spot and contract markets, Delay in Startup considerations for construction projects, and many other factors. This makes setting a roadmap of recovery from the very beginning of any claim quite crucial.

CTA has been involved with both traditional and renewable insurance claims and has adjusters with specific industry experience to deal with all manner of issues involving material damage and subsequent business interruption that may arise. Our adjusters will take a proactive approach to such claims with one eye on progressing settlement quickly at the same time as ensuring that the loss is mitigated as much as is possible.

Charles Taylor Adjusting (CTA) Expertise:

CTA has qualified engineers on staff throughout all Australian offices with diverse backgrounds ranging from "big picture" Project Engineering/Construction right through to detailed design work. Our Engineering Adjusters hold Adjusting qualifications and are members of the Australasian Institute of Chartered Loss Adjusters (AICLA), the Australian & New Zealand Institute of Insurance and Finance (ANZIIF), or other UK-based professional bodies of equivalent or higher standards.

We ensure outcomes are concisely reported to Insurers to match their requirements in documenting the circumstances of the loss in a clear and logical manner, allowing them to reach a conclusion in respect to policy response.

For further information, please contact:

Omar Mostafa
Executive Adjuster – Natural Resources and Engineering
T: +61 7 3839 9999
E: omar.mostafa@charlestaylor.com

Andrew Hodkinson
Regional Head – Australia & New Zealand, Executive Adjuster – Natural Resources and Engineering
T: +61 8 9321 2022
E: andrew.hodkinson@charlestaylor.com

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Charles Taylor Adjusting (CTA) is one of the leading loss adjusting businesses in the market. We focus on commercial losses and claims in the aviation, marine, natural resources, property, casualty, technical & special risks markets, many of which are large and complex in nature.

CTA is a business of Charles Taylor. Charles Taylor provides insurance services, claims and technology solutions to all parties within the global insurance market. Its technical expertise, technological tools and breadth of solutions enable its clients to outperform, by addressing complexities and challenges across every stage and aspect of the insurance lifecycle and operating model.

Charles Taylor employs approximately 3,100 staff in more than 120 locations spread across 30 countries in Europe, the Americas, Asia Pacific, the Middle East and Africa. It has earned the trust of a diversified, bluechip international customer base that includes national and international insurance companies, mutuals, captives, MGAs, Lloyd's syndicates and reinsurers, along with brokers, distributors and corporate insureds.

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Charles Taylor
@CTcharlestaylor