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The Hydropower Plants Dams

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Abstract
In this work we summarized the all the concepts of hydropower plants dams as well as all hydropower plants.

Introduction
There are many ways to generate electricity in modern day. One of them is to use the gravitational force of falling water, which is also known as hydroelectricity. Hydroelectricity occurs in a dam, where the falling water is used to generate enough force to turn a turbine that is connected to an electricity generator. With this action, potential energy of water is transformed into mechanical energy and then into electrical energy. This is both an efficient and green way of generating electricity: it is not as hard as the geothermal electricity because people do not have to find a perfect area to generate it; and it is also not as polluting as the nuclear power plants are. Therefore, hydroelectricity is much greener than the nuclear power plants which generate electricity, and much easier to generate than the geothermal electricity, where it is economically attractive, provides security of supply and has low levels of CO_2emissions Hydropower has been using in thirty country worldwide and its production is estimated at 1/5 total global production with 90% efficiency. The greatest benefit from the hydropower program is the abundant low-cost energy the projects contribute to electric power grids. Because hydroelectric power plants burn no fuel, operating costs are low and are immune to rising fossil fuel prices, when construction costs were low. As a result, these plants are playing a significant role in keeping electricity costs affordable for consumers, creating a positive impact on the economy. Not only, but a dams which use to produce energy also used to irrigation and keep water to expected drought periods. So hydropower is considered a major renewable energy where it just produce through magnetic induction, the generator converts the mechanical energy of the turbines to electricity.

In Sudan there's 92% primary energy consumption comes from fossil fuels and 8% from hydropower. However, the current installed capacity is about 60% of hydropower. The country is making efforts to integrate more renewable energy resources and seeks 11% of renewable electricity generation except hydropower by 2031. Sudan has also adopted a national energy efficiency plan in 2012 and has set cumulative energy efficiency targets of 11.8% and seeks 32% by 2020[1, 2, and 3]

Classification of Hydropower Plants According to Capacity
Hydropower plants classified according its capacity to six types large, medium, small, mini, micro, pico and will be discuss below in details [4].
1. Large hydropower plants: >100 MW
2. Medium hydropower plants: 25-100 MW
3. Small: 1-25 MW

4. Mini: 100 KW-1 MW
5. Micro: 5-100 KW
6. Pico: <5 KW

Classification of Hydropower Plants According To Head

There are three types of hydropower plants according to Head, high (above 300 m), medium (30 - 300 m), and low (30 m and less)head power plants.

General Classification of Hydropower Plants

Because each project may serve specific targets to specific purpose, so hydropower plants may classify according to purpose to:

Single purpose

When whole purpose of power plant is to produce electricity then such a project is known as a single purpose hydropower plant

Multipurpose

When water used in hydropower project is to be used for other purposes like, irrigation, flood control or fisheries then such a project is known as multipurpose hydropower plant

Classification of Hydropower Plants According To Facility Type

This classification is according to the extent of water flow regulation available the hydroelectric where power plants could be classified according to this consideration into:

Run-Of-River plants

Such a plants work daily according to the nature and limit to the flow in the river. Power generation depends on the quantity of flow. Sometimes a small storage reservoir or pond is built, which can store a few hours' supply of water to the plant, when the river flow exceeds the amount required by the plant. Such a scheme is a called Run-Of-River plant with poundage. The poundage or stored water is used in generation power during the hours when the demand is in excess of the flow of the river at the moment.

Reservoirs (storage)

During the rainy season water is stored in reservoirs that it can be utilized during other seasons to supplement the flow of the river whenever the flow of the river falls below a specific minimum. Power can be generated directly from the reservoir. Sometimes canal are constructed to convey water from the reservoir for irrigation purposes.

In-stream

When the velocity of water i.e. kinetic energy following in the stream is used for conversion into electrical power, then the system is known as In-stream.

Pumped Storage

Water after working in turbines is stored in the tailrace reservoir. During low load, say night time, the water is pumped back from the tail to the head reservoir drawing excess electricity from the grid or from the nearby steam plant. During peak load, this water is used to work on turbines to produce electricity. It is always economical to run the steam power plants all the times at full plant capacity factor. Whenever the load demand is less than the full plant capacity, the surplus energy instead of being wasted is transmitted to pump is installed at the tailrace of the hydroelectric plant. And the advantage of this plant can be summarized as follows:

a) Substantial increase in peak load capacity at low cost
b) High operating efficiency
c) Better load factor
d) Independence of stream flow conditions

Advantages and Disadvantages of Hydroelectricity

One of the effective methods of producing power is through the use of streaming or falling water. This can be harnessed through the construction of dams across rivers. This process is referred to as hydroelectricity. The principle will utilize the constant flow of water in order to move the turbines, which enable the use of the flowing water's kinetic energy. As a result, the magnets in the generator will rotate and produce electricity. The water that gets out of the turbine will be returned to the stream found under the dam. Despite the fact that this technology is not capable of emitting greenhouse gases, there are issues causing it to be on the headlines. Many are concerned that blocking the rivers by building huge dams can have severe social and environmental impact. Some of the issues include blocking of passage for migratory fish, changing of the river's normal flow, and increasing possibility of earthquakes and displacement of communities within the area. Many companies are now looking at the potential to utilize water resources to power up their facilities. Consequently, this option has been criticized by local communities as it can disrupt the normal ecosystem. Hence, when considering hydroelectricity, it is important to look at the positive and negative effects that it entails. To begin with, here are a few points to ponder from the list of pros and cons of hydroelectricity as stated below [5].

List of Pros of Hydroelectricity

It is Renewable

Since this method uses water from the earth to produce electricity, the resource is renewable. Naturally, water that evaporates from the surface of the earth will form clouds and eventually falls back to the earth formed as snow or rain. This means that it will never have to run out of supply and it will not become scarce.

Source of Clean Energy

Basically, hydroelectric power is a clean and green alternative source of energy. In fact, the creation of hydroelectricity will not cause any contamination. Moreover, it will not produce any greenhouse gases or toxins that will pollute the environment.

It is stable and Reliable

This type of energy source is considered dependable as there are no issues so far as electric power generation is concerned. Many countries with huge hydropower potential utilize hydroelectricity as their main energy source.

Requires Low Operating Cost

The good thing about hydroelectricity when it comes to cost is that it requires low maintenance and operating cost. It also requires minimal replacements due to the fewer parts that are present in it. More so, the dams built in these locations have been designed for long-term use. Hence, these facilities will be capable of providing hydroelectric power for a long period of time.

Matches Current Demand

Altering the water streams, creating dams, and getting power can be easier said than done. However, it is not very hard to get going. Once the establishment is in place, it will be easier to deflect the flow of water from one place to another. For instance, if the demand for water is low in a particular area, it will be lowered, redirected and stored until the need arises.

List of Cons of Hydroelectricity

Causes Environmental Damage

Due to the interruptions in the natural flow of water, there are many identified results that can affect the environment. Consequently, it can influence the movement of fish as they move or migrate. This is because fish environments can be influenced with a number of factors, including safe spots, water levels, and water speed. When one of these factors will be altered, there can be a possible interruption in the ecosystem for sure.

Cost of Building is Expensive

Undoubtedly, power plants are very expensive to create, regardless of the type of building. Although hydroelectric power plants are not that complicated to build, it may still require a huge amount of money to begin with. The only advantage is that it will not require specialists to maintain or support personnel that need to be paid large sums of money. So perhaps it will make a good investment to think it can provide an essential source of energy.

May Cause Droughts

A great possibility that happens when building hydroelectric power plants is the occurrence of local droughts. The cost of energy and power are identified depending on the accessibility of water. This can be greatly influenced by a dry spell, causing people not to acquire the power they need.

Floods in Lower Areas

Local populations in low lying locations can become victims of floods due to possible strong water currents that might be released from the dam. More so, it can affect the livelihood of people living in these areas. As a result, more people are then forced to move out to pursue the construction of the dams needed for generating hydroelectricity.

Shortage of Water Supply

Huge dams are built across rivers in countries rich with potential hydroelectric power source. This can cause the interruption of the natural flow of water from one direction to another. When one location does not require too much water supply, it will be redirected to another place so that those looking to build dams in the area can get the much needed water. However, it can cause conflict in the long run when there is scarcity of water supply in that particular area and the water redirected to the dams must be stopped.

Final Thoughts

Building dams in certain locations with potential for hydroelectric power can pose a lot of challenges. Although hydroelectric power plants can be good alternative sources of energy for everybody, there are issues that can hinder their creation. For this reason, it is essential to equate the pros and cons of hydroelectricity when planning to build one. Of course, it can't be denied that there should always be a gamble when trying to start something new. But perhaps local statistics must be carefully analyzed first before trying to build a revolutionary structure in the community. At least it should comply with safety requirements and should not compromise the environment and the people living within it [6].

Types of Dams

Dams can be classified according their purposes, the type of materials used in its constructions, and their geometry. all though each situation demands a unique proposal for the type of dam, but a broad classification based on the construction material can be made in dividing the types of dams that have been commonly constructed as embankment dams, which are constructed of earth fill and/or rock fill, and concrete dams, which are constructed of mass concrete [7].

Embankment Dams

These can be defined as dams constructed of natural materials excavated or obtained from the vicinity of the dam site. The materials available are utilized to the best advantage in relation to their characteristics as an engineered bulk fill defined zones within the dam section. The natural fill materials are placed and compacted without the addition of any binding agent. Two main types of embankment dams that are commonly constructed include the following

Earth-Fill or Earthen Embankments

These may be classified as dams use compacted soil for constructing the bulk of the dam volume. An earth fill dam is constructed primarily of selected engineering soils compacted uniformly and intensively in the relatively thin layers and at a controlled moisture content. Some of the common sections designed for earth fill embankment dams are:

Rocks-Fill Embankments

In these types of dams, there is an impervious core of compacted earth fill or a slender concrete or bituminous membrane but the bulk of the dam volume is made of coarse grained gravels, crushed rocks or boulders. The stability of the outer shell of a rock fill dam relies on the frictional forces acting in between each rock gravel piece which ensures its safety against sliding kind of failure during earth quakes.

Concrete Dams

The use of mass concrete in dam construction started from about 1900 for reasons of ease of construction and to suit complex designs, like having spill way within the dam body. From about 1950 onwards, mass concrete came to be strengthened by the use of additives like slag or pulverized fuel ash, in order to reduce temperature induced problems or avoid undesirable cracking or to reduce the total cost of the project. Amongst concrete dams, too, there are many varieties, the principal types are :

Gravity Dams

A gravity dam is one which depends entirely on its own mass for stability. The basic gravity profile is triangular in shape, but for practical purposes, is modified at the top. Some gravity dams are slightly curved in plan, with the curvature being towards the river upstream. It is mostly due to aesthetic and other reasons, rather than having an arch action for providing greater stability.

Buttress Dams

This type of dams consists of a continuous upstream face supported at regular intervals by buttress walls on the downstream side. These dams are generally lighter than the solid type of dam but likely to induce slightly higher stresses at the foundation since most of the load now passes through the buttress walls and not spread uniformly over the foundation as in a solid gravity dam.

Arch Dams

These types of dams have considerable upstream curvature in plan and rely on an arching action on the abutments through which it passes most of the water load on to the walls of the river valley. This type of dam is structurally more efficient gravity dams and greatly reduces the volume of concrete required. Of course, a prime necessity in constructing an arch dam is to have sound foundation and abutments.

Selection of Dam Type

As far as technical feasibility is concerned, often more than on type of dam is adequate for a selected dam site location. The final selection, then, is either based on economic considerations, on preferences of designer or owner or on the decision of a consulting board. Following is a list of factors which the dam designer must consider in selecting the most appropriate structure for a site [8]:

a. Topography

Narrow valleys with high rock abutments favor concrete dams; low rolling hills favor earth dams. Hydraulic fill dams are frequently associated with wide, flat alluvial plains with minimal topographic relief.

b. Dam Foundation

Rock foundations, properly cleaned of weathered material and treated for water tightness, are ideal for any type of dam. Dense sand-and-gravel foundations are adequate for all embankment damps, and for small concrete dams when proper seepage control measures are implemented.

Compressible silt and clay foundations preclude the consideration of concrete dams and require special care for rock fill dams. Loose sand foundations in a seismic environment are subjected to potential seismic liquefaction and are adequate for any type of dam. If the loose materials are excavated for their physical conditions improved, then an embankment dam could be considered.

c. Availability of Construction Materials

Materials are required for the construction of the embankment (core, shells, filters, slope protection) and manufacture of concrete. When adequate materials are available near a site, embankment dams can usually be built at a lower cost than concrete dams. Availability of sands and gravels, but absence of impervious clays may favor the choice of a concrete dam. On the other hand, if an impervious soil is readily available, the design may favor a homogeneous embankment dam with a few internal granular filters provided for seepage control.

d. Flood Hazard

The possibility of flooding during construction favors either a concrete type of dam or a rock fill dam with or without downstream reinforcing. Associated with flooding is the spillway requirement. Often the cost of constructing a spillway is high. For such cases, combining spillway and dam into one structure (concrete dam) may be advantageous. In other cases, where the excavated material from a separate spillway can be used in the construction of the embankment, an earth fill embankment may be advisable.

e. Seismic Hazard

Potential fault rupture along the dam foundation precludes the consideration of any rigid structure such as a roller-compacted or a concrete-type dam, Embankment dams with large zones of sand and gravel are recommended in these cases. Potentially strong earthquake ground motion may rule out the consideration of rigid structures (concrete) or embankment dams built with loosely placed granular soils (hydraulic and tailings dams).

f. Construction Time

When construction time is limited, it is often necessary toadopt a structure which is not necessarily the most economical; for example, a dumped--rockfill rather than a smaller concrete structure, or flatter homogeneous clay dam rather than a zoned embankment.

e. Climate

Construction of embankment dams during the rainy season is often limited to the pervious zones, making rock fill dams more appropriate. During freezing weather, precautions must be taken to avoid damage to freshly poured concrete in concrete dams. Rock fill dams may prove to be cheaper to construct in severe climates.

f. Diversion Works

Valley configuration, hydrologic, and schedule considerations can often pose serious construction difficulties which require expensive works.

g. Government Regulations

Federal and state governments have issued regulations relating to the construction and operation of dams. The safety, the environmental impact, and the purpose of the dam, as judged by the public agencies, will often suggest the most suitable type of structure for any given set of circumstances.

h. Available Resources

At some sites, neither skilled contractors for a specified construction nor adequate labor force may be available. For example, a country may have neither the experience nor the equipment necessary for the construction of a roller-compacted concrete dam or for the concrete face in a rock fill dam. In such cases, a simpler earth embankment dam may be more appropriate. The numerous factors influencing the selection of the type of dams that have been discussed clearly indicate that such selection is far from easy and that no general rules can be advanced to aid the designer in this task. However, experience accumulated in years of practice has indicated the following comparison between the advantages and the disadvantages of dams.

Mechanism of Work

As it mentioned that hydropower plant is a system with three parts: a power plant where the electricity is produced; a dam that can be opened or closed to control water flow, and a reservoir (artificial lake) where water could be stored. Energy from the sun evaporates water in the Earth’s oceans and rivers and draws it upward as water vapor. When the water vapor reaches the cooler air in the atmosphere, it condenses and forms clouds. The moisture eventually falls to the Earth as rain or snow, replenishing the water in the oceans and rivers. Gravity drives the moving water, transporting it from high ground to low ground. The force of moving water can be extremely powerful and that is might be used to manage turbines.

Catchment Area

The whole area behind the dam draining into a stream or river across which the dam has been constructed is called the catchment area. The characteristics of the catchment include its size, shape, surface, orientation, altitude, topography and geology. The bigger the catchment, steeper is the slope, higher is the altitude, and greater is the total runoff of water.

Reservoir

Artificial or natural inland body of water used to store water to meet various demands. Where the storage is to be during times of plenty for subsequent use in times of scarcity is fundamental to the efficient use of water resources. The water has being managed by reservoir.

Dam

Dams are detention structures use for storing water of streams and rivers. The water stored in the reservoir created behind the dam may be used gradually depending on demand. This definition implies no restrictions upon the purpose, material used, or size of the dam. Thus barrier sills and weirs could also be covered under the general umbrella provided by word "dam", in practice however, dams are considered barrier structures, more complex than sills and weirs, and they requires for their design, construction, operation, and maintenance the concerted effort of a number of technical disciplines.

Spillways

Spillway is a channel that carries excess water over or around a dam or other obstruction where it is a structure used to provide the controlled release of flows from a dam or levee into a downstream area, typically the riverbed of the dammed river itself, sometimes they may be known as overflow channels. Spillways ensure that the water does not overflow and damage or destroy the dam. The spillway is designed to pass flows larger than can be used for hydroelectric generation. The importance of the spillway cannot be overemphasized. Most dam failures have occurred because the spillway was incapable of passing a particular flood, with the result that the dam was overtopped and breached. Many spillways with adequate capacity have failed because severe erosion occurred at the base of the spillway, resulting in damage to the spillway, the dam, or both.

Conduits

It is channel for conveying water or inverted siphons to carry flow under railways and highways.

Surge Tanks

Surge tank (or surge chamber) is a device introduced within a hydropower water conveyance system having a rather long pressure conduit to absorb the excess pressure rise in case of a sudden valve closure. It also acts as a small storage from which water may be supplied in case of a sudden valve opening of the turbine. In case of a sudden opening of turbine valve, there are chances of penstock collapse due to a negative pressure generation, if there is no surge tank.

Penstock

Penstock is a steel or reinforced concrete conduit to resist high pressure in the water conveyance system and may take off directly from behind a dam, from a fore bay, or from the surge tank end of a head race tunnel penstocks.

Draft Tubes

A bulkhead gate used to permit dewatering of the draft tubes for inspection and repair of turbine parts and draft tubes. And it is at the end of the turbine increases the pressure of the exiting fluid at the expense of its velocity. This means that the turbine can reduce pressure to a higher extent without fear of back flow from the tail race. At the bottom, the water passage bends up from vertical to a horizontal alignment, and this passage is known as the draft tube. The functions of a Draft Tube are two-fold: (a) Achieves the recovery of velocity head at runner outlet, which otherwise would have wasted as exit loss, and (b) Allows the turbine to be set at a higher elevation without losing advantage of the elevation difference. The second objective allows easier inspection and maintenance of the turbine runners.

Powerhouse

The powerhouse of a hydroelectric development project is the place where the potential and kinetic energy of the water flowing through the water conducting system is transformed into mechanical energy of rotating turbines and which is the further converted to electrical energy by generators. In order to achieve these functions, certain important equipment's are necessary that control the flow entering the turbines from the penstocks and direct the flow against the turbine blades for maximum efficient utilization of water power. Other equipment's necessary are couplings to link the turbine rotation to generator and transformers and switching equipment to convey the electric power generated to the power distribution system. The major equipment in the powerhouse is the turbine-generator unit. The remainder of the equipment serves to control, protect, and provide services to the main unit; the powerhouse provides support and housing for the turbine-generator unit and all auxiliary equipment. The powerhouse is located at the end of the waterway and as low as possible below the elevation of the reservoir water. This gives the maximum possible head for the turbine.A powerhouse also accommodates equipment that is necessary for regular operation and maintenance of the turbine and power generating units. For example, overhead cranes are required for lifting or lowering of turbines and generator during installation period or later for repair and maintenance. For the crane to run, guide rails on columns are essentially required. The maintenance of a unit is done by lifting it by the crane and transporting it to one end of the power house where abundant space is kept for placing the faulty unit. A workshop nearby provides necessary tools and space for the technicians working on the repair of the units.The general types of powerhouses in use are indoor, semi outdoor, outdoor, and underground. The indoor powerhouse contains the turbine-generator unit and all auxiliary equipment under a roof. The building is of sufficient height to permit the handling of equipment by means of an indoor crane. In the semi outdoor plant, the generator floor is fully enclosed, but the equipment is handled by an outdoor gantry crane or mobile crane through hatches in the roof. The outdoor powerhouse usually has the generator in a steel cylindrical housing set on top of the powerhouse structure that contains the turbine and powerhouse equipment. The cylindrical housing takes the place of a superstructure. The equipment can be handled by either a gantry crane or a mobile crane. Underground powerhouses are usually associated with large hydro generation units and pumped storage units. The rock shell is formed by the excavation from the walls and roof of the powerhouse. The type of powerhouse selected is based upon an economic analysis which conseillers first costs and operation and maintenance cost. And following is a list of auxiliary equipment and system usually required for a power house.

a. Electrical Systems

• Main control board
• Generator excitation equipment
• Station service switchgear
• Storage battery and charger
• Generator voltage switchgear, buses, and surge equipment
• Generator neutral grounding equipment
• Lighting
• Cable trays
• Grounding mat

b. Mechanical Systems

• Turbine governing equipment
• Water supply system for cooling and service
• Lubricating oil and/or hydraulic oil
• Heating, ventilating, and air conditioning
• Compressed air
• CO_2 fire protection
• Dewatering, building, and sanitary drainage
• Lifting
• Turbine shutoff valve
• Draft tube gates

c. Switchyard

• Transformer
• Circuit breakers
•Takeoff structure

Turbine

Because this form is the prime mover which transforms the energy of water into mechanical energy of rotation and whose prime function is to drive a hydroelectric generator thus would be discussed in details. The turbine runner and the rotor of the generator are usually mounted on the same shaft, and thus the entire assembly is frequently referred to as the turbo-generator. Hydroelectric plants utilize the energy of water falling through a certain difference in levels which may range from a few meters to 1500m or even 2000m. To handle such a wide range of pressure heads, various turbines differing in design of their working is employed. Modern hydraulic turbines are divided into two classes - impulse and reaction. An impulse turbine is one in which the driving energy is supplied by the water in kinetic form, and a reaction turbine is one in which the driving energy is provided by the water partly in kinetic and partly in pressure form. For the reaction type of turbine, the turbine section is assumed to begin at the entrance to the turbine case and end at the exit from the draft tube. It may be noted that this setting for a reaction turbine ensures the following characteristics:

1. The wheel passage remains completely filled with water.
2. The water acting on the wheel vanes is under pressure greater than atmospheric.
3. The water enters all-round the periphery of the wheel through the scroll case.
4. Energy in the form of both pressure and kinetic is utilized by the wheel.

For the impulse type turbine, the following characteristics of the turbine setting differentiate it from the impulse type of turbines:

1. The wheel passages are not completely filled with water since a jet emanating from the penstock nozzle strikes the buckets of the runner
2. The water acting on the vanes or buckets located at the wheel periphery is under atmospheric pressure
3. The water impacts on the runner at one point or at a few discrete points, depending upon the number of nozzles.

There are a variety of types of turbines used at hydropower facilities, and their use depends on the amount of hydraulic head (vertical distance between the dam and the turbine) at the plant. The most common are Kaplan, Francis, and Pelton wheel designs. Some of these designs, called reaction and impulse wheels, use not just the kinetic force of the moving water but also the water pressure.

Tailrace

The water after having done its useful work in the turbine is discharged to the tailrace which may lead it to the same stream or to another one. The design and size of tailrace should be such that water has a free exit and the jet of water, after it leaves the turbine, has unimpeded pas-sage.

The gravitational potential energy stored in the water is used to turn generators and create electricity. Electrical generators are turned by massive turbines, which are within tunnels in the dam wall-water flows through the tunnels with great pressure due to the great height, at which is kept in the dam. If there is a greater volume of water or there is a very large difference between the water level and where it flows out, then more power comes out of the water as it has greater potential energy. For example: Hydro power generation works well in mountainous countries as the water can be stored at very high pressures. The dam wall increases with width as you go down towards the base this is because the water pressure gets greater as depth increases. This difference in height of the water is called the head. The generator contains two main parts: the rotor and the stator. The rotator is the part which rotates and the wire has a huge magnet inside of it; and the stator is the part which is covered in copper. The electrical current is created when the rotor spins around the copper wire on the stator. This is the charge which is then used as electricity. Thus the following steps could be sufficient to know the mechanism of hydropower plant work.

1. Water in a reservoir behind a hydropower dam flows through an intake screen, which filters out large debris, but allows fish to pass through.
2. The water travels through a penstock.
3. The force of the water spires a turbine at a low speed

4. Inside the generator, the shaft spins coils of copper wire inside a ring of magnets. This creates an electric field, producing electricity.
5. Electricity is sent to a switchyard, where a transformer increases the voltage, allowing it to travel through the electric grid.
6. Water flows out of the penstock into the downstream river.

Hydropower can also be generated without a dam, through a process known as run-of-the-river. In this case, the volume and speed of water is not augmented by a dam. Instead, a run-of-river project spins the turbine blades by capturing the kinetic energy of the moving water in the river. Hydropower projects that have dams can control when electricity is generated because the dams can control the timing and flow of the water reaching the turbines. Therefore these projects can choose to generate power when it is most needed and most valuable to the grid. Because run-of-river projects do not store water behind dams, they have much less ability to control the amount and timing of when electricity is generated [9, 10].

Advantages and Disadvantages of Hydropower Development

It is obvious that hydropower development is a renewable energy source, and that its renewability is a significant advantage. The hydropower development occurs at existing dam sites; the environmental impact is minimal or nonexistent. However, keep in mind that significant changes can occur when an existing dam site is developed for power generation for example, water that would normally flow over a spillway, where a large amount of aeration would take place, is now funneled through turbines, where little-or no aeration occurs. The resulting substantial difference in the rate of aeration at a given point in the river can have a notable influence on the dissolved oxygen content of a considerable reach of river. In certain areas, especially those near large municipalities, the environmental impact can be significant. While the fuel costs of hydropower plants are negligible, their construction and capital equipment costs are usually substantially greater per unit of installed capacity than those of thermal power plants. This can be seen as either a benefit or a detriment. The economic feasibility of hydropower development is very sensitive to the difference between a discount rate, used to bring future income and costs to present value, and an assumed escalation rate, used to predict the future cost of electricity. The discount rate is taken as the loan interest rate, which is usually fixed. The escalation rate is an estimate, which can vary greatly. In a period of escalating inflation, for example, a hydroelectric project which is already in place looks like a very good investment. When considering hydropower development within a given region, it is also important to look at the overall economics of that region. For example, it should be noted that hydropower development means that a substantially larger percentage of the investment capital can stay within a given region, since much of the developmental work can be done by local engineers and contractors. The more sophisticated coal-fired and nuclear power plants are designed and built by specialized constructors, which often means that large amounts of capital leave the local economy. In many instances, the same is true for the amount of capital necessary for fuel for thermal power plants. This substantial drain on the economy can be very significant. There are other advantages of hydropower, and especially of small hydropower. Many future possibilities in small hydropower development will depend on the economic climate. There is a definite market for small turbine technology. Should this market be developed, it can be expected that significant improvements, both in operational characteristics of turbines and in reduced cost, can lead to small hydropower facilities being more cost-effective. Cost savings of approximately 30 percent have already been realized in Europe by utilizing modular construction for small hydropower facilities. There are many other aspects of small hydropower that have not been explored is yet. In many cases in developing nations, the small hydropower station becomes the catalyst for the development of small manufacturing facilities. One case in point is electrolytic manufacturing of fertilizer. It should also be pointed out that the current mini processor technology has developed to the point that it is feasible to operate a system of small hydropower plants on a completely automated basis, with only a traveling crew of workers needed for maintenance. In some cases, the number of small sites that are developable could supply the same amount of power as one large nuclear power plant, without the safety or security hazard normally involved with a large-scale development, If the total amount of power is distributed over several small plants, overall reliability can increase, since it is very unlikely that all plants would suffer an outage at the same time. There are, however, also several disadvantages to small hydropower development. The most obvious is the fact that economy of scale does not prevail, these results in high initial cost for a relatively low installed capacity. In many cases, these plants are run-of-river; that is, their capability for generating power fluctuates wildly with the seasons, and this prevents a system of small power plants from acting as an equivalent base-load plant. In many areas of the world, peak power is available in late spring, whereas peak demand occurs in midsummer or midwinter. This mismatch of power need and availability can be quite serious. In addition to the lost economy of scale, there are other disadvantages which relate to the head available. For example, low-head facilities are those in which the available head is less than approximately 66 ft (20 m), since available power is proportional to the product of flow and head, larger amounts of flow must be handled in order to generate a given power level at lower head. This means that the size of the machine increases, producing a disproportionate increase in the cost for the amount of power developed. This problem also places a responsibility on the engineer for extremely careful design of inlet and outlet facilities since hydraulic losses which would be insignificant in higher-head installations become of major concern. It can be said that the escalation of nonrenewable energy production costs, which occurred through the 1970s, has made hydropower more attractive. The future of hydropower development depends greatly on the ability of hydropower engineers to find innovative ways to reduce fixed costs of development while providing for a minimal environmental impact. It is the aim of this handbook to provide the background material for effectively meeting the demand for well-designed economical hydropower facilities [11].

Environmental Impacts of Hydroelectric Power Plants

While hydropower generation does not emit global warming gasses or other air pollutants, the construction and operation of hydropower projects can have environmental and societal consequences that greatly depend on where the project is located and how it is operated. Dams that have flooded areas with live vegetation can emit methane, a powerful global warming gas, as that organic material decomposes. For example, the Tucurui dam in Brazil created a reservoir in the rainforest before clearing the trees. As the plants and trees began to rot, they reduced the oxygen content of the water, killing off the plants and fish in the water, and released large quantities of methane. Hydropower projects can reduce the flows in rivers downstream if the upstream flows are trapped behind a reservoir and/or diverted into canals that take the water off stream to a generation unit. Lowering the flows in a river can alter water temperatures and degrade habitat for plants and animals. Less water in the river can also reduce oxygen levels which damage water quality. Water is typically stored behind a dam and released through the turbines when power is needed. This creates artificial flow patterns in the downstream river that may be very different from the flow patterns a river would naturally experience. For example, rivers fed mostly by snowmelt may experience much higher flows in the winter and spring than the summer and fall. Hydropower operations may differ from these natural flow patterns, which has implications for downstream riparian and aquatic species. If water levels downstream of a hydropower project fluctuate wildly because of generation operations, fish could be stranded in suddenly shallow waters. If operations cause a more static flow schedule throughout the year than what the river would normally experience, the movement of sediment along a river section could be disrupted, reducing habitat for aquatic species. Fewer seasonal flow events could also cause a riparian corridor to thicken into a less dynamic channel as saplings that would usually be seasonally thinned by high flows are able to mature. Dams can also block the migration of fish that swim upstream to reach spawning grounds. In the Pacific Northwest and California, large dams have blocked the migration of Coho, Chinook, and sockeye salmon from the ocean to their upstream spawning grounds. The number of salmon making the journey upstream has fallen 90 percent since the construction of four dams on the lower Snake River. Some steps are being taken to move fish around the dams, such as putting them in barges or building fish ladders, but success has been limited. Downstream fish passage can also be a challenge since young fish can be chewed up in the turbines of the dam as they head towards the ocean. The flooding of land to create reservoirs can also eliminate areas where people live or grow crops. The Balbina dam in Brazil, for example, flooded 2,360 square kilometers, an area the size of Delaware. Population density is typically higher along rivers, leading to mass dislocation of urban centers. The Three Gorges Dam in China dislocated nearly 1.2 million people. Wildlife habitats destroyed by reservoirs can be especially valuable. In South America, 80 percent of the hydroelectric potential is located in rain forests, one of the most rich and diverse ecosystems on Earth. The Rosanna dam in Brazil destroyed one of the few remaining habitats of the black-lion tamarind, a rare and beautiful species of long-haired monkey [12].

Economic Impact of Hydropower

Economy is the main principle of design of a Hydropower plant. Hydropower plant economics is important in controlling the total power costs to the consumer. Power should be supplied to the consumer at the lowest possible cost per KWh. Hydropower is the only renewable energy technology that is commercially available on a large scale. The reason being is hydropower plants have no such byproducts like high content of sulphur because the whole process of electricity generation from water input through the turbines and water output do not change the nature of the water, hence, saving expenses on sustaining a clean environment. Also, the electricity generation efficiency (the ratio between the useful output of an energy conversion machine and the input, in energy terms) of hydropower is the highest, which led to being one of the lowest cost of electricity. Hydropower has been using in thirty country worldwide and its production is estimated at 1/5 total global production with 90% efficiency. The greatest benefit from the hydropower program is the abundant low-cost energy the projects contribute to electric power grids. Because hydroelectric power plants burn no fuel, operating costs are low and are immune to rising fossil fuel prices, when construction costs were low. As a result, these plants are playing a significant role in keeping electricity costs affordable for consumers, creating a positive impact on the economy [13, 14].

Conclusion

Hydroelectric power is one of the leading renewable energy sources in the world and the case is no different in Sudan. This is considering its many benefits and the distribution of the economically feasible hydropower resource. It provides the low cost in generation, maintenance and flexibility in supply according to the demand. Hydropower is the one of the best renewable energy in terms of satisfying the energy need in a larger scale and in terms of the opportunity it provides for implementing adequate mitigation measures for its negative effectives.

Sudan has entered into a period of rapid economic drop in early decades. The country has prepared plan and strategy to guide the economy into a sustainable path but energy had been forgotten, where the energy sector since it is the main sector that is of due importance to make sure the continuing growth of the economy, especially like inexpensive hydropower. Where Sudan has a lot of areas and a lot of rivers and large water resources if it used, it could be insure of a country future. And now Sudan is so needy to use these graces. If this resource tapped it can provide not only hydroelectric power but could also be a source of social, economic and environmental development by providing various additional services such as navigation, tourism, irrigation in case of multipurpose hydropower projects. Exploiting this resource brings various social and economic advantages to the country which might not be possible without it. This helps to compensate any detrimental effects these projects might have most importantly hydropower holds the key to making the country's dreams in terms of satisfying the energy demand along with building a zero net emission economy, where the social and economic development targets stated on the development plans are a reality.

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