Sector: Energy	
Sub-Sector/Technology Option: Hydropower	
Technology Application: Large hydropower plants (over 5MW[32]) to support national energy demands.	
Introduction Worldwide, hydropower is the single largest source of renewable energy in the electricity generating sector. This renewable energy source is found to be cost-effective, reliable and most technically matured with rapid deployment. Additionally, installation of hydropower facilities can deliver co-benefits beyond the energy sector since it does not only provide energy management but water management services (flood & drought control) and supports tourism. Guyana has a high dependence on imported petroleum-based products to service its energy needs. The electricity generating power sector is now the second largest consumer of imported fossil fuels products (31% in 2013) (GEA, 2014; 2015). Moreover, the industrial and residential consumers, accounted for 33% and 37% consumption in 2013 respectively, of electricity generated using fossil fuels (GEA, 2015). Hydropower has the potential to make significant contribution towards Guyana's energy needs, diversify its energy mix and increase its energy security.	
Technology Characteristics	
Features	Hydropower can be classified by head (difference between the upstream and downstream water levels), size (based on installed capacity) and facility type. The main types of hydropower (based on facility type) are run-of-river, reservoir (storage hydropower), pumped storage and in-stream technology. Guyana considers a capacity over 5MW as large hydropower. The most common type of hydroelectric power plant is the storage or reservoir hydropower. This kind of system uses a dam to store water in a reservoir and electricity is produced when water is released from the reservoir to spin the turbine that activates a power generator. Electricity generated by the hydropower facility depends on the 'head' or the vertical distance through which the water falls and the flow rate (measured as volume of water per unit time). Power plants with 'high head' are usually most common, storing water at an increased elevation. The reservoir is also used to store water during the rainy season and can be released during dry periods.

[31] IRENA categorizes small hydropower projects with an installed capacity of up to 20MW (IRENA 2013).
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	The key components of a typical reservoir-type hydropower plant include dam, storage or reservoir, water tunnel, powerhouse, turbine generators, on-site electrical substation and switchyard and ancillary components including electrical inter-connection system to connect to the national grid.
Capital Investment Cost	Investments costs include (i) construction costs, (ii) costs related to electromechanical equipment for energy transformation, (iii) costs associated with planning, environmental assessments, permitting, historical and water quality monitoring and mitigation (Kumar *et al*, 2011), (iv) equipment costs, (v) owners costs (IRENA, 2015). Construction costs are usually site specific based on characteristics of topography, geology and the construction and design of project. These costs could lead to different investment costs and levelized cost of electricity (LCOE) for projects with same capacity. Costs associated with electromechanical equipment follows the international price trend for components (Kumar *et al*, 2011). For hydropower projects where the installed capacity is less than 5MW, the electromechanical equipment costs dominate and, in general, as the capacity increases the costs are increasingly influenced by the costs of construction (Kumar *et al*, 2011). According to the Intergovernmental Panel on Climate Change (IPCC) the average recent investment costs for storage (reservoir) hydropower projects is USD 1000 to 3000/kW[33] (Kumar *et al*, 2011). According to IRENA (2015), the levelised cost of electricity (LCOE) for hydropower ranged from USD0.02/kWh to USD0.35kWh[34].
Operating Cost	The IPCC posits that operation and maintenance costs were found to be low and typically averaged around 2.5 % of investment cost (per kW) (Kumar *et al*, 2011). This cost excludes equipment replacement and/or refurbishment.
Maturity	Hydropower is being deployed rapidly and is technically a mature, predictable and typically a price-competitive

[33] This figure was computed based on a number of assessments conducted for the IPCC.

[34] This range was computed based on data collected from 2,444 hydropower projects contained in the IRENA Renewable Cost Database for projects commissioned and proposed. It should be noted that the local market, structure of the power generation system, grid capacity, grid provisioning services, number of kilowatt hours generated relative to investment are some of the factors that can impact the overall cost of the investment, (IRENA, 2015).

	technology. This technology is well-advanced with more than a century of experience.
Country Specific Applicability	
Status of technology in country	Even though hydropower is not new to Guyana, the country, currently, has no operational plants. The first hydropower plant was constructed in 1957 using the Tumatumari Falls on the Potaro River with an installed capacity of 1500kW using two (2) 750kW turbines to provide electricity to the British Guiana Goldfields Ltd mining operation (GEA, 2014). Subsequently, a 0.5 MW run-of-river hydropower was constructed in 1999 using the Moco Moco Creek to service the Lethem community, Region 9, but this site too is now defunct (GEA, 2014). Plans are in place to rehabilitate both sites. A number of studies, potential site assessments and feasibility studies were conducted over the years. It was found that Guyana has significant potential to develop hydropower as a source of energy for electricity generation and a number of initiatives are being explored. These include (i) further site assessment to identify critical potential sites; (ii) construction of a 330kW run-of-river hydropower station at the Chiung River, Kato; (iii) exploring a 60MW hydropower project on the Kurupung River; (iv) development of a large hydropower plant; (v) feasibility assessment of a possible energy transmission system for electric interconnection with Guyana, Suriname, French Guiana and Northern Brazil (GEA, 2014). In 2012, Guyana signed a Memorandum of Understanding with Brazil establishing a working group to conduct feasibility studies for the development of the 4,500MW hydropower project in the Upper and Middle Mazaruni area, intended for energy exports to Brazil and potentially for industrial development. In addition to the Amaila Falls projects, other planned hydropower development projects include the rehabilitation of the Moco-Moco and the Tumatumari hydropower stations.
Market potential	The technology is commercially viable on a large scale and is found to be the least costly technique of storing large quantities of energy. The technology also allows for adjustments in the quantity of electrical energy produced to that demanded by consumers.
Scale of application and time horizon	Medium to Long Term
Institutional and Organisational requirements	The institutional and organizational requirements for installing hydropower plants are embodied in the mandates of the GEA, the framework of the Ministry of

	Public Infrastructure (responsibility for energy), the Environmental Protection Agency and other natural resource institutions.
Operation and maintenance	Hydropower plants will require lower maintenance comparable to other applications. Installation and operation of these plants will also require training and capacity building to ensure expertise and skills are available locally for maintenance operations.
Scale/size of beneficiary group	The direct beneficiary groups are those connected to the national grid. However, the entire country will benefit indirectly due to reduction of national expenditure on fuel importation for electricity generation.
Acceptability to local stakeholders	The technology is widely accepted by local stakeholders.
Endorsement by experts	The technology is endorsed both by local and international experts.
Barriers and Disadvantages	▪ The legal framework to allow for interconnection to the national grid through power purchase agreement since the local utility company GPL holds a monopoly on the generation and supply of electricity. ▪ Operating hydropower project in a river with large sediment load poses technical challenges – the increases sediment load induces wear on the hydraulic machinery and other structures of the plant. ▪ May entail population displacement or relocation of communities living within or near the reservoir or construction sites. ▪ Environmental and social issues are geographic and site dependent. The construction and installation of hydroelectric power plants will have some impact on the ecosystem, biodiversity and surrounding communities as a result of modification of the natural and human environments for dam storage, transmission and distribution lines and plant operations. ▪ May have water use conflicts in cases where there are competing uses of water. ▪ Modification of volume and seasonal patterns of river flow and changes in water temperature and quality ▪ Need for very long transmission lines to supply the main load centres, as in the case of Guyana.
Mitigation Benefits	
Greenhouse gases abatement potential	Comparatively, hydropower has higher GHG abatement potential than electricity generated using fossil fuels. While GHGs are emitted at the three (3) stages of hydropower plants – construction, operation and maintenance, and dismantling – emissions are expected to be far less when compared to emissions emitted from fossil-based power plants.

Potential Development Benefits: Economic, Social, Environmental	
Economic benefits	▪ Allows for energy diversification and energy security. ▪ Reduce national expenditure on fuel importation for electricity generation. ▪ Energy supply to meet future projected demand.
Social benefits	▪ The operation of hydroelectric plants, and its multi-purpose designs, allow for co-benefits through water management services, such as militating against fresh water scarcity through hydro storage and tourism activities. ▪ Increased employment opportunities.
Environmental benefits	Hydropower is a renewable energy used to generate electricity with less GHG emissions (compared to fossil- fuel based electricity generation).

References:

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