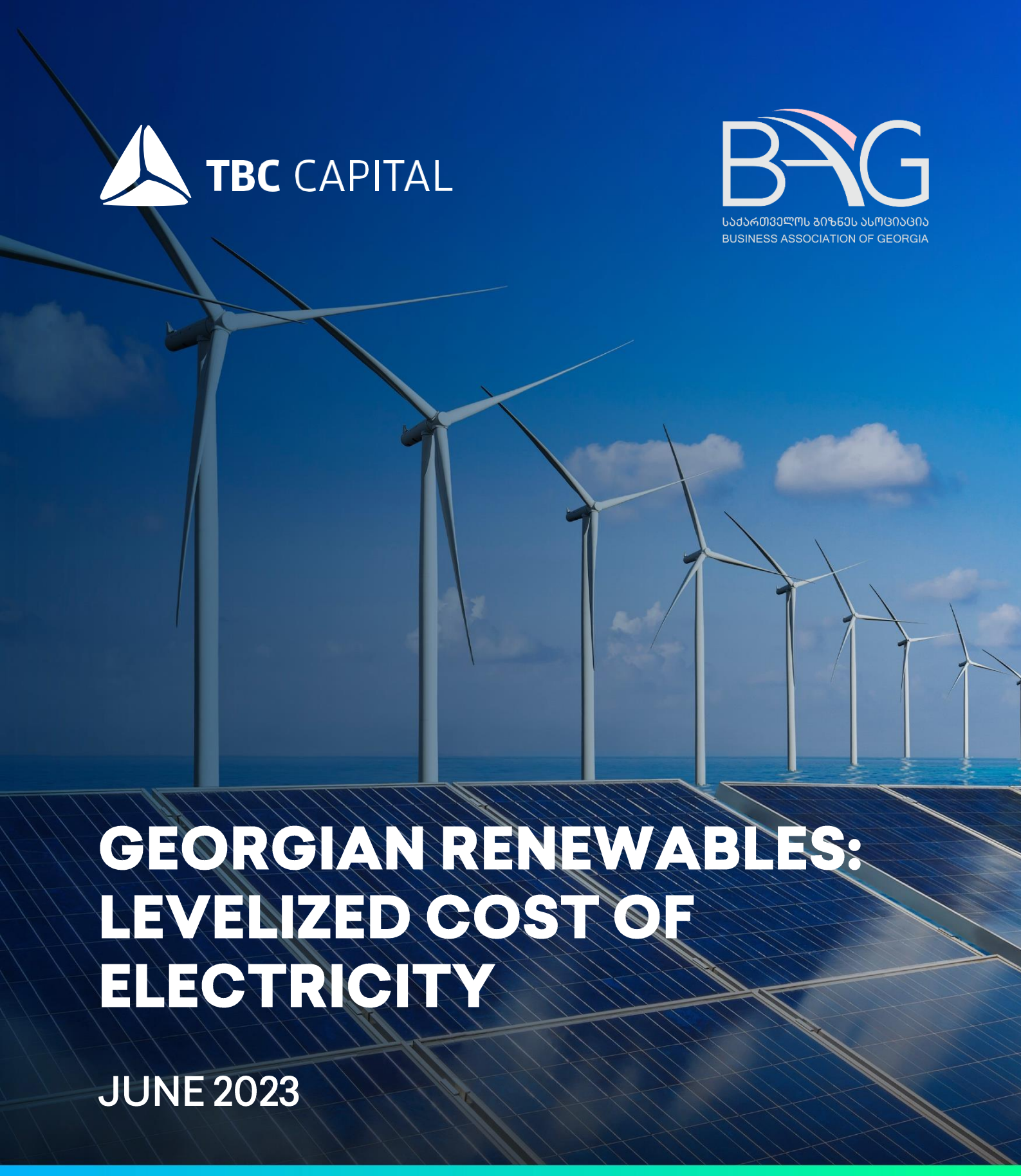

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BUSINESS ASSOCIATION OF GEORGIA

GEORGIAN RENEWABLES: LEVELIZED COST OF ELECTRICITY

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Content

Executive Summary

The levelized cost of electricity is useful in identifying a comprehensive cost of each generated unit of electricity and additionally can be assumed as the price of electricity at which the power plant can financially break even.

The document provides the analysis of the levelized cost of electricity for two types of hydropower plants, the traditional dam based and run-of-river plants, onshore wind power plants, and solar photovoltaic power plants.

The weighted average numbers indicate the highest levelized cost of electricity for dam based hydropower plants at 128.7 USD/MWh, followed by solar plants (96.6 USD/MWh) and onshore wind power plants (83.4 USD/MWh), with run-of-river HPPs having the lowest levelized cost at 71.3 USD/MWh.

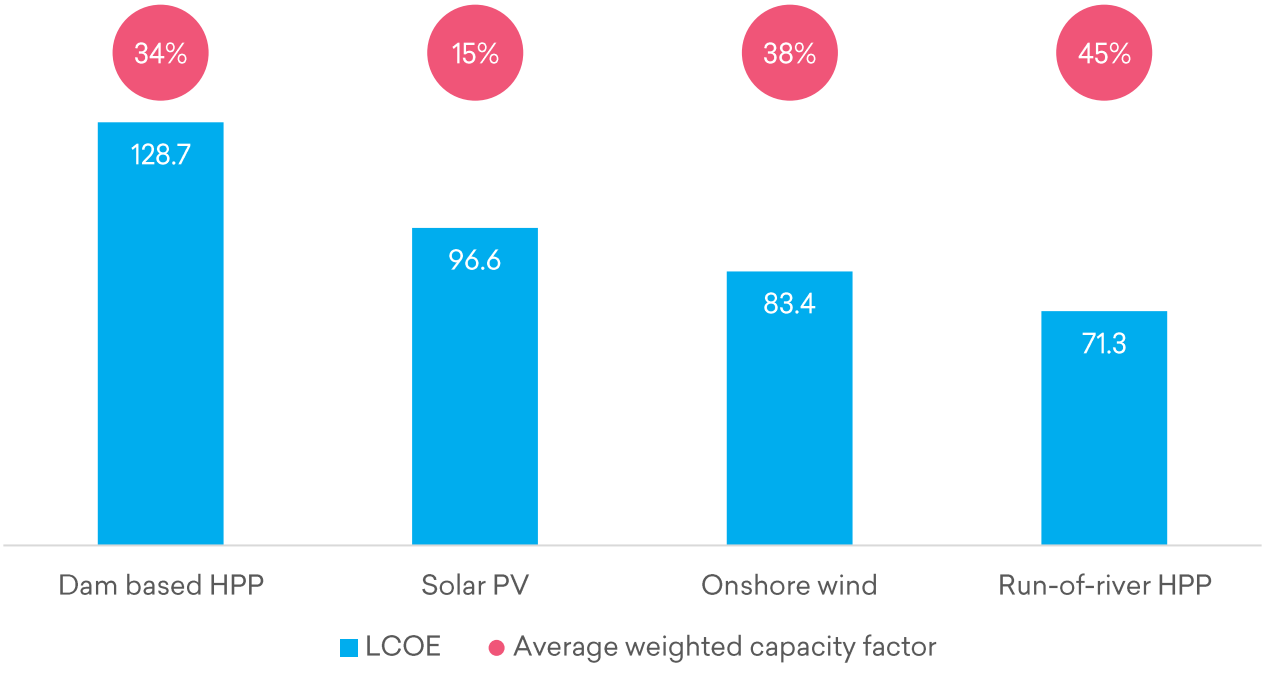
Given the fact that no two project can be identical in terms of the capital and the operational costs or the generated output due to various affecting factors, the results of the levelized cost of electricity analysis in this document are provided as ranges as well as weighted averages for each technology discussed.

The provided breakdown of the calculated levelized cost of electricity between the capital and operational costs offers an understanding of the varying capital intensities of the technologies.

The sensitivity analysis of varying capacity factors has shown that the utilization factor of the power plants are one of the central drivers of the final levelized cost of electricity.

Levelized cost of electricity (LCOE)

USD/MWh



Source: TBC Capital

Hydropower Plants

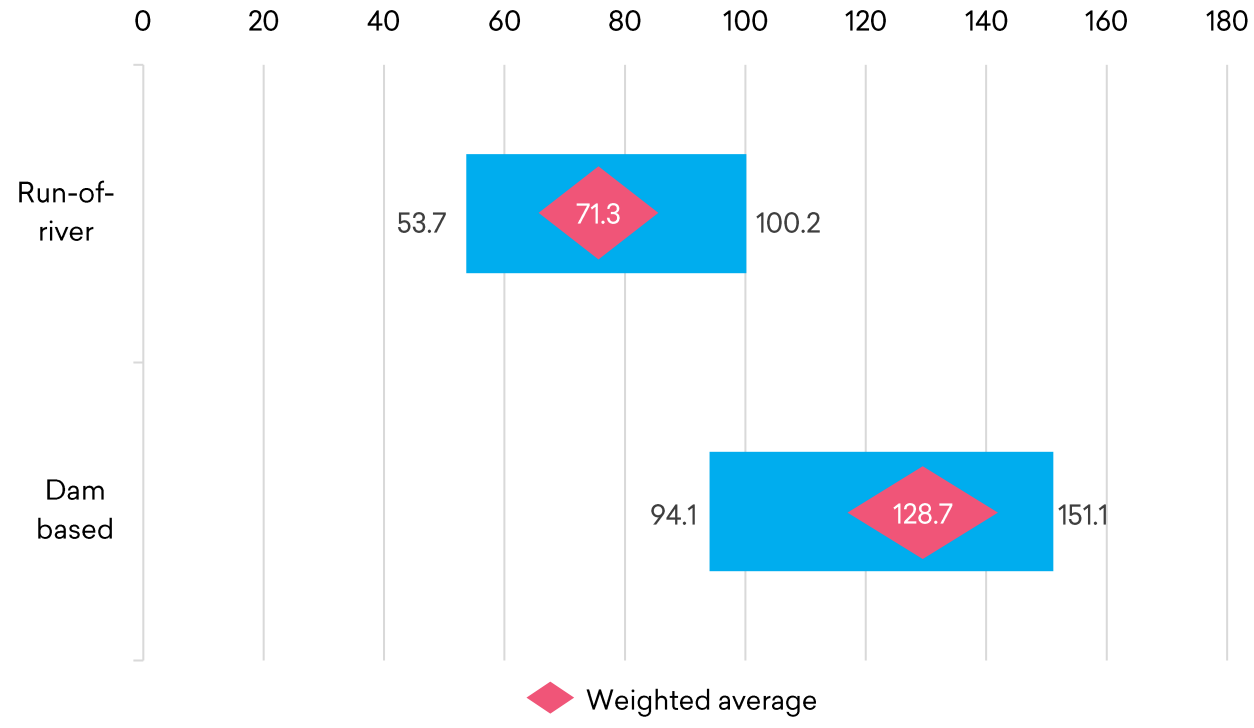
When analyzing the levelized cost of electricity, hydropower electricity generation is further broken down into two groups: the more traditional dam based hydropower and run-of-river hydropower. The diverse capital intensity of the two technologies highly affects the final levelized cost of electricity.

The calculations are based on an assumed average 45 year expected availability of the power plants for dam based plants and 30 years for the run-of-river plants without any additional major capital expenditures. As for the utilized discount rate in the calculations, it is set at annual 12% rate (more details available in the Annex of the document).

The levelized cost of electricity varies from project to project. The LCOE for run-of-river hydropower plants ranges from 53.7 USD/MWh to 100.2 USD/MWh. At 71.3 USD/MWh, the weighted average LCOE of the different results using the installed capacities provides a more uniform picture.

The range of LCOE for the traditional dam based hydropower plants is similarly diverse and ranges from 94.1 USD/MWh to 151.1 USD/MWh. The installed capacity based weighted average LCOE for the technology stands c. 0.8x higher compared to the LCOE of run-of-river hydropower plants at 128.7 USD/MWh.

LCOE ranges for hydropower plants
USD/MWh

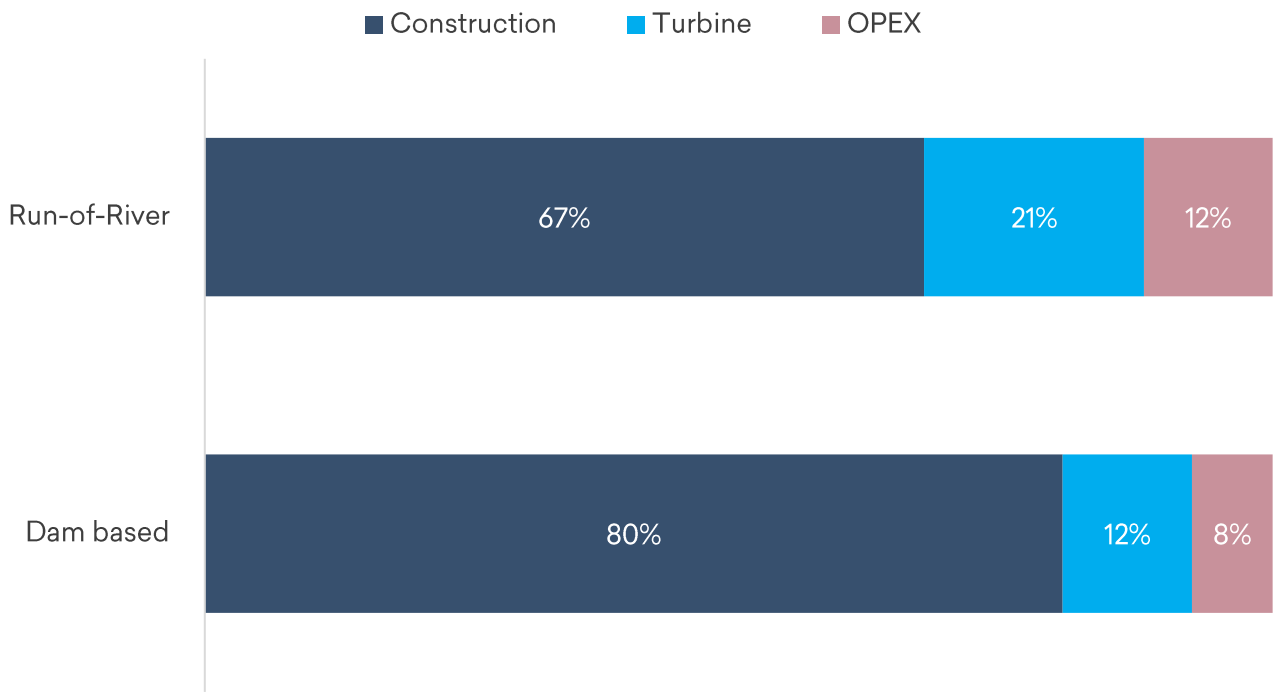


Source: TBC Capital

The different capital intensity of the two covered hydropower technologies is evident in the levelized cost of electricity breakdown. For each plant type the calculated LCOE has been split in three major cost types: the construction costs, the turbine costs and the operational expenditures incurred in the expected availability of the plants.

The traditional dam based hydropower plants are more capital intensive with the capital expenditures accounting for c. 92% of the total LCOE, compared to the c. 88% of the total LCOE in case of the run-of-river hydropower plants.

LCOE breakdown for hydropower plants
% of total



Source: TBC Capital

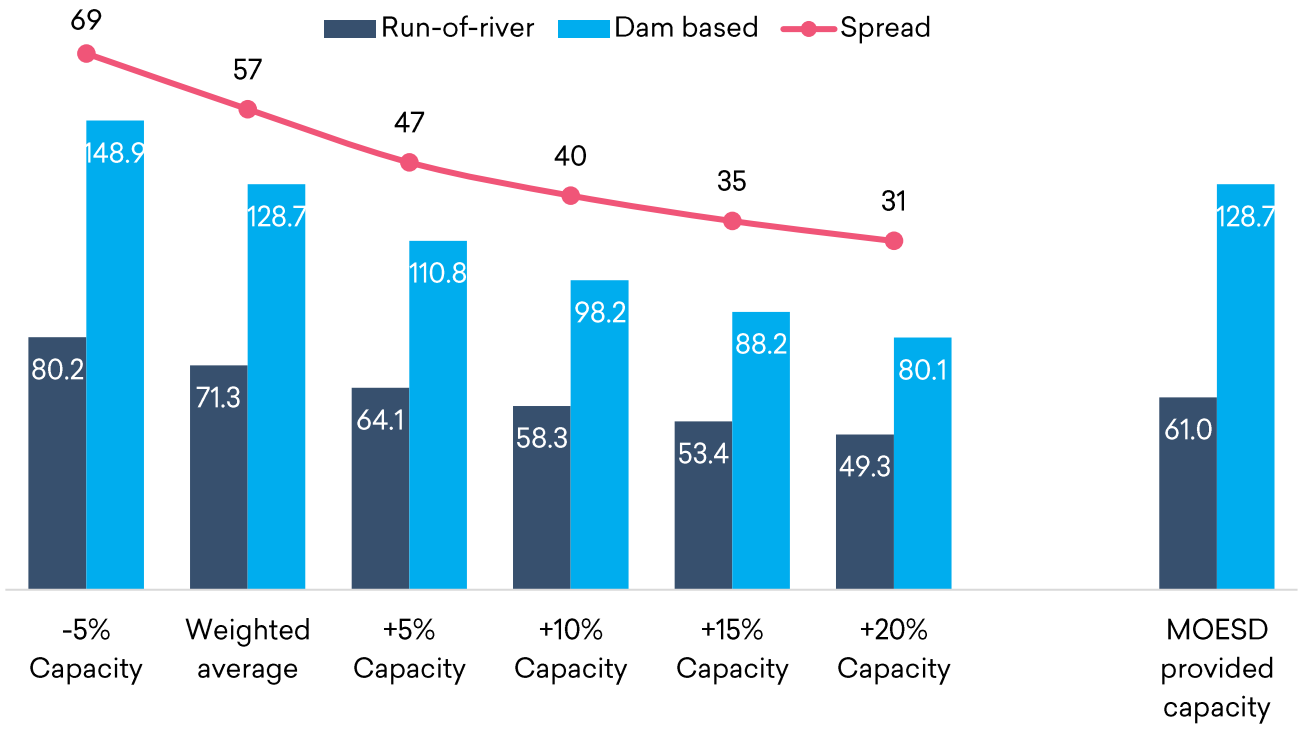
The presented calculations of the levelized cost of electricity for the two hydropower technologies are based on a sample of projects for which the weighted average capacity factor stands at c. 34% for dam based plants and c. 45% for run-of-river plants.

A capacity factor based sensitivity analysis for the levelized cost of electricity is important since the ratio displays a wide range of possibilities for different plants in the sample.

The capacity factor sensitivity analysis shows that even though levelized cost of electricity is highly affected by the changing factor for both technologies, the traditional dam based hydropower plants are more sensitive.

The spread between the levelized cost of electricity for run-of-river plants and dam based plants decreases from 69 USD/MWh for a hypothetical weighted -5% capacity factor to 31 USD/MWh for a hypothetical weighted +20% capacity factor.

Capacity factor sensitivity for hydropower plants' LCOE
USD/MWh



Source: TBC Capital

Onshore Wind Power Plants

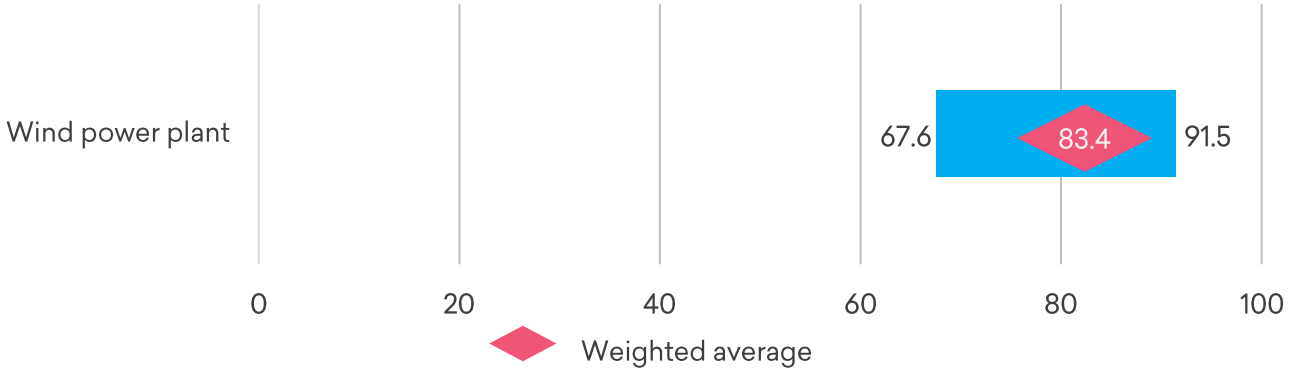
With only one operational wind farm in Georgia, the calculation of the levelized cost of electricity for the onshore wind power plant entails more assumptions and planned projects compared to the hydropower plants.

The levelized cost of electricity for onshore wind power plants ranges from 67.6 USD/MWh to 91.5 USD/MWh. The range is mainly resulted by the different types of wind turbines accounted for in the projects, which in turn also affects the number of expected available years.

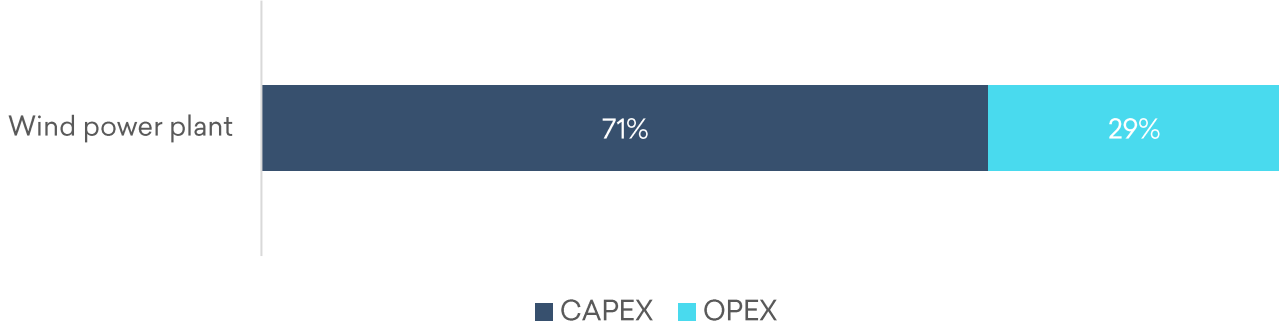
Similar to the hydropower plants, the calculated LCOEs for the wind power plants have been weighted based on the installed capacities, resulting in an average LCOE of 83.4 USD/MWh for the technology, setting it as the technology with relatively low LCOE.

Among the covered technologies, onshore wind power plants are the most OPEX intensive, accounting for c. 29% of the total LCOE.

LCOE range for wind power plants
USD/MWh



LCOE breakdown for wind power plants
% of total

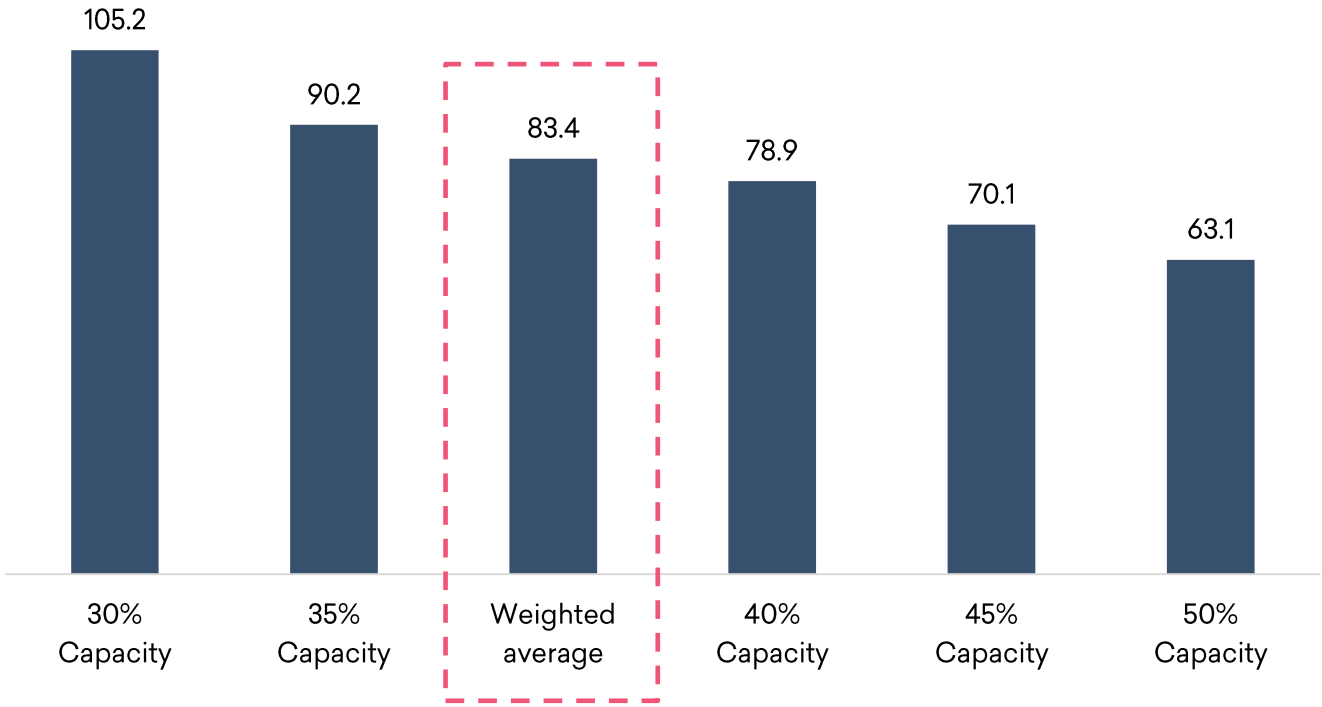


Source: TBC Capital

The weighted LCOE for the technology has been calculated using a sample of projects with a weighted average capacity factor of c. 38%. The sensitivity analysis for onshore wind power plants, displaying potential capacity factors ranging from 30% to 50% provides further basis that the technology is prone to having a low LCOE among the covered plants in the report.

Capacity factor sensitivity for wind power plants' LCOE

USD/MWh



Source: TBC Capital

Solar Power Plants

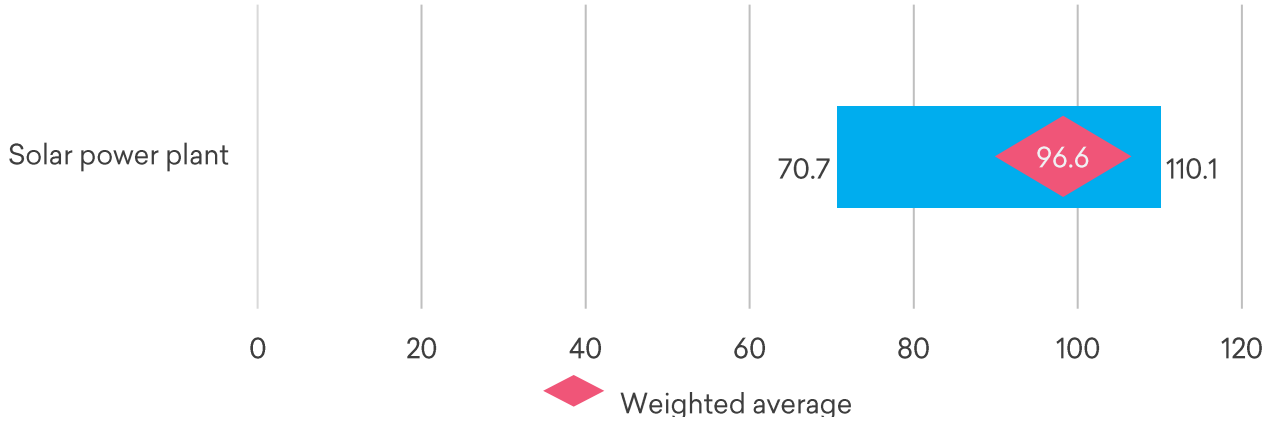
Similar to the wind power plants, the solar photovoltaic power plants are also scarce in the Georgian electricity market. The majority of the plants are micro power plants, mainly intended for domestic and commercial buildings' personal use. Therefore, the levelized cost of electricity for this technology is also partially based on planned projects.

The levelized cost of electricity for solar power plants has a relatively narrow range compared to other technologies, starting from 70.7 USD/MWh and reaching 110.1 USD/MWh.

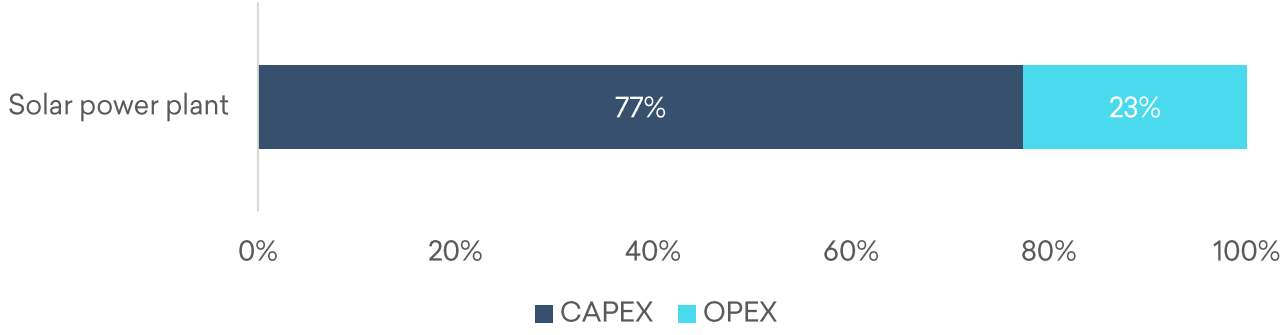
Similar to other technologies covered in the document, the calculated LCOEs for the solar power plants have been weighted based on the installed capacities, resulting in an average LCOE of 96.6 USD/MWh for the technology. The result sets the technology's LCOE lower than only the most capital intensive dam based hydropower plants.

Similar to the onshore wind power plants, the solar photovoltaic plants are also more OPEX intensive when compared to both of the covered hydropower technologies.

LCOE range for solar power plants
USD/MWh



LCOE breakdown for solar power plants
% of total



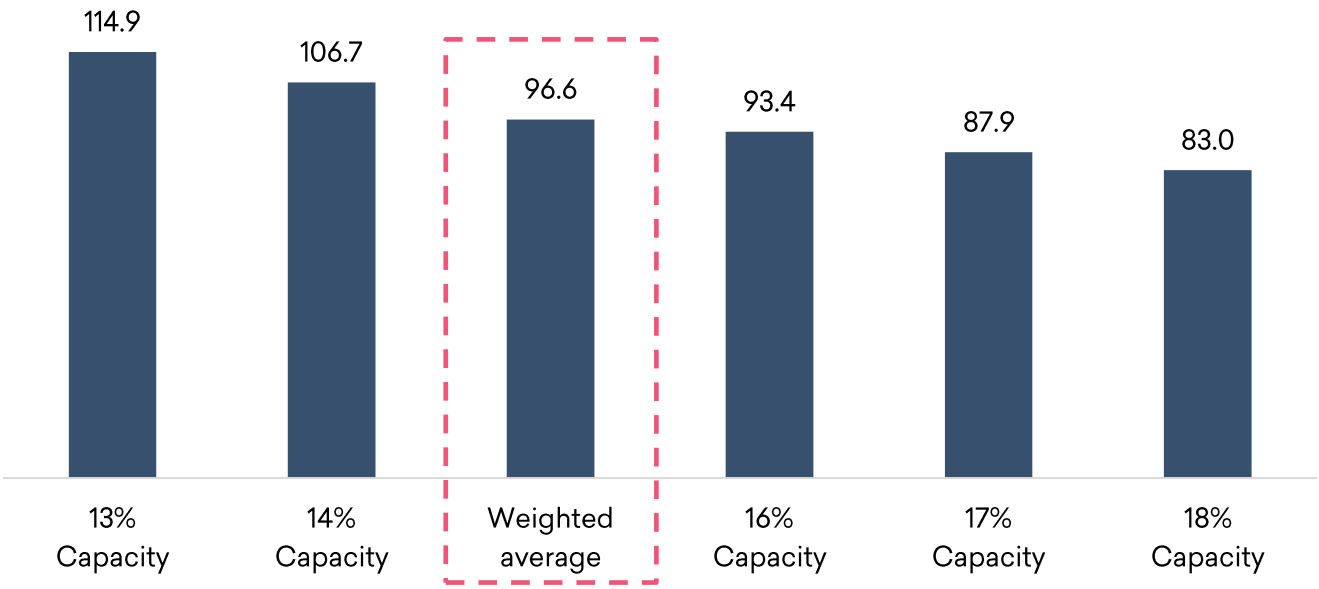
Source: TBC Capital

Even though Georgia is considered to have high solar energy potential with the annual irradiance days of 250 to 280[1], the technology demonstrates the least utilization factor among the covered technologies in this document.

The levelized cost of electricity for the solar power plants has been calculated for a sample of existing as well as hypothetical plants for which the installed capacity based weighted average capacity factor is equivalent to 15.4%.

A sensitivity analysis of various capacity factors for the solar power plant sample shows that on average, each percentage point increase in the capacity factors renders the final levelized cost of electricity down by c. 6%.

Capacity factor sensitivity for solar power plants' LCOE
USD/MWh



Source: TBC Capital; [1] IEA Georgia Energy Profile

Annex

Methodology

The levelized cost of electricity in this document is calculated using the following formula:

$$\text{LCOE} = \frac{\text{Total cost}}{\text{Total generation}}$$

where,

$$\text{Total costs} = \sum \frac{\text{Total costs}_n}{(1 + \text{discount rate})^n}$$

and

$$\text{Total generation} = \sum \frac{\text{Generation}_n}{(1 + \text{discount rate})^n}$$

The total costs include the capital costs as well as operating costs. The capital costs are comprehensive and include the pre-development costs as well as the construction, infrastructure and turbine/panel costs.

The total costs and the electricity generation numbers are discounted in this methodology in order to scale the distant values.

The LCOE calculations are highly sensitive towards the selected discount rate. Therefore, one of the main assumptions in calculating the LCOE is the discount rate.

The UK Generation Costs Update (Mott MacDonald, 2010) and the UK Department of Energy and Climate Change suggest a 10% discount rate. However, given the non uniform costs of capital, a 12% discount rate has been integrated in the model for the Georgian electricity market. The chosen discount rate is equivalent to the weighted average cost of capital for the selected projects and the overall sector in Georgia.

A detailed description of the utilized methodology can be found in the UK Generation Costs Update.

For the two hydropower plant technologies covered in the document, the capital expenditures are distributed based on the installed capacities of individual projects and the type of technology.

For the traditional dam based hydropower plants, the capital expenditures are distributed among five years, with the major construction costs mainly focused in the first three years and the turbine cost incurred in the final year.

As for the run-of-river hydropower plants, the capital expenditures are distributed between two years for plants with installed capacities of less than 10 MW and three years for plants with installed capacities exceeding 10 MW. As in the case of traditional dam based hydropower plants, the turbine costs for run-of-river plants are also incurred in the final year of construction.

The capital expenditures for the onshore wind and solar power plants are not distributed and are carried out in the initial year of each individual project.

Sample LCOE Calculation

Hypothetical 140 MW Dam Based Hydropower Plant

Year	CAPEX (USD mln)	OPEX (USD mln)	Total Cost (USD mln)	Output (TWh)	Discount Factor (based on 12%)	Discounted Total Cost (USD mln)	Discounted Output (TWh)
0	50		50		1.00	50	0.00
1	125		125		0.89	111.6	0.00
2	125		125		0.80	99.6	0.00
3	200		200		0.71	142.4	0.00
4		4.0	4.0	0.55	0.64	2.5	0.35
5		4.0	4.0	0.55	0.57	2.3	0.31
6		4.0	4.0	0.55	0.51	2.0	0.28
7		4.0	4.0	0.55	0.45	1.8	0.25
8		4.0	4.0	0.55	0.40	1.6	0.22
9		4.0	4.0	0.55	0.36	1.4	0.20
10		4.0	4.0	0.55	0.32	1.3	0.18
11		4.0	4.0	0.55	0.29	1.1	0.16
12		4.0	4.0	0.55	0.26	1.0	0.14
13		4.0	4.0	0.55	0.23	0.9	0.13
14		4.0	4.0	0.55	0.20	0.8	0.11
15		4.0	4.0	0.55	0.18	0.7	0.10
16		4.0	4.0	0.55	0.16	0.7	0.09
17		4.0	4.0	0.55	0.15	0.6	0.08
18		4.0	4.0	0.55	0.13	0.5	0.07
19		4.0	4.0	0.55	0.12	0.5	0.06
20		4.0	4.0	0.55	0.10	0.4	0.06
21		4.0	4.0	0.55	0.09	0.4	0.05
22		4.0	4.0	0.55	0.08	0.3	0.05
23		4.0	4.0	0.55	0.07	0.3	0.04
24		4.0	4.0	0.55	0.07	0.3	0.04
25		4.0	4.0	0.55	0.06	0.2	0.03
26		4.0	4.0	0.55	0.05	0.2	0.03
27		4.0	4.0	0.55	0.05	0.2	0.03
28		4.0	4.0	0.55	0.04	0.2	0.02
29		4.0	4.0	0.55	0.04	0.1	0.02
30		4.0	4.0	0.55	0.03	0.1	0.02
31		4.0	4.0	0.55	0.03	0.1	0.02
32		4.0	4.0	0.55	0.03	0.1	0.01
33		4.0	4.0	0.55	0.02	0.1	0.01
Sum	**500**	**120**	**620**	**16.5**		**426.5**	**3.15**
Levelized Cost of Electricity (USD/MWh)							**135.3**

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