Energy Consumption and GHG Emissions in the South Caucasus

Varadurga Bhat and Ashwath Naik*

In recent years, the World has been experiencing the consequences of climate change, and the South Caucasus has been affected by this phenomenon too. Energy security and environmental security have been affected by the dependence on fossil fuels and damages associated with energy exploitation, such as the rise in greenhouse gas (GHG) emissions. The development of renewable energy (RE) helps to meet growing energy demand and to mitigate climate change. Dependence on energy imports can be reduced, local resources can be utilized, and energy supplies can be diversified by deploying RE technologies in the region. Thus, it is one of the most attractive and reliable options for achieving sustained low-carbon growth. Against this background, this paper analyzes the trends in energy consumption and GHG emissions during 1995-2012 in the South Caucasus countries: Armenia, Azerbaijan and Georgia. Special focus is accorded to the prospects of RE in these countries based on their potential and policy framework. The paper concludes that the South Caucasus has substantial RE potential. However, with the exception of hydropower, other sources of RE are minimally utilized. Proper policy framework with clearly defined goals for RE generation and effective implementation are needed in this regard to ensure affordable and sustainable energy in these countries.

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Introduction

The South Caucasus region connects the East and the West, and the North and the South. It also plays a strategic role in global energy security due to its location along the energy transit corridor between Central Asia and Europe. In recent years, the regional countries, Armenia, Azerbaijan, and Georgia are experiencing the impacts and consequences of climate change such as: increases in temperature, heat waves, and droughts, increase in natural disasters such as landslides, avalanches, floods and mudflows, changes in precipitation patterns, melting of glaciers, and etc. This has led to economic losses and caused damage to infrastructure, offsetting the growth efforts. Dependence on fossil fuels in order to meet increasing energy demand to support growth is posing a threat to energy security. Environmental security is also affected due to the rise in greenhouse gas (GHG) emissions and other damages associated with extraction, use and transportation of fossil fuels**.** Being vulnerable to the impacts of climate change, these transitional economies need to develop sustainable pathways to economic growth by ensuring energy and environmental securities. Development of renewable energy (RE) helps to meet growing energy demand and to mitigate climate change. It can reduce the dependency on energy imports, help diversify energy supplies, and improve utilization of local natural resources. Thus it is one of the most attractive and reliable options in the drive to achieve sustainable low-carbon growth.

Against this background, this paper analyzes the trends in energy consumption and GHG emissions during 1995-2012 in Armenia, Azerbaijan and Georgia. Special focus is accorded to the prospects of RE in these countries based on their potential and policy framework. Data on energy consumption are extracted from World Bank and International Energy Agency (IEA) database. Information on GHG emissions has been extracted from CAIT Climate data explorer. Growth rates are estimated in order to identify the major trends in energy use and GHG emissions. Data on RE potential and policies are gathered from the database of International Renewable Energy Agency (IRENA). Trends in regional energy consumption and GHG emissions are compared against global averages.

The South Caucasus region is inhabited by 0.23% of the global population, and contributes 0.20% to the global Gross Domestic Product (GDP) in Purchasing Power Parity (PPP) terms (Table 1). Its share in global population has declined during 1995-2012

due to the slow growth rate of the population (0.18%), particularly in Armenia and Georgia where the negative grows have been observed. However, the share in GDP has increased remarkably during the same period due to significant growth in GDP (10.45%). Among the three countries, Azerbaijan had the highest regional share in GDP (74.04%) and population (57.74%) in 2012, followed by Georgia and Armenia. Between 1995 and 2012, Azerbaijan witnessed a remarkable increase in its regional share in GDP and population due to spectacular GDP growth and high growth rate of its population. However, during the same period, the shares of Armenia and Georgia have declined, and both countries have experienced negative population growth. All these economies are transitioning to emerging markets. In PPP terms, the highest growth rate of GDP was seen in Azerbaijan (12.38%), followed by Armenia (7.64%) and then Georgia (5.94). Per capita income (PCI) has significantly grown in all three countries during 1995-2012. The highest growth in PCI in PPP terms was seen in Azerbaijan (11.29%), followed by Armenia and Georgia.

However, the share in GDP has increased remarkably during the same period due to significant growth in GDP (10.45%). Among the three countries, Azerbaijan had the highest regional share in GDP (74.04%) and population (57.74%) in 2012, followed by Georgia and Armenia.

Trends in energy consumption

Despite their geographical proximity, Armenia, Azerbaijan and Georgia have different energy profiles. As Soviet republics, they had integrated energy systems. The collapse of the Soviet Union in 1991 led to disintegration of the economies and energy systems of these countries. Armenia and Georgia are net importers of energy, while Azerbaijan is a major exporter in the region.

Table 1: Economic and energy profiles of South Caucasus countries

Indicators		Armenia	Azerbaijan	Georgia	South Caucasus	World
GDP, PPP (billion 2011 Intl $)	1995	6.99 (16.12)	25.51 (58.81)	10.88 (25.07)	43.38 (0.08)	52353.37
	2012	21.65 (10.85)	147.69 (74.04)	30.15 (15.11)	199.49 (0.20)	97601.99
	Growth rate (%)	7.64	12.38	5.94	10.45	3.74

Population (millions)	1995	3.22 (20.61)	7.69 (49.13)	4.73 (30.26)	15.64 (0.27)	5705.84
	2012	2.98 (18.50)	9.30 (57.74)	3.83 (23.76)	16.10 (0.23)	7089.45
	Growth rate (%)	-0.45	1.09	-1.17	0.18	1.27
PCI, PPP (2011 Intl$)	1995	2169.43	3319.77	2297.69	2773.41	9175.40
	2012	7267.98	15888.22	7881.33	12391.11	13767.21
	Growth rate (%)	8.09	11.29	7.11	10.27	2.48
Energy use (mtoe)	1995	1.64 (8.53)	13.90 (72.14)	3.73 (19.33)	19.27 (0.21)	9207.55
	2012	2.97 (14.58)	13.69 (67.22)	3.71 (18.19)	20.37 (0.15)	13253.1
	Growth rate (%)	3.37	-0.08	-0.03	0.78	0.99
Energy use (tons of oil equivalents per capita)	1995	0.51	1.81	0.79	1.23	1.61
	2012	1.00	1.47	0.97	1.27	1.87
	Growth rate (%)	3.81	-0.61	1.33	0.60	2.25
Energy Intensity (kgoe/$1 GDP constant 2011 PPP)*	1995	0.24	0.54	0.34	0.44	0.18
	2012	0.14	0.09	0.12	0.10	0.14
RE (% of total energy consumption)	1995	9.27	1.37	46.39		17.28
	2012	6.57	2.85	28.69		18.12

*Note***:** Growth rates are exponential. Figures in parentheses are the percentage share of countries in the South Caucasus region for the respective values

Source: Calculated from data extracted from the World Bank database

In 1995, the region's total energy use was 19.27 million tons of oil equivalents (mtoe). (Table 1). By 2012, this had increased to 20.37 mtoe, with a growth rate of 0.78%. But this increase was not uniform throughout the period. The growth rate of regional energy use was less than the global growth rate. Hence the share of the region in global energy use gradually declined during 1995-2012, from 0.21% to 0.15%.

Energy use is the highest in Azerbaijan (13.69 mtoe) followed

by Georgia (3.71 mtoe), and then Armenia (2.97 mtoe) (Table 1). The highest growth rate during 1995-2012 was seen in Armenia (3.37%). Its share in energy use of the region also registered an increase from 8.53% to 14.58%. Azerbaijan remained the highest consumer of energy throughout 1995-2012, though there was a decline in its regional share from 72.14% to 67.22% due to the negative growth registered in volume of energy use. Georgia also witnessed negative growth in energy use and in its regional share. The region's per capita energy use is below the global average. Per capita energy use of Armenia and Georgia increased during 1995-2012, while in Azerbaijan this figure saw negative growth (though it remained above the global average).

Energy intensity (a ratio of energy use to GDP) of the South Caucasus region was higher than the world average in 1995, indicating the region's relatively poor energy efficiency (Table 1). Between 1995 and 2012, energy intensity has dropped considerably across all three countries, demonstrating that the entire region has become more energy efficient in comparison to the global average. Azerbaijan has the lowest energy intensity in the region and accordingly more energy efficiency, which is continuing to decline due to the combination of high GDP growth and comparatively slower growth in energy use.

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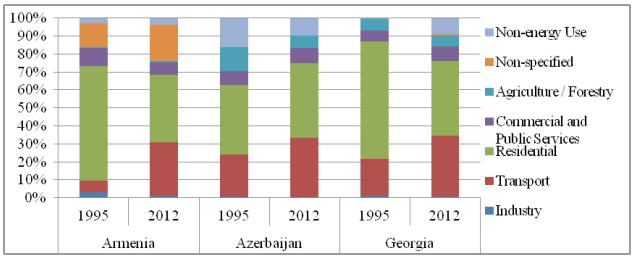
Households are the largest consumer group in the region (Figure 1). The residential sector consumed more than 30% of the total energy consumption in the three regional countries. The transport sector and then the industrial sector are the next major drivers of energy consumption. During 1995-2012, the share of industrial energy consumption declined in both Armenia and in Azerbaijan. The highest increase during this period was observed in energy consumption in the transport sector, and its share in the energy mix of all these countries.

Figure 1: Trends in share of sectors in total final energy consumption of South Caucasus countries during 1995-2012



Source: Calculations based on IEA database

Imported fossil and nuclear fuels meet around 70% of the energy needs of Armenia and Georgia.1 Heavy dependence on imported energy has placed an increased burden on their balance of payments. Fossil fuels remained the main source of energy in all countries. In 2012, energy from fossil fuels accounted for 78%, 81% and 64% of the total final energy consumption of Armenia, Azerbaijan, and Georgia respectively.2 Fossil fuel consumption increased during 1995-2012 in Armenia and Georgia, but declined in Azerbaijan. The share of fossil fuels in total energy consumption increased in all three countries, and the highest increase was observed in Georgia (from 43% to 67%), due to increased consumption of oil and natural gas.

In Armenia and Georgia, the major challenge is to ensure sustained energy supplies, whereas for Azerbaijan, a producer of fossil fuel-based energy, the challenge is to ensure environmental security.

Armenia can meet only 35% of its energy demand through domestic resources. More than half of its energy needs are met by natural gas. Azerbaijan is well-endowed with fossil fuel reserves, particularly oil and natural gas. Energy production in Azerbaijan mainly relies on natural gas and oil. Georgia satisfies its energy demand primarily from imported oil and natural gas, as well as domestically produced hydropower. It also receives in-kind payments for functioning as a pipeline transit country, which has made natural gas prices lower. In Armenia and Georgia, the major challenge is to ensure sustained energy supplies, whereas for Azerbaijan, a producer of fossil fuel-based energy, the challenge is to ensure environmental security.

Electricity produced from fossil fuels in 2012 accounted for 42%, 22%, and 95% of total electricity production in these coun-

1 World Bank (2016) 'World Development Indicators', Available at: http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators. (Accessed: 16 August, 2016).

2 IEA database. Available at: www.iea.org (Accessed: 16 August, 2016).

tries respectively.3 In Armenia, electricity generation is based on nuclear energy and thermal plants consuming imported fuels and from hydro power plants (HPPs). Azerbaijan produces 90% of its electricity from natural gas and is a net exporter of electricity. Georgia is also an exporter of electricity, though this is subject to seasonal variations. Most of Georgia's electricity needs are met by hydro and thermal power plants.

RE is yet to be utilized fully in the South Caucasus countries. Though the region is rich in resources for the generation of RE, it is significantly under-exploited. In 2012, Armenia consumed 6.57% of its total energy from renewables, whereas for Azerbaijan this figure is just 2.85% (Table 1). Georgia revealed a promising figure of 28.69%. The share of renewables in the total energy mix of Georgia contracted from 46.39% due to a fall in biofuels consumption, as households switched to natural gas. However, the majority of RE is only hydro energy (particularly large HPPs) in all these countries. RE generation from other sources such as wind, solar, geothermal and biofuels is almost negligible. The share of RE in total energy consumption has declined in Armenia and Georgia during 1995-2012, while it rose slightly in Azerbaijan.

Trends in GHG emissions

In 1995, the total GHG emissions of the South Caucasus region was 78.12 million tons of carbon dioxide equivalents (MtCO2e), which constituted 0.23% of global GHG emissions (Table 2). Azerbaijan was the largest emitter with a share of 77% (60.27 MtCO2e). Armenia was the lowest emitter, with a share of just 9%. Georgia contributed 10.58 MtCO2e of GHGs, which accounted for about 14% of the regional emissions. Between 1995 and 2012, global GHG emissions increased significantly, at a rate of 2.04%. But the South Caucasus has recorded a slow growth of 0.94% in its GHG emissions. The share of the region in global GHG emissions also gradually declined to 0.19%, though there was an increase in the volume of emissions to 89.42 MtCO2e in 2012. Azerbaijan's regional share in GHG emissions remained almost the same, whereas Armenia's share increased slightly to 10%, while Georgia's share dropped to 12%. However, the volume of GHG emissions increased in all these countries to 9.30 MtCO2e, 69.34 MtCO2e and 10.78 MtCO2e respectively. Until 2002, the GHG emissions of all three countries saw a gradual

3 World Bank (2016) *World Development Indicators*. Available at: http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators. (Accessed: 16 August, 2016).

decline due to reductions in energy use, but increased thereafter as this trend was reversed. Within the region, Armenia recorded the highest and statistically significant growth rate in its total GHG emissions during 1995-2012 (2.15%), whereas Azerbaijan and Georgia witnessed below average growth in the region (0.86% and 0.48% respectively). The region's per capita GHG emissions also remained below the global average throughout the period 1995-2012. Azerbaijan experienced the highest per capita GHG emissions in the region, followed by Armenia and Georgia. During 1995-2012 per capita GHG emissions in Armenia and Georgia registered an increase while that of Azerbaijan declined slightly.

Table 2: Trends in GHG emissions in South Caucasus countries

Indicators		Armenia	Azerbaijan	Georgia	South Caucasus	World
Total GHG Emissions ($MtCO_2e$)	1995	7.27 (9.30)	60.27 (77.15)	10.58 (13.55)	78.12 (0.23)	34309.97
	2012	9.30 (10.40)	69.34 (77.54)	10.78 (12.06)	89.42 (0.19)	47598.55
	Growth rate (%)	2.15	0.86	0.48	0.94	2.04
Per capita GHG Emissions ($toCO_2e$ per capita)	1995	2.25	7.84	2.24	4.99	6.01
	2012	3.12	7.46	2.82	5.55	6.71
	Growth rate (%)	2.59	-0.23	1.65	0.76	0.77
Energy Emissions per GDP (kgCO2e/$)	1995	65.02	211.23	84.80	155.96	46.68
	2012	28.15	39.85	26.68	36.59	35.96

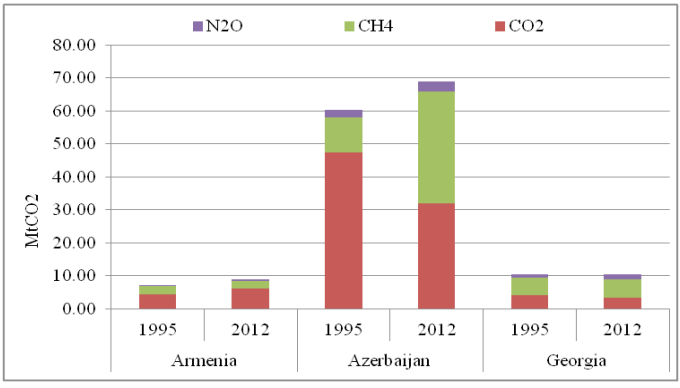
Note: Growth rates are exponential. Figures in parentheses are the percentage share of countries in the South Caucasus region for the respective values

Source: Calculations based on data taken from CAIT Climate Data Explorer

Carbon dioxide (CO2) is the top GHG emitted in Armenia (Figure 2), accounting for 69% of the country's total GHG emissions in 2012. Methane (CH4) was the next major GHG, constituting 24% of total emissions. Nitrous Oxide (N2O) had a marginal share of 6%. Between 1995 and 2012 the volume of CO2 and N2O emissions increased, while CH4 emissions declined. Accordingly, the share of CO2 in Armenia's total GHG emissions significantly increased at a rate of 2.79%. However, there was a marked decline in the share of CH4, which dropped from 33% to 24%. The share of N2O marginally declined from 7% to 6%.

Until 2011, CO2 was the leading GHG emitted by Azerbaijan; however in 2012 it was surpassed by CH4. CO2 recorded a significant negative growth rate of 2.63% during 1995-2012, while CH4 registered a significant positive growth of 7.07%. N2O had a marginal share in total GHG emissions of Azerbaijan. CH4 had the largest share in Georgia's total GHG emissions throughout 1995-2012 due to increased emissions from waste. CO2 emissions registered a negative growth during this period. This is the result of activities in the land use, land use change and forestry (LULUCF) sector.

Figure 2: Trends in GHG emissions by Gas



Source: CAIT Climate Data Explorer

The energy sector bears primary responsibility for GHG emissions in South Caucasus countries (Figure 3). In 2012, it contributed 65%, 85% and 75% of the total GHG emissions in Armenia, Azerbaijan and Georgia respectively. During 1995-2012, the contribution of energy sector emissions increased in Armenia. However, Georgia witnessed negative growth in the energy sector emissions. Azerbaijan saw a positive growth in the energy

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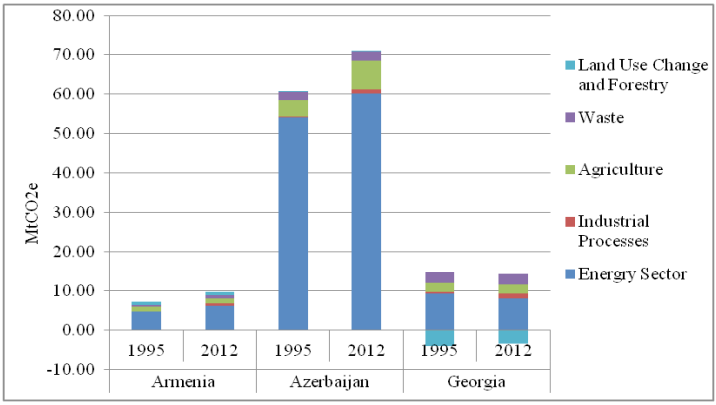
related emissions in this period, but the share of the energy sector in its total GHG emissions declined. The agricultural sector is the second largest emitter of GHG in Armenia and Azerbaijan. Emissions from waste constituted about 25% in the total GHG emissions of Georgia in 2012. Emissions from the agricultural sector grew in all three countries. There was a marked increase in the emissions from industrial processes during 1995-2012 in all three countries, though its contribution to the total GHG emissions of these countries was the lowest of all sectors. Activities in the LULUCF sector accounted for removals of GHGs from the atmosphere in Georgia.

Figure 3: Trends in GHG emissions by sector

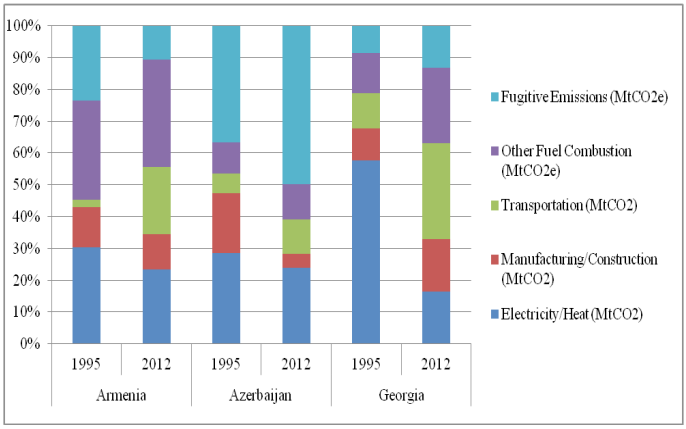


Source: CAIT Climate Data Explorer

Electricity/heat generation, other fuel combustion, and fugitive emissions constituted the bulk of GHG emissions within the Armenian energy sector in 1995. Fugitive emissions gradually declined and emissions from the transportation sector increased significantly during 1995-2012. Fugitive emissions and electricity/heat generation constituted a major part of GHG emissions within the energy sector of Azerbaijan. Fugitive emissions and transportation sector emissions significantly increased, while emissions from electricity/heat generation registered negative growth between 1995 and 2012. Electricity/heat generation accounted for 58% of energy sector emissions in Georgia in 1995. But during 1995-2012, there was a huge decline in emissions from electricity/heat generation. Emissions from the transportation sector were the highest within the Georgian energy sector, followed by other fuel combustion, manufacturing/construction

and fugitive emissions in 2012, all of which experienced remarkable increases during 1995-2012.

Figure 4: Breakdown of GHG emissions within the energy sector



Source: Calculations based on data extracted from CAIT Climate Data Explorer

Per capita GHG emission of the region is significantly below the world average (Table 2). Azerbaijan has per capita emissions above global average, though this figure fell slightly during 1995-2012. Per capita emissions of Armenia and Georgia also remained below regional and global averages throughout this period, despite increases in their values.

The ratio of energy sector emissions to the country's GDP or emission intensity of GDP is used to determine the role of energy in climate change. It shows the annual volume of emissions generated in a country per unit of its GDP, by activities relating to the energy sector. The emission intensity of GDP in the South Caucasus is above the world average (Table 2). However, there was a huge drop in emission intensity during 1995-2012, to a degree that was steeper than the global average. In 1995, all the South Caucasus countries had higher emission intensities than the world average. But these values consistently declined during this period for all the countries. Since 1999, Armenia's emission intensity has remained below the global average. From 2001, the emission intensity of Georgia also fell below the world average. Azerbaijan is the only country in the region whose emission intensity is above regional and global averages.

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Decline in emission intensities is attributable to the spectacular growth in the GDP of all three countries during this period, whereby the growth rate of GDP exceeded the growth rate of emissions. For Georgia, this is due to a decline in energy emissions as well as a rise in GDP. Increased deployment of energy efficiency along with RE technologies are also responsible for the relatively lower growth of emissions leading to reduction in the values of energy emissions per GDP.

Prospects of RE in the South Caucasus countries

The region has significant potential to develop RE. Only Armenia and Azerbaijan have set RE targets. No goals have been set for the development RE in Georgia. Country-specific RE potentials and targets are shown in Table 3 and Table 4 respectively.

Armenia

Armenia has significant potential for RE generation. Proper utilization of its solar potential can reduce its dependency on energy imports. The country's small hydro potential has been evaluated at about 340 GWh/year.4 The country has good solar, wind and biomass potential. The average annual solar radiation is approximately 1,720 kWh/m2,5 and more than a quarter of the territory has solar resources with an intensity of 1,850 kWh/m2. Armenia has large forestry and agricultural areas capable of generating biomass energy and biogas. The average annual wind velocity in Armenia is unevenly distributed at 1.0-8.0 meters per second. Ararat Valley has strong mountain valley winds. The Jermaghbyur region (on the Syunik volcanic plateau), Karkar and Gridzor regions have geothermal potential.

Being a non-Annex I Party to the Kyoto Protocol, Armenia does not have specific quantitative commitments to reduce GHG emissions.

Armenia has developed relevant legal and economic frameworks to support RE. RE feed-in tariffs were introduced in 2007, which provide 15 year guaranteed benefits for selected technologies. Feed-in-tariffs are applicable to wind and small hydropower plants, while net metering is applicable to solar photovoltaics (PV). The Renewable Resources and Energy Efficiency Fund provides financial support. The National Programme on Energy Savings and Renewable Energy is in force since 2007. The Scaling Up Renewable Energy Program for Armenia was introduced in 2014 as an update to the Renewable Energy Roadmap 2011. It established new RE production targets. Armenia ratified the United

4 Gigawatt hour per year.

5 Kilowatt hour per square meter.

Nations Framework Convention on Climate Change (UNFCCC) in 1993. Being a non-Annex I Party to the Kyoto Protocol, Armenia does not have specific quantitative commitments to reduce GHG emissions. Nonetheless, Armenia has already submitted its voluntary political commitment to reduce GHG emissions. So far six CDM projects have been registered in the country.

Table 3: RE Resource potential in the South Caucasus countries

Country	RE Potential
Armenia	Utility scale solar PV: 1,700 – 2,100 GWh/year Concentrating solar power: 2,400 GWh/year Distributed solar PV: 1,800 GWh/year Wind: 650 GWh/year Geothermal: at least 1,100 GWh/year Small hydro: 340 GWh/year Landfill gas: 20 GWh/year Biogas: 30 GWh/year Biomass: 230 GWh/year Solar thermal hot water: 260 GWh/year Geothermal heat pumps: 3,500 GWh/year Total electricity: 7,400 – 8,700 GWh/year Total heat: 4,690 GWh/year
Azerbaijan	Solar: > 8,000 MW Wind: 15,000 MW Bioenergy: 900 MW Geothermal: 800 MW Small hydro: 700 MW
Georgia	Solar: 60–120 GWh/year Wind: 5,000 GWh/year Biomass: 3,000–4,000 GWh/year Small hydro: 5,000 GWh/year Geothermal: 3000 GWh/year

Source: Republic of Armenia, 2014, Azernews, 2016, Energy Charter Secretariat, 2012

Azerbaijan

Azerbaijan has favorable conditions for the exploitation of solar energy. But the high cost of energy generation has stopped the country from installing large-scale plants. Absheron peninsula, Kura-Araz lowland and Nakhchivan Autonomous Republic have an estimated average solar energy potential of 0.8–1.2 kW/m2 . The Greater and Lesser Caucasus, the Absheron peninsula, the Talysh Mountains, the Kura lowland, and the Caspian-Guba region are rich in thermal waters for exploitation of geothermal en-

ergy. The districts of Lenkoran, Massaly, and Astara have an estimated average geothermal production capacity of about 25,000 m3 per day. Absheron peninsula, Caspian Sea coastal areas, and islands in the northwest of the Caspian Sea have the highest wind energy potential in the country. The Ganja-Dashkasan area in the west and the Sharur-Julfa region in the Nakhchivan Autonomous Republic also have significant wind energy potential. The major hydropower resources of the country are located in lower reaches of the Kura River, Aras River, creeks flowing into the Caspian Sea, reservoirs, and canals. Vast agricultural, forestry areas, and solid waste generation in the country offer attractive bioenergy potential.

In Azerbaijan, RE targets were set by the government and significant funding has been allocated for the development of its legal framework. The State Program on the Use of Alternative and Renewable Energy Sources (2005-2013) was approved in 2004, and established RE targets for the country. The State Agency on Alternative and Renewable Energy Sources (SAARES) was established in 2009 to create institutional responsibility for the development of RE. It is responsible for the development, implementation and regulation of state policies relating to RE. Azerbaijan ratified the UNFCCC in 1995 and is a non-Annex I country. The country has five CDM projects registered and two projects at the validation stage.

Table 4: RE targets adopted by South Caucasus Countries

	2020 21% of RE sources in total power generation				
	2025 26% of RE sources in total power generation				
	RE generation capacity and production targets 2020-2025				
		Capacity installed (MW)		Generation (GWh/a)	
	Electricity	2020	2025	2020	2025
	Small hydro	377	397	1049	1106
	Wind	50	100	117	232
	Geothermal	50	100	373	745
	Solar PV	40	80	88	176
	Heat				
	Geothermal heat pumps	12	25	16	33
Armenia	Solar thermal	10	20	13	25
Azerbaijan	Energy	9.7% of total consumption by 2020, 2,000 MW of installed capacity by 2020			
	Electricity	20% of consumption by 2020			
Georgia	None				

Source: IEA/IRENA Joint Policies and Measures Database, Republic of Armenia, 2014

Georgia

Georgia has vast untapped RE potential. Its hydropower production potential stands among the highest in the world. Out of 26,000 rivers, 300 are significant in terms of electricity generation. There are 250-280 sunny days per year in most regions, and the average annual number of hours of sunshine is over 2000. The largest solar energy potential is in the mountainous areas in the north and south. Average wind speed in different regions varies from 2.0 m/s to 9.0 m/s. There is significant wind energy potential in Javakheti region, as well as in the southern part of the Black Sea coast. Likhi Mountain region is also a promising site for wind energy generation. Crop and animal farming residues, municipal waste, sewage treatment residues, and wood are all potential sources of bioenergy. Georgia also has significant geothermal resources, particularly thermal waters, the majority of which are found in the western part of the country.

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Georgia does not have official targets for RE generation. It also lacks a proper supportive mechanism, and a policy framework dedicated to the promotion of RE. The State Programme for Renewable Energy 2008 was introduced to boost investments in RE and maximize the benefits of its vast RE potential. As part of the program, the government established the Georgian Energy Development Fund (GEDF) to facilitate investment in renewables. The incentives provided under this program are limited to hydropower. Feed-in-tariffs are only available to small HPPs with capacity of under 0.1 megawatt (MW). All other RE sources have been neglected. Georgia, as a non-Annex I party to the Kyoto Protocol, does not have international obligations to reduce GHG emissions. It has seven CDM projects registered, and one at validation stage.

The major barriers to RE in the region include the high cost of investment leading to weak competitiveness of RE compared to fossil fuel-based energy; lack of experience with RE technologies; absence of substantive analysis of RE potential; absence of proper legal and institutional framework; lack of technical capacity among local financiers; lack of confidence and poorly developed local markets. Along with these obstacles, lack of clearly defined goals and specific policies dedicated to the promotion of RE; and neglect of all RE sectors other than hydro power.

Conclusion

RE can help the South Caucasus countries to alleviate energy poverty, reduce energy dependency, support growth, reduce expenditure, and create employment. It also helps to mitigate climate change by reducing GHG emissions and to prevent the devastating environmental impact of energy exploitation. Though all these countries have substantial RE potential, they have not exploited it to the fullest extent, given the prevailing focus on the profit-generating oil and gas sector. There were no incentives to switch to RE, due to sufficient supply of fossil fuels at low prices. Hydropower is the only source of RE generation in these countries. RE generation from wind, biofuels and geothermal sources play a marginal role in the energy profile of South Caucasus countries. Recently, there has been growing awareness regarding the role of RE in ensuring sustainable energy supplies. Each country has found RE beneficial in its own geopolitical and economic context. Armenia and Georgia need RE to achieve energy independence, by reducing heavy reliance on energy imports and securing uninterrupted power supplies. For Azerbaijan, this is needed to ensure sustainable growth and to exploit its huge potential. Among the three countries, Armenia is the most advanced in the region in terms of RE deployment. Armenia has a roadmap for RE development, and Azerbaijan has a state program dedicated to RE development. Georgia has not adopted any policy or action plan. It also lacks goals for RE generation. Proper assessment of RE potential, coherent policies and instruments, effective institutional framework, effective implementation of policies, and regional integration will all help the South Caucasus countries to utilize their RE potential.