

Scaling Up: Floating Solar Prospects in Central and West Asia

Regional Knowledge and Support Technical Assistance
Afghanistan, Azerbaijan, Kyrgyz Republic

Cindy Cisneros Tiangco, PhD

Senior Energy Specialist

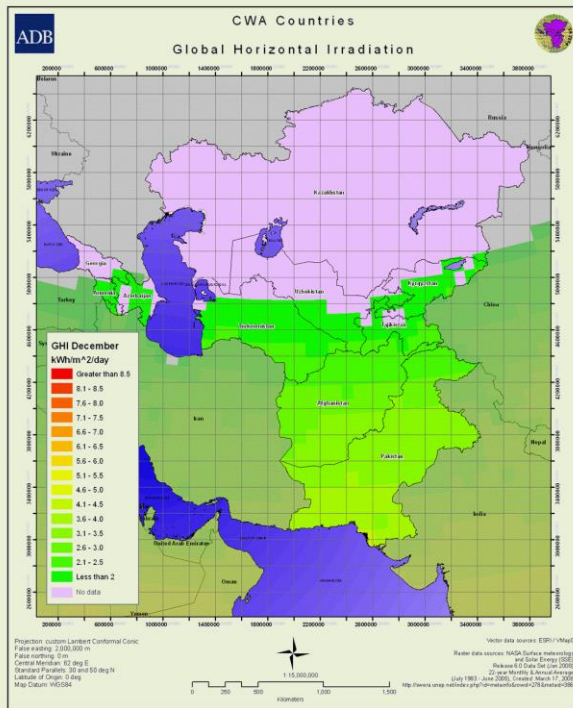
Energy Division

Central and West Asia Department

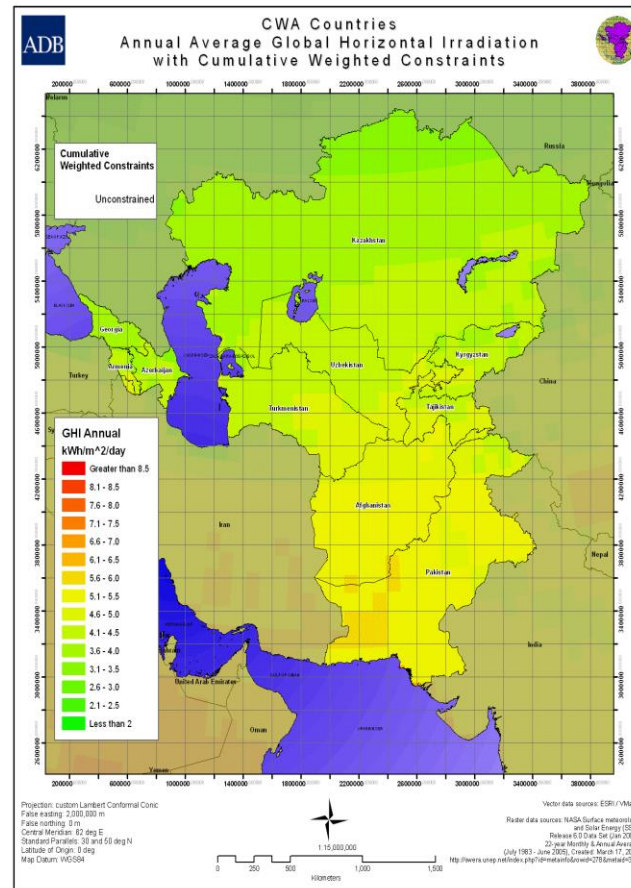
ctiangco@adb.org

Central and West Asia Solar PV Resources

Monthly variation of Theoretical Global Horizontal Irradiation in the Region (solar photovoltaic potential)



Average Annual Global Horizontal Irradiation In the Region with Cumulative constraints



Weighted exclusion factors applied for:

Practical Resources:

- Airports/runway alignments, railroads, urban areas, pipelines
- National borders (5 km buffer)
- Areas with population density > 100 persons/km²
- Areas >20km away from roads (for construction access)
- seismic danger areas
- **Areas with elevation >3000m or slopes >10%**

Ecological Resources

- Snow and ice areas, shifting sand dunes and salt pans, tundra, swampland, All environmentally protected areas

GHI data based upon 12 year half hourly satellite images;
Validated by 92 measuring stations worldwide.
Accuracy of GHI estimates is around +/- 5%; provides good quality prediction of long term average irradiance
For more details see

http://www.3tier.com/static/ttcms/us/documents/publications/validations/3TIER_Global_Solar_Validation.pdf

Review: Potential FPV Sites in Central & West Asia

Country	Potential site	Surface area (ha)	Marked polygon	Theoretical capacity (MW)
Afghanistan	Naghlu Reservoir	~1,150	200 ha	100 - 200 MW
	Qargha Reservoir	~80	10 ha	5 - 10 MW

1,230

up to 210 MW

Afghanistan



Qargha Reservoir

- 15km west of Kabul; recreational area also used for trout fishing and hatchery
- Planned (i) to provide additional drinking water to Kabul, (ii) irrigation to expand horticulture, and (iii) feed a hydropower plant
- Marked polygon is 10 ha; theoretically can fit a maximum 10MW of FPV



Review: Potential FPV Sites in Central & West Asia

Country	Potential site	Surface area (ha)	Marked polygon	Theoretical capacity (MW)
Armenia	Lake Sevan	500,000	35,000 ha	17-35 GW
	Aparan Reservoir	180	15 ha	7-15 MW
	Spandaryan Reservoir	1,080	100 ha	50-100 MW
		501,260		up to 35,115 MW

Armenia

- Spandaryan reservoir
 - 10.8 km² (1,080 ha) surface area
 - Starting point of the Voratan HPPs cascade

✂ *Marked polygon represents 100 ha which theoretically can accommodate 50-100 MW*



Review: Potential FPV Sites in Central & West Asia

Country	Potential site	Surface area (ha)	HPP generation capacity (MW)	Marked polygon	Theoretical capacity (MW)
Azerbaijan	Jeyranbatan reservoir	1,390		200 ha	100-200
	Mingacevir (HPP)	60,500	424.0	14000 ha	7000-14000
	Yenikend (HPP)	2,261	150.0	850 ha	425-850
	Semkir (HPP)	11,500	280.0	2000 ha	1000-2000
	Varvara (HPP)	2,140	16.5	100 ha	50-100
	Sarsangh (HPP)	1,385	50.0	150 ha	75-150
	Boyukshor Lake	1,620		100 ha	50-100

80,796

921 MW

up to 17.4 GW

Azerbaijan



Review: Potential FPV Sites in Central & West Asia

Country	Potential site	Surface area (ha)	Marked polygon	Theoretical capacity (MW)
Georgia	Tbilisi Sea	837	200	100
	Tsalka	3370	500	250
	Shaori	1180	100	50
	Jinvali	1152	100	50
	Tkibuli	8600	100	50
	Sioni	1040	100	50
			16179	1100

Georgia

- **Tbilisi Sea or Tbilisi Reservoir**
 - Created in 1953 as a reservoir and became a popular recreation spot

✂ *Marked polygon represents 200 ha which theoretically can accommodate 100-200 MW*



Review: Potential FPV Sites in Central & West Asia

Country	Potential site	Surface area (ha)	Marked polygon	Theoretical capacity (GW)
Kazakhstan	Lake Balkhash	1,640,000	100,000 ha	50-100
	Lake Kapchagay	184,700	30,000 ha	15-30
			1,824,700	up to 130 GW

Kazakhstan

- Lake Kapchagay
 - Major reservoir in Almaty Region and popular resort area
 - 60 km North of Almaty
 - Surface area: 1,847 km² (or 184,700 ha)

✂ *Marked polygon represents 30,000 ha which theoretically can accommodate 15 – 30 GW*



Review: Potential FPV Sites in Central & West Asia

Country	Potential site	Reservoir surface area (ha)	HPP generation capacity (MW)	Marked polygon	Theoretical capacity (MW)
Kyrgyz Republic	Toktogul (HPP)	28,400	1,200	4000 ha	2,000 - 4,000
	Kurpsai (HPP)	1,200	800	10 ha	5 - 10
	Tashkomur (HPP)	N/A	450	15 ha	7 - 15
	Shamaldy-Sai (HPP)	N/A	240	10 ha	5 - 10
	Uch-Krugan (HPP)	400	180	2 ha	1 - 2

30,000

up to 4,037 MW

Kyrgyz Republic

Naryn Cascade



Image © 2018 CNES / Airbus



Review: Potential FPV Sites in Central & West Asia

Country	Potential site	Surface area (ha)	Marked polygon	Theoretical capacity (MW)
Pakistan	Tarbela Reservoir	25,900	1200 ha	6 - 12 MW
	Ghazi-Barotha Reservoir	512	150	75 - 150 MW
	Mangla Reservoir	25,100	300	150 - 300 MW

51.512

up to 462 MW

Pakistan

- Mangla Reservoir
 - 108km South-east of Islamabad

✂ Marked polygon represents 300 ha which theoretically can accommodate 150-300 MW



Review: Potential FPV Sites in Central & West Asia

Country	Potential site	Surface area (ha)	Marked polygon	Theoretical capacity (GW)
Tajikistan	Kayrakkum Reservoir	51,300	10,000 ha	5-10 GW

Tajikistan

- Kayrakkum Reservoir
 - Large artificial reservoir in northwestern Tajikistan
 - Supplies water for irrigation and hydropower production
 - 513km² (or 51,300 ha) surface area

✘ *Marked polygon represents 10,000 ha which theoretically can accommodate 5 – 10 GW*



Review: Potential FPV Sites in Central & West Asia

Country	Potential site	Surface area (ha)	Marked polygon	Theoretical capacity (GW)
Turkmenistan	Altyn Asyr ("Golden Age") Lake	190,000	10,000 ha	5-10 GW
	Hanhowuz Reservoir – Karakum Canal		10,000 ha	5-10 GW

up to 20 GW

Turkmenistan

- Hanhowuz Reservoir – Karakum Canal
 - The reservoir is component of Karakum canal system and was create to control the erratic Tejen River
 - Plays an important role in agriculture in the region

✂ *Marked polygon represents 10,000 ha which theoretically can accommodate 5- 10 GW*



Review: Potential FPV Sites in Central & West Asia

Country	Potential site	Surface area (ha)	Marked polygon	Theoretical capacity (GW)
Uzbekistan	Lake Aydar	300,000	10,000 ha	5-10 GW

Uzbekistan

- Lake Aydar
 - Aydar Lake and Kyzylkum Desert is an area of tourist activities such as fishing, yurting and camel backing
 - Surface area: 3,000km² (or 300,000 ha)

✂ Marked polygon represents 10,000 ha which theoretically can accommodate 5 – 10 GW



Summary: Potential FPV Scale-up in Central & West Asia

Country	# of Potential Sites Explored	Total Surface Area (ha)	Theoretical FPV Potential Capacity in GW (2ha/MW)	Total Marked Polygons (ha)	Total Theoretical Capacity - Polygons (GW)	2015 Total Installed Capacity (GW)
Afghanistan	2	1,230	0.6	210	0.1 to 0.2	0.6
Armenia	3	501,260	250.6	35,115	17 to 35	4.1
Azerbaijan	7	80,796	40.4	17,400	9 to 17	7.4
Georgia	6	16179	8.1	200	0.1 to 0.2	4.3
Kazakhstan	2	1,824,700	912.4	130,000	65 to 130	22.1
Kyrgyz Republic	5	30,000	15.0	4,037	2 to 4	3.9
Pakistan	3	51,512	25.8	1,650	0.825 to 1.65	22.8
Tajikistan	1	51,300	25.7	10,000	5 to 10	5.5
Turkmenistan	2	190000	95.0	20,000	10 to 20	4
Uzbekistan	1	300,000	150.0	10,000	5 to 10	12.9

32 3,046,977 1,523 228,612 ~114 to 229 88

Proposed ADB Technical Assistance Floating Solar Energy Development – (AFG, AZE, KGZ)

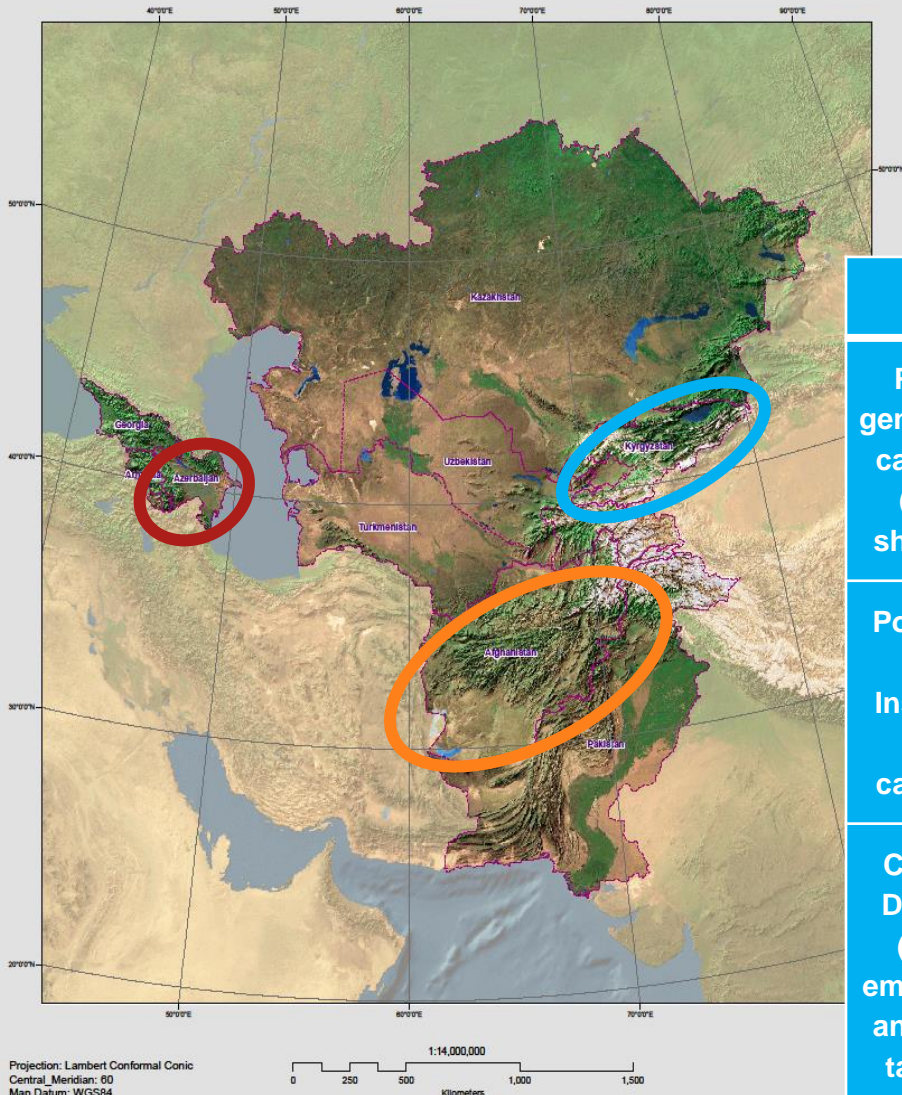
RATIONALE

- CWRD countries are heavily reliant on either fossil fuels, hydropower, or imported fuels and power, which make them carbon-intensive, energy insecure, and vulnerable to climate and external supply shocks.
- Solar potential is untapped due to lack of technical skills and knowledge on new technologies, costs, benefits and financing options.
- **The cost of solar energy has decreased** rapidly in recent years, offering impetus for these countries to **diversify** to indigenous low-carbon technologies to **enhance energy security and reduce emissions**.
- Undiversified power supply in target countries: Azerbaijan, 85% fossil fuels; Kyrgyz Republic, 90% hydro; Afghanistan, 80% imported
- Significant potential for replication in Kazakhstan, Georgia, and rest of Central & West Asia.

Approach and Components:

- Pilot testing and scaling up of emerging ‘floating’ solar photovoltaic (FPV) technology;
- business models formulation to encourage private sector participation;
- institutional capacity building (hands-on training through pilots, regional training via CAREC, study tours to leading FPV countries)

Generation mix, potential and installed capacity, NDC targets – (AFG, AZE, KGZ)

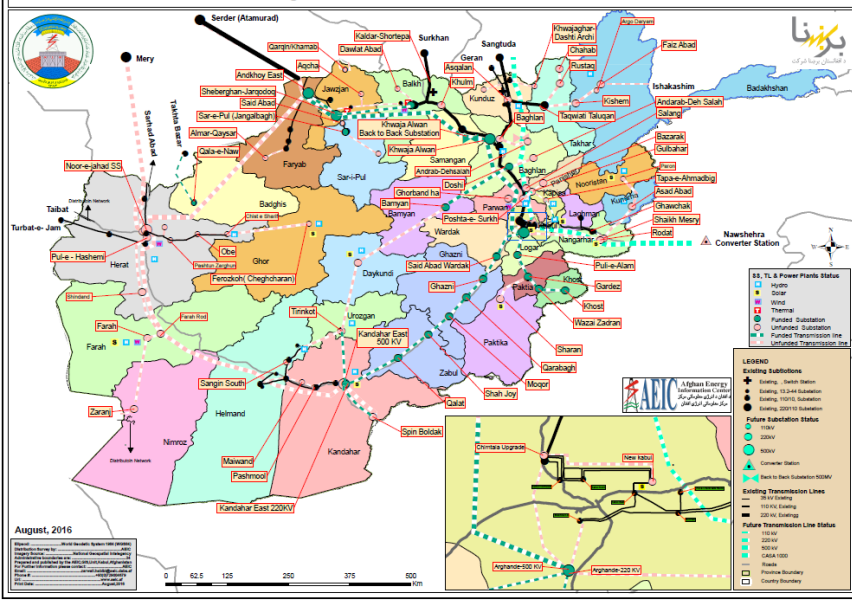


Southwest Asia – **Afghanistan**, Pakistan
Caucasus – Armenia, **Azerbaijan**, Georgia
Central Asia – Kazakhstan, **Kyrgyz Republic**,
Tajikistan, Turkmenistan, Uzbekistan

		Afghanistan	Azerbaijan	Kyrgyz Republic
Power generation capacity (MW, share %)	Total	520	7,905	3,786
	Thermal	200 (38.5%)	6,764 (85.5%)	716 (18.9%)
	Hydro	254 (48.9%)	1,105 (14%)	3,070 (81.1%)
	Wind	-	-	
	Others	65 (12.5%)	35 (0.5%)	
Potential and Installed PV capacity	Technical Potential	220,000 MW	115,200 MW	267,000 MW
	Installed capacity	A 20MW ADB financed project is being tendered	Around 35MW	None
Carbon Dioxide (CO ₂) emissions and NDC targets	million tons CO ₂ ^a	8.66	32.73	7.05
	Tons CO ₂ /capita ^a	0.27	3.36	1.19
	NDC ^b	-13.6% by 2030	-35% by 2030	-11.4% to -13.75% by 2030

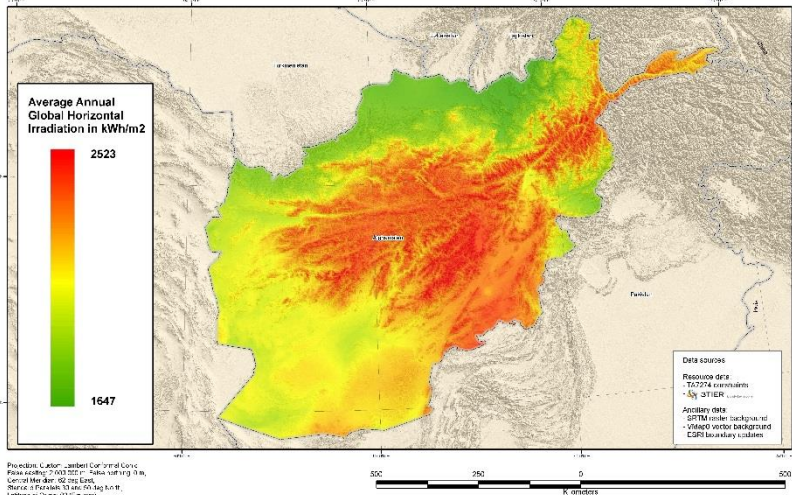
Pilot country - Afghanistan

Afghanistan National Grid Plan

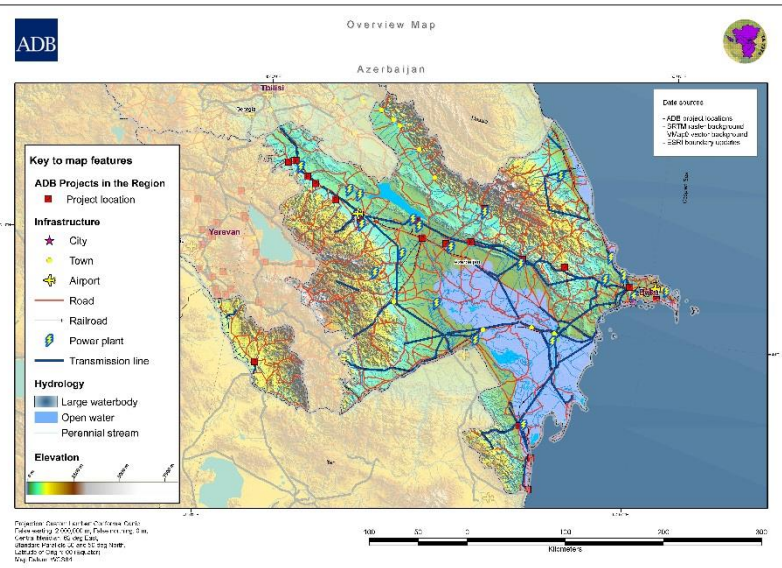
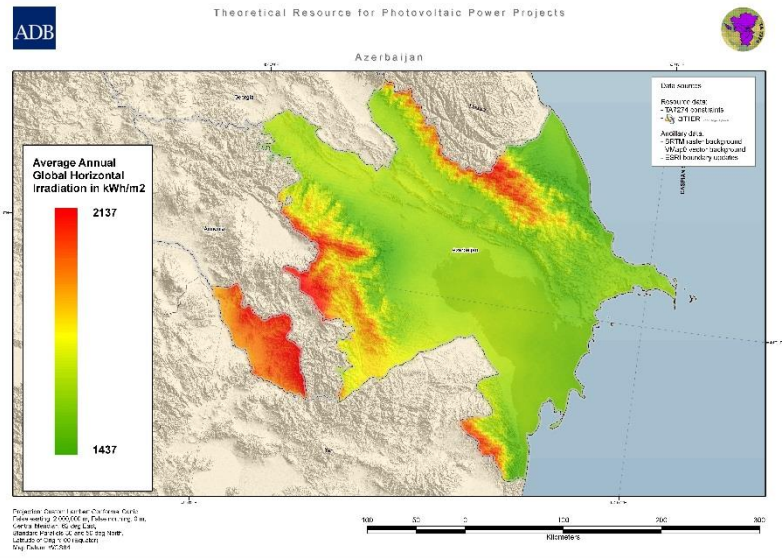


- Only 30% of population connected to the grid (among the lowest globally; targets 83% by 2030)
- Installed capacity only 519 MW
265 MW Thermal (diesel and furnace oil), with **generation cost of \$0.25-\$0.35 per kWh**;
254 MW Hydro needing or under rehab
- **Imports 80% of power supply** from Turkmenistan, Iran, Tajikistan and Uzbekistan
- **1,250 MW Signed PPSAs:**
TAJ 300 MW – seasonal (hydro); UZB 300 MW
TKM 300 MW (up to 500 MW); IRAN 150 MW
- imports bill increased 14 times from \$16 million in 2007 to \$224 million in 2016.
- Insufficient and unreliable supply affecting access to health services, education, and sanitation and restricts economic growth.
- aims to diversify into renewable energy but the long-standing unrest hinders development
- Security risks and rugged terrain
- **2,500 MW Suppressed demand;**
- **Island grids**

Theoretical Resource for Photovoltaic Solar Power Projects
PV Potential (GHI (kWh/m² per year))
Afghanistan



Pilot country - Azerbaijan



- Energy resource-rich and one of the world's oldest oil producing countries
- Power generation installed capacity of 7,400MW with 100% electrification. **Generation capacity is 85% fossil fuel, 14.9% hydro and negligible share of other renewables.**
- Azerbaijan plans to increase the share of renewable energy sources to 20% by 2020
- **Energy policy** - aims to increase renewable energy capacity to 2.5GW by 2020 including 600MW of solar PV. The solar PV capacity is around 35MW
- **INDC:** 35% reduction in the level of GHG emission by 2030, compared to 1990.
- **Solar PV** - operational solar module maker, Azguntex LLC, which owns a 75MW solar panel manufacturing facility since 2012. The Azguntex was established by the State Agency on Alternative and Renewable Energy sources.
- Irradiation: 1,400 – 1,500 kWh/m².year

Pilot country - Kyrgyz Republic



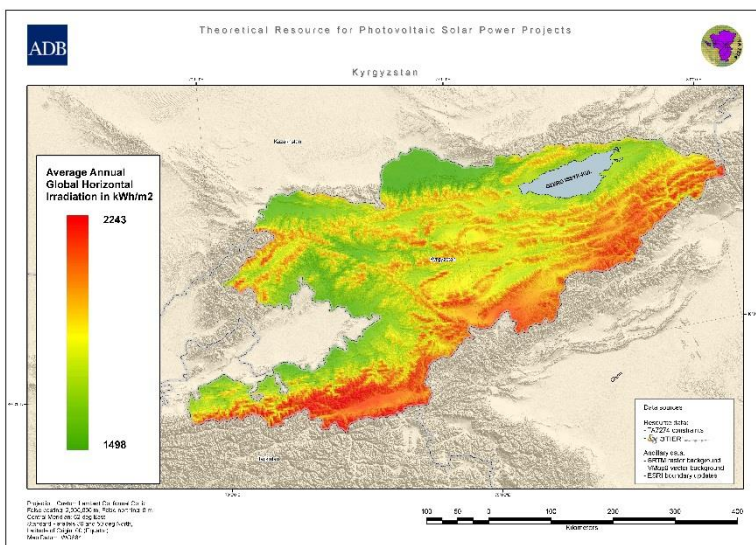
Land area: approx 200,000 km²
 Population: 6 million people

Primary energy sources:

- oil (32.7%)
- coal (31%)
- hydro (30.3%)
- natural gas (6%)

Electric power sources:

- hydropower (89.94%)
- coal (7.26%)
- oil (<1%)
- natural gas (<1%)

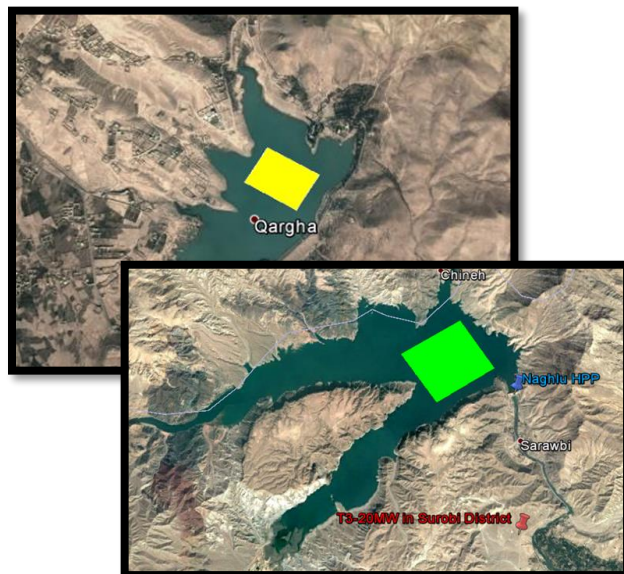


	Biomass	Solar PV	Wind	Small Hydro
Installed Renewable Electricity Capacity 2012 in MW	0	0	0	41.4
Technical Potential for Installed Renewable Electricity Capacity in MW	200	267,000	1,500	1,800

Sources: EBRD (2009); Botpaev et al. (2012); Ministry of Energy of the Kyrgyz Republic (2010); Hoogwijk and Graus (2008); Hoogwijk (2004); JRC (2011); SRS NET & EEE (2008); EIA (2013); Renewable Facts (2013); EIA (2010); World Bank (2014); DESERTEC (2012); and UNDP calculations.

RE-KSTA FSED: Potential Pilot Sites

Afghanistan Naghlu Reservoir / Lake Qargha



- Qargha lake; recreational area developed for trout fishing, and hatchery (~25 MW potential)
- Naghlu Reservoir (over 200 MW potential)

Azerbaijan Lake Boyukshor



- The largest of 9 lakes in the Absheron peninsula
- Saline and was used as a dumping site; on-going remediation program (over 500 MW potential)

Kyrgyzstan Toktogul Reservoir



- The largest reservoir in Central Asia, feeds 1,200MW HPP
- (over 20 GW potential)



Proposed ADB Technical Assistance Floating Solar Energy Development – (AFG, AZE, KGZ)

Potential for scale up, replication and showcasing various configurations, uses and benefits of FPV:

1. Qargha dam and reservoir in AFG: used for recreation and trout fishing and hatchery and is planned to supply additional drinking water to Kabul, provide irrigation, and feed a hydropower plant (HPP). Water conservation is essential in this dry and rugged topography. Qargha lake could fit at least 10 MW, while the Naghlu reservoir* could theoretically fit at least 200 MW of FPV.
2. Lake Boyukshor in AZE is saline and used as a dumping site for sewage and oil effluents. FPV could demonstrate climate-resilient lake restoration while displacing fossil-based power. The lake could theoretically fit 500 MW FPV and there are 8 more such lakes in Baku.
3. The 1,200 MW Toktogul HPP and reservoir supplies 40% of KGZ power, exports power and provides irrigation water to Uzbekistan. FPV could balance the seasonality of hydro with year-round generation. The lake could theoretically fit over 20 GW of FPV.

Implementation arrangements and counterpart in-kind contribution

1. ADB will be the TA executing agency working with the country executing agencies and CAREC-ESCC country focal persons.
2. The counterparts are: Da Afghanistan Breshna Sherkat (DABS), the Ministry of Energy and OJSC Temiz Shahar of Azerbaijan, and OJSC Electric Power Plants (EPP) of the Kyrgyz Republic.
3. The TA consultants will support TA administration and coordination, working closely with, assisting, and training the existing project management units (PMUs) in DABS, EPP and Temiz Shahar.
4. The country counterparts and their PMUs will provide data, office space, and technical staff, and assist in data collection, meeting arrangements and others, needed to accomplish the tasks. The TA is expected to be implemented over 31 months.

* The ADB-funded 20 MW land-based PV plant expected to be constructed in 2018 is 2 km away from and will be connected to the 100 MW Naghlu HPP