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Potential of Renewable Energy Sources in Uzbekistan

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Introduction

Contemporary energy policies in many countries worldwide emphasize great importance of renewable energy sources as a road map for reform and future development (Lund, 2007). Most developed countries have coherent renewable energy targets, while most of the developing countries put high emphasis on the extension of power generation from renewable energy sources (REN21, 2007). In Uzbekistan, the potential of some renewable energy sources is sufficiently high, but it requires increased awareness and the development of an incentive driven renewable energy propagation policy for a rapid and effective expansion of the renewable energy source utilization (IRG, 2005).

Indeed, Uzbekistan possesses an enormous potential of solar, biomass and biogas energy sources, while the potential of small scale hydropower and wind is also significantly high. However, the share of renewable and non-fossil fuels in Uzbekistan account currently for 600 *ktoe* (0.33%) (Abdullaev et al., 2000). Moreover, the geographic distribution of the available renewable energy sources is uneven and hence 'one policy fits all' approach in renewable energy source application may not be appropriate. Moreover, there are social, cultural and institutional factors that prevent renewable energy sources from being an optimal solution: inefficiency on the demand side, people's poor knowledge of the economic and ecological advantages of the available renewable energy sources and a coherent incentive policy to promote the use of renewable energy sources (IRG, 2005) being few of them.

The urbanization rate is around 35% and more than 65% of the population lives in rural settlements in Uzbekistan. Currently, 1500 remote rural settlements with 1.5 million (5%) people are not connected to the grid in the country due to a remote and low intensity allocation of these settlements. Renewable electricity sources could serve as an optimal energy solution for these settlements. Moreover, off-grid renewable energy source application in the remote areas could ease and accelerate the renewable energy penetration since it is not only economically viable but also cheaper than the traditional energy sources that require an expansion of the existing distribution infrastructure and high operational and maintenance costs.

First of all however, the techno-economic potential, the scope of the current renewable energy utilization process and the opportunities for the future expansion should be reviewed. The present section discusses the available theoretical potential, the current trends in renewable energy utilization in the country, analyses their technical feasibility and economic viability, and attempts to identify high priority beneficiaries (i.e. remote settlements, residential consumers, or state and public authorities) for each of these resources.

Hydropower potential

GW of this potential is already being exploited, the share of the large scale hydropower stations being 70% and small hydropower stations being 30% (REEEP, 2011). The currently installed hydropower capacities produce ca. 6 *THz/year* of electricity. The level of precipitation in Uzbekistan is low with an average annual rate of 200-220 *mm* and the country is not endowed with a significant number of glaciers (Perelet, 2007). Hence most of the hydropower resources available in the country originate in the neighboring Kyrgyzstan and Tajikistan. The Styr Darya river formed in Kyrgyzstan is shared also with Uzbekistan and Kazakhstan and the Amu Darya river originating in Tajikistan is shared also with Turkmenistan and Uzbekistan. It is worthwhile to bear in mind that peace and development processes in the riparian Afghanistan will make that country another major beneficiary of the Amu Darya river basin, putting even more constraint to the water availability in Uzbekistan both for irrigation and energy generation purposes.

Currently, the theoretically available hydropower potential accounts to nearly 12 GW of exploitable capacity in the four main river basins of Uzbekistan (Table 1). Around 1.2

Considering the fact that the country generated an annual gross electricity amount of 44-48 *TWh/year* between 1992 and 2008 reveals that the currently installed hydropower facilities are more technologically efficient in comparison with the fossil fuel based generation facilities. Indeed, the share of hydropower in the total installed capacity corresponds to 10% while it produces 12.5% of the electricity. However, the efficiency of the small scale hydropower generation is relatively low in comparison with the large scale hydropower due to the seasonal decrease of the flow. As most of the available large hydropower generation capacity is already being exploited, the technically feasible undiscovered hydropower potential mainly corresponds to small scale electricity generation, which will be less efficient.

Table 1: Gross theoretical hydropower potential of all major rivers basin in Uzbekistan

Basins	Gross Capacity (*GW*)	Energy (*TWh/yr*)	Output Share (*%*)	Capacity intensities (*kWh/sq km*)
Chirchiq-Angren basin	4.079	35.74	33.40	202.00
Ferghana valley	2.933	25.66	24.00	166.00
South-West	4.250	37.10	34.80	20.70
The Lower	0.969	25.66	7.80	5.64

Amudarya				
Total	12.231	107.00	100.00	98.60

Source: (IRG, 2005)

The theoretically exploitable hydropower capacity equals the current total installed electricity generation capacity of the country using all the fuels. Nevertheless it is realistic to assume that no utilization of all of this theoretical potential is techno-economically feasible, nor all the techno-economically feasible potential can be exploited in the medium or even long term. However, it is clear that hydropower has a substantial role to play in the future energy supply of Uzbekistan. It also offers a number of environmental advantages, in terms of avoided power generation based on diminishing fossil fuels and reduction of atmospheric emissions.

The Asian Development Bank (ADB) funded technical assistance study carried out by the International Resource Group (IRG, 2005) for the Ministry of Agriculture and Water Resources of Uzbekistan concluded that the small scale hydropower generation is the most promising off-grid renewable energy resource for meeting the agricultural energy demand in Uzbekistan. Due to the high share of agricultural production in the national economy of Uzbekistan, the largest part of the water received in the rivers is used for irrigation purposes. Consequently, the share of water spent for irrigation corresponds to ca. 95% of the total received waters in the most downstream Lower Amu Darya region, while the figure is still high in the upper regions. Due to the high irrigational water demand, the amount that can be dedicated for power generation is very limited especially in the internal canals which were artificially built for sustaining arid agricultural production in a dry climate. Hence the prospect of the Rogun dam being constructed in Tajikistan revives the inevitable danger of changing the water flow regime in the Amu Darya River, to which the agriculture sector of the downstream countries cannot withstand.

Moreover, small scale hydropower generation is relatively more expensive in terms of each unit of installed capacity in comparison with the large hydro power generation facilities and has a longer payback period (Twidel & Weir, 2006). Therefore small scale hydropower is less attractive for the investors. Additionally, due to a relatively much higher capacity and consequently high amount of capital investment requirements among the renewable sources, the small scale hydropower generation demands state or public organization initiated and controlled project realization and operation, hence is not preferred or affordable for the individual consumers. As mentioned above, another disadvantage of small scale hydropower generation in the sharp continental climate is its not functioning during the winter period due to the decreased water flow. The internal canals and small river basins freeze completely during a certain period that corresponds to the peak energy demand and hence does not provide a standalone energy solution. Therefore utilization of small scale hydropower should be realized in combination with some other sources that can replace the small hydropower production during the winter.

Hence, the small scale hydropower generation can be a more preferred renewable energy solution as a government funded medium or small scale project, especially for meeting the agricultural energy demand due to its correspondence in terms of demand-supply time period. As for the residential consumption, small scale hydropower can be used as a supplement to the centralized electricity supply system during the periods of availability of water, but is not a promising solution for meeting the residential electricity demand as it is not a remote standalone renewable energy resource.

Solar potential

Similar to most of the Asian countries, solar power is considered as one of the most promising renewable energy source in Uzbekistan. The number of sunny days is very high with more than 300 sunny days a year all over the country (Komilov, 2002). Approximately 75% of the country consists of deserts, which is favorable for solar PV and solar thermal power utilization. However its utilization is yet not organized despite this high potential.

A study by Abdullaev and Isaev (2005) revealed that among the renewable sources solar photovoltaic (PV) power generation might be the most appropriate residential energy source from a technical point of view

(*Table 2*) with gross solar radiation potential of 50793*Mtoe*, of which 176.8*Mtoe* is technically exploitable. The technically exploitable amount is triple the amount of the current total primary energy production of 55*Mtoe* (including exports).

The solar radiation intensity (insolation) varies slightly due to the geographic location and natural condition within the country, where only few pre-mountain areas are in the range of low techno-economic viability due to a lower insolation rate. In average the insolation ranges from 0.80 to 1.21 in Uzbekistan, which is higher than the most Western European Countries and slightly lower than the South European countries such as Italy and Spain (Figure 1).

Table 2: General solar energy characteristics in Uzbekistan

Characteristics	Winter	Summer
Solar elevation		
North: 45°35' n.l.	68°	21°
South: 37°10' n.l.	76°	29°
Daily sunshine duration, *hours/day*	3 - 5	10 – 13
Days without sun, *days/year*		
North	45-50	10 – 15
South	22 - 25	1 – 4
Average sunshine duration, *hours/year*		
North	2800	
South	3050	

Direct solar radiation intensity (S), *kW/m²*	
on plains	0.80 - 0.94
on high-altitude stations	0.94 - 1.06
on Kyzylcha station, S_{max}	1.21
Duration of minimal sunshine, *hours/month*	80.0 - 100.0

Source: (Abdullaev & Isaev, 2005)

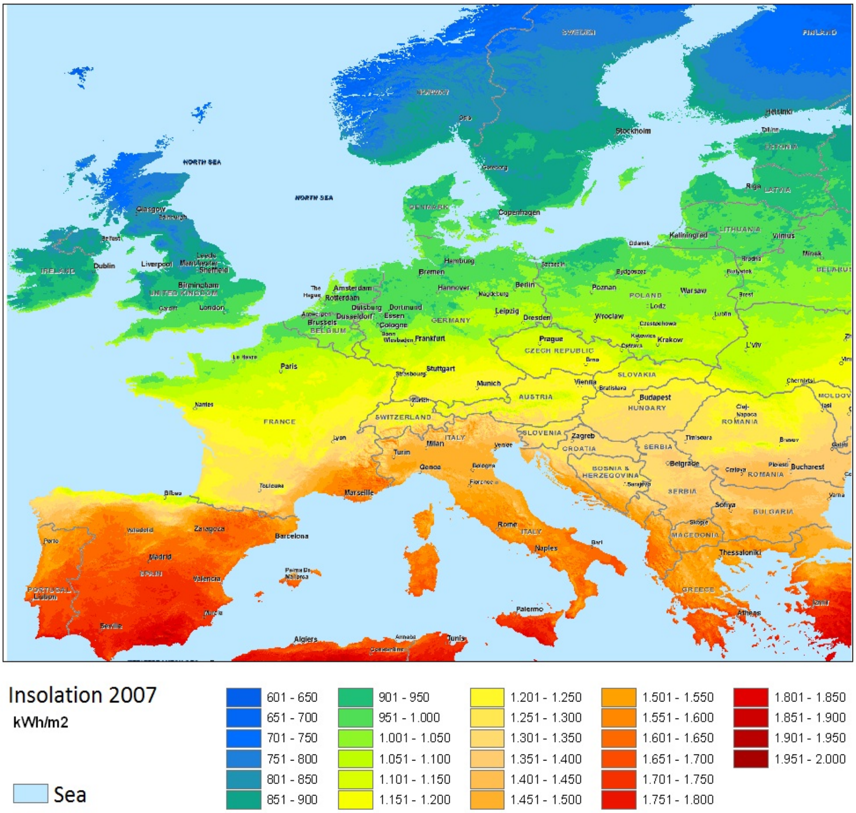

Figure 1: Average daily solar insulation map of the European continent, 2007 *Source:* (SolarGIS, 2011)

Table 3 shows the solar potential of photoelectric energy in the provinces of Uzbekistan conditional to 1% of the total area of the province being covered with solar panels of 10% and 18% conversion efficiency. The range 10% and 18% conversion efficiency rate is based on the potential of the current photovoltaic panels available on the market (Probst et al., 2001).

Table 3: Technical potential of solar photoelectric energy in the provinces of Uzbekistan based upon 1% of area usage

No.	Province	Area (*thousand sq km*)	10% efficiency (*TWh/year*)	18% efficiency (*TWh/year*)
1	Karakalpakistan Rep.	164.90	130.00	224.00
2	Andijan	4.20	0.18	0.33
3	Bukhara	39.40	23.00	41.00
4	Jizzakh	20.50	9.80	17.5.00
5	Kashkadaryo	28.40	14.00	25.00
6	Navoi	110.80	58.00	105.00
7	Namangan	7.90	0.34	0.60
8	Samarkand	16.40	8.40	15.00
9	Surkhandaryo	20.80	13.00	36.00
10	Sirdaryo	5.10	1.10	2.00
11	Tashkent	15.60	4.90	9.10
12	Fergana	7.10	0.29	5.30
13	Khorezm	6.30	2.10	3.80
	Total	447.40	265.11	484.63

Source: (IRG, 2005)

As seen from Table 3, only 0.1% to 0.2% coverage of the country's area can provide a sufficient amount of electricity (including the exports) currently. However, the price of the solar photovoltaic panels is relatively high compared to the subsidized centrally supplied electricity prices, while additional accumulators are required for night time electricity supply, which increase the capital investment amount substantially.

Currently a square meter PV panel (without accumulators) with an average production capacity of 100 *Wp*[1] costs ca. US$ 270-300 in Uzbekistan and the price of the accumulators vary depending on their capacity and quality. Hence total PV installation costs for an average family as well as small business can only be guessed at this level. Cost-Benefit Analysis (CBA) of the PV system application can be provided only after obtaining precise data and information on the crucial indicators. Some of these indicators are the total costs, benefits, average per capita electricity and natural gas demand and household electricity and natural gas consumption levels.

Expansion of photovoltaic (PV) electricity generation in Uzbekistan requires more technical innovation penetration such as PV charged electricity storage accumulators and efficient electricity consuming appliances being the most crucial ones for efficient solar power utilization.

Due to the diverse geographic allocation of the population, some large solar power generation plants are being studied with an explicit spatial approach by the Government of Uzbekistan and some international investors. The Russian oil giant Lukoil, in cooperation with the Asian Development Bank is planning the construction of a 100 *MW* solar facility which is expected to be enlarged to 1*GW*. However, exact dates for this project are not clear yet (Business Insider, 2011).

In comparison to the solar PV power generation, solar space heating and hot water supply requires relatively less initial capital investments and less technological innovation penetration. Therefore it has more perspective in terms of quick penetration and dissemination in the residential sector. Although there is no figure about the current level of energy consumption for space and water heating, it should be considered that, due to a sharp continental climate, the solar thermal potential is high during the summer when the demand is at its minimal point while the potential reaches its minimum during the winter when the demand is at its peak.

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[1] Wp (Watt-peak) is a measure of the nominal power of a photovoltaic solar energy device under laboratory illumination conditions. Related units such as kilowatt-peak or kilowatts-peak (kWp) and megawatts-peak are also used, and in the context of domestic installations kWp is the most common unit encountered.

Moreover, although the Table 4 gives the potential of solar thermal in electric power units of *THz*, actual energy value for gross solar thermal potential is 90 and 180 *ktoe* for 40% and 80% collector efficiency respectively under 1% total area coverage. This is an enormous thermal energy, however cannot be used for other purposes than space and water heating.

Although there is no exact figure for Uzbekistan, space heating and hot water supply account for 65% of the residential energy consumption in the Western countries (Stettler, 2010). Bearing in mind the fact that the population of Uzbekistan with lower life standards has less electricity consuming devices and lower thermal insulation efficiency, we can assume that the figure is at least similar in Uzbekistan. Hence solar thermal potential can be utilized in the residential sector for space and water heating for domestic uses, especially in the rural areas where central supply of hot water for heating and domestic purposes is not organized contrary to the urban areas.

IRG (2005) accounted the residential energy demand of the rural population in Uzbekistan as 3370.6 *GWh/year*. Concluding from above that 65% of this energy was used for space and water heating, a residential demand for solar thermal energy of 2191 *GWh/year* can be assumed. This leads to a conclusion that only 0.001 to 0.002 % of the total area coverage (or 450 – 900 km^2) with solar thermal heaters can meet the energy spent for space and water heating in the rural residential sector (ca. 19 *million people*).

Based on their purpose, public buildings can also switch to solar thermal water heating with relatively small investments while solar thermal space heating may require significantly higher investments for renovation and improved thermal insulation. Another potential beneficiary of the solar thermal power in Uzbekistan may be the greenhouse based agricultural production, which is also responsible for most of the natural gas consumption in the agricultural sector. IRG (2005) indicates the greenhouse heating and livestock and poultry keeping demand of energy as 166 *GWh/year*, which can easily be met by applying solar thermal heaters.

Table 4: Technical potential of solar thermal energy in the provinces of Uzbekistan for heat supply based upon 1% area usage

No.	Province	40% Collector efficiency (*TWh/year*)	80% Collector efficiency (*TWh/year*)
1	Karakalpakistan Rep.	520.00	1040.00
2	Andijan	0.72	1.44
3	Bukhara	92.00	184.00
4	Jizzakh	39.20	78.40
5	Kashkadaryo	56.00	112.00
6	Navoi	232.00	464.00
7	Namangan	1.36	2.72
8	Samarkand	33.60	67.20
9	Surkhandaryo	52.00	104.00
10	Sirdaryo	4.40	8.80
11	Tashkent	19.60	39.20
12	Fergana	1.16	2.32
13	Khorezm	8.40	16.80
	Total	1060.00	2120.00

Source: (IRG, 2005)

Wind potential

Uzbekistan, a double landlocked country with no coastal area, consists of 25% mountainous valleys and 75% desert covered oasis. Therefore the average yearly wind speed on the whole territory of the country is estimated between 2-2.5 m/sec, which indicates a non-promising future for wind power engineering in Uzbekistan, especially for wind turbines of middle and high power (Abdullaev & Isaev, 2005).

Consequently the wind energy potential in Uzbekistan is relatively less exploitable in comparison with the solar and hydropower potential

(*Table 5*). Even in the provinces with a reasonable potential wind resource is very seasonal and it is necessary to study the coincidence between peak wind months and the electricity demands.

Table 5: Gross Potential of Wind Energy in the Provinces of Uzbekistan

No.	Province	Area of wind resource *km²*	Gross potential *W/m²*	Gross energy *GWh/year*
1	Karakalpakistan Rep.	1649	93	10752.20
2	Andijan	42	20	60.00
3	Bukhara	294	90	2421.80
4	Jizzakh	205	49	649.60
5	Kashkadaryo	284	58	1162.00
6	Navoi	1108	104	7931.40
7	Namangan	79	28	155.40
8	Samarkand	164	61	690.60
9	Surkhandaryo	208	30	434.80
10	Sirdaryo	51	58	212.00
11	Tashkent	156	100	1066.00
12	Fergana	71	34	49.60
13	Khorezm	63	55	264.00
	Total	4474	84	25849.00

Source: (IRG, 2005)

Interestingly however, the techno-economic potential of wind energy in the country is studied more than the other sources, including also some pilot projects (Gov.uz, 2011). The IRG (2005) study however found two of the districts as techno-economically feasible for wind power generation: Bekobod district in the Tashkent province and Maydanak district in Karakalpakistan.

With about 3 *million tons* of annual output, cotton stalks deserve more attention for efficient use in energy generation. Combined combustion in the natural gas powered turbines would increase the energetic value derived per kilogram of cotton stalk, but it requires prerequisites such as

Biomass potential

Due to its large agricultural sector Uzbekistan has an enormous potential of biomass energy generation. Main source of biomass in the country is cotton stalks (*Table 6*). Almost all of this cotton stalk resource is consumed for cooking and space heating in the rural areas by using the most conservative combustion process.

Table 6: Gross and technical potential of agricultural biomass residues (cotton stalks) in the provinces of Uzbekistan (1998)

No,	Province	Area of cotton fields (*thousand hectares)*	Produced cotton stalks (*thousand tons/year*)	Gross energy potential (*ktoe/year*)	Technical power potential (*GWh/year)*
1	Karakalpakistan Rep.	145	290	111	145
2	Andijan	110	220	84	110
3	Bukhara	129	258	99	129
4	Jizzakh	111	222	85	111
5	Kashkadaryo	173	346	132	173
6	Navoi	44	88	34	44
7	Namangan	91	182	70	91
8	Samarkand	97	194	74	97
9	Surkhandaryo	120	240	92	120
10	Sirdaryo	141	282	108	141
11	Tashkent	108	216	83	108
12	Fergana	127	254	97	127
13	Khorezm	100	200	76	100
	Total	1496	2992	1145	1496

Source: (IRG, 2005)

With about 3 million tons of annual output, cotton stalks deserve more attention for efficient use in energy generation. Combined combustion in the natural gas powered turbines would increase the energetic value derived per kilogram of cotton stalk, but it requires prerequisites such as buying from the population, properly drying, chopping and storing as well as upgrading the thermal power furnaces to ones that allow combined biomass combustion.

Moreover, there are some other locally available resources in the remote areas of the country. Muynak town surrounded with infertile wetlands that are located in the seabed of the shrunk Aral Sea and its surrounding, has a large amount of annually re-growing reed output. It can be a local solution both for biogas production and for traditional combustion just like the cotton stalks in the other areas. The potential of these resources is not studied so far.

Another source of biomass is the household waste. Urban areas with already existing waste collecting infrastructure can enjoy waste combustion in the dense cities such as the capital Tashkent, Andijan and Samarkand. However, public awareness and waste sorting should be organized before being able to use the household waste as a source of energy. Already existing landfills cannot be used for combustion due to the existing hazardous content such as mercury and lead based batteries and incombustible polymer products. Hence organizing efficient use of biomass requires increased public awareness, and capital investments and not less importantly– a behavioral change.

Conclusions

The potential of small scale hydropower, solar and biomass energy sources is enormous in Uzbekistan, while exploitable wind potential is available seasonally in some regions. Small scale hydropower is an optimal solution for a centralized larger scale and state or public institution funded renewable energy projects in the rural areas. The wind power potential viable in certain areas also requires state intervention for project realization due to a higher initial capital requirement. Solar PV is the most appropriate energy source for individual household application, however is expected to have a very long payback period due to the low residential electricity tariffs. Hence the economic viability of solar PV sources should be studied more deeply for precise conclusions. The most appropriate, easy to install and easily affordable source is solar thermal heaters which can be used by the households as well as in the public facilities such as rural hospitals, libraries and schools.

To exploit these renewable energy sources which are enormous considering the total demand for electricity of 48 THz/year, it is absolutely necessary that a behavioral change occurs. It is also crucial that the current energy supply is used more efficiently. This is possible for example by steadily replacing the electricity consuming appliances such as light bulbs, TV-sets and refrigerators with new, more efficient ones. To discover whether such a behavior change is possible, the perceptions of the people towards renewable energy utilization should also be investigated.

References

[1] Abdullaev, D.A., Chub, V.E., Isaev, R.I. & Tolkacheva, G.A., 2000, *Wind and Solar Energy as a Source of Reducing Environmetnal Pollution,* In ICEHM2000. Cairo, 2000, Cairo University

[2] Abdullaev, D.A. & Isaev, R.I., 2005, *Resources of Solar Radiation and Wind Energies in Uzbekistan and System of Their Combined Utilization*, ISESCO Science and Technology Vision, pp.76-82

[3] Business Insider, 2011, *Russia's Lukoil to Establish Solar Energy Plant in Uzbekistan*, [Online] Available at: http://www.businessinsider.com/russias-lukoil-to-establish-solar-energy-plant-in-uzbekistan-2011-9 [Accessed 22 October 2011]

[4] Gov.uz, 2011, *Issues of using renewable energy sources. [Online]* Available at: http://www.parliament.gov.uz/en/events/other/3848 [Accessed 10 October 2011]

[5] IRG, 2005, *Off-grid renewable energy development for the republic of Uzbekistan. Technical Assistance Consultant's Report,* Washington, DC: Asian Development Bank International Resource Group

[6] Komilov, A., 2002, *Renewable Energy in Uzbekistan, Potential and Perspectives. Renewable Energy for Sustainable Development*, DAAD and Oldenburg University Press, pp.246-56

[7] Lund, H., 2007, *Renewable energy strategies for sustainable development*, Energy 32, p.912–919

[8] Perelet, R., 2007, *Central Asia: Background Paper on Climate Change. Human Development Report Office Occasional Paper*

[9] Probst, P. et al., 2001, *Rapid CIS-process for high efficiency PV-modules: development towards large area processing*, Thin Solid Films, 387

[10] REEEP, 2011, *Policy DB Details: Uzbekistan* (2009), [Online] Available at: http://www.reeep.org/index.php?id=9353&text=policy&special=viewitem&cid=91 [Accessed 22 October 2011]

[11] REN21, 2007*, Renewables - Global Status Report. REN21 - Renewable Energy Policy Network for the 21st Century*

[12] SolarGIS, 2011, *iMaps project*, [Online] Available at: http://solargis.info/imaps/#c=19.145168,83.496094 [Accessed 22 October 2011]

[13] Stettler, Y.N., 2010, *Cost Efficiency of Thermal Insulation. Term paper on Energy Economics and Policy Course,* Geneva: ETH

[14] Twidel, J. & Weir, A.D., 2006, *Renewable energy resources*, New York: Taylor & Francis