Green Power for Mobile

Supported by

International Finance Corporation
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Tcell

Tcell – Tajikistan – Feasibility Study

In March 2011, Swedish telecom major TeliaSonera Eurasia signed an agreement with the GSMA for a Feasibility Study to be conducted by the Green Power for Mobile (GPM) team. The study encompassed technical and financial feasibility analyses on a large number of base stations in TeliaSonera's existing and planned networks in Nepal, Tajikistan and Azerbaijan, and identified those that are most suitable for green power solutions.

Introduction

A Field Implementation Manager from GSMA's GPM Team was mobilised to each of the above operations where he stayed with each operation for about one month undergoing the information collection and analysis required to study their feasibility for renewable energy on both technical and financial grounds.

The entire projects duration spanned about 70 days, and its Primary Objective was to ensure that TeliaSonera maximises Return on Investment (ROI). Additional objectives of the project were:

- Provide recommendations on alternative energy technology, equipment sizes, new technologies, equipment trial possibilities, forecast CAPEX, forecast ROI & forecast NPV for base stations
- To support establishment of a centre of excellence within TeliaSonera through the provision of training materials and a training curriculum from GSMA Green Power for Mobile
- To assist with vendor identification and RFP (Request for Proposal) interpretations
- To provide a monitoring and evaluation framework (Key Performance Indicators) for assessing the technical and financial performance of the sites
- To provide TeliaSonera with a global platform from which to publicise its environmental

initiatives, through GSMA publicity materials/communication channels

- Introduce TeliaSonera to development banks including the International Finance Corporation (IFC – member of World Bank Group) to investigate financing options to support green power networks

In each of the three operations, a kick-off and close-out presentation was delivered to the technical team and senior management outlining the results of the analysis done. Moreover, an in-depth training on the technical simulation and financial analysis for renewable energy systems were delivered to multiple personnel within each operation.

At each of the operations, the following has been explored in detail to come up with a sound feasibility analysis for renewable implementation:

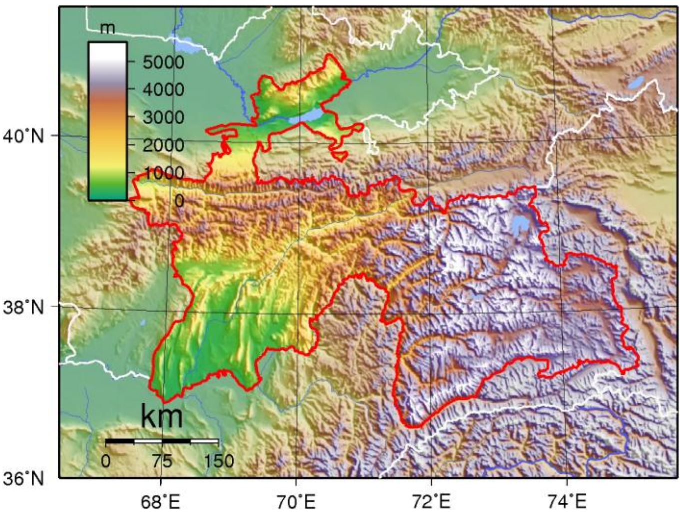
- Site technical information:
  - Power consumption, power plant, expansion plans
  - Outages, traffic volumes, operational pattern
  - Site layouts, connectivity
  - Equipment specifications and feedback on performance
- Equipment and service costing of existing service providers and system integrators
- Financial modelling information:
  - Interest rates, custom duties, insurance and transpo, etc.
  - Traffic patterns and call tariffs
- Logistical costs
- Meteorology office visit, NASA info, 3tier.com, GPM database

About Tajikistan

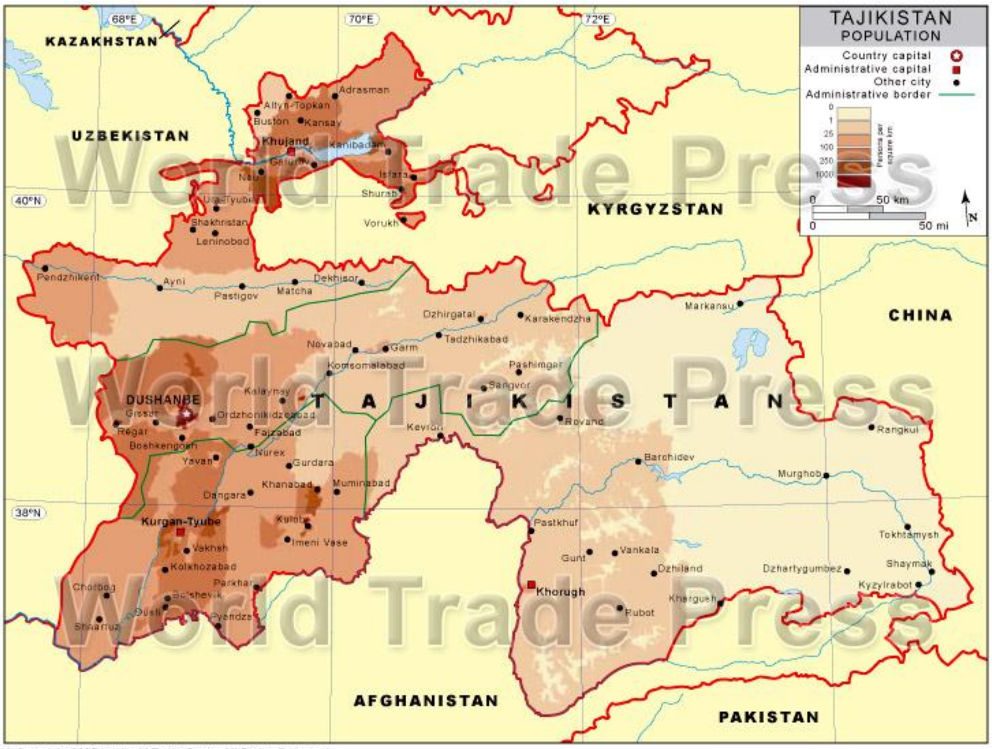
Tajikistan is a mountainous landlocked country in Central Asia. Afghanistan borders it to the south, Uzbekistan to the west, Kyrgyzstan to the north, and People's Republic of China to the east. Tajikistan consists of 4 administrative divisions: these are the provinces (viloyat) of Sughd and Khatlon, the autonomous province of Gorno-Badakhshan (abbreviated as GBAO), and the Region of Republican Subordination.

Each region is divided into several districts. Dushanbe – the capital – is located on the southern slopes above the Kofarnihon valley. Tajikistan's area is about 143,100 km^2 (55,251 sq mi) and its population is approximately 8 million. Per capita GDP in Tajikistan is US$2,103.

93% of Tajikistan is mountainous with altitudes ranging from 300m (980ft) to almost 7,500m (24,600ft), and nearly 50% of Tajikistan's territory is above 3,000m (9,800ft). The mountainous region to the east of the country is very low in population density as the majority of the population inhabits the western part of the country.[1]



[1] Wikipedia



Power Situation in Tajikistan

The 4 major sources of household fuel in Tajikistan are firewood, electricity, cow dung, and natural gas. Households and industry rely heavily on imported petroleum, natural gas, and—to a lesser extent— electricity, primarily from Uzbekistan. Tajikistan has an estimated 5.6 billion cubic meters of recoverable natural gas reserves, but due to financial barriers (and bureaucracy), it has been unable to increase its production.

Tajikistan has the potential of being one of the world's leading per capita producers of energy if it were to expand its system of dams and hydroelectric plants. As it stands, due to the east-west configuration of its electricity grids, the country imports and exports electric energy without satisfying or affording its electricity needs. Large parts of the country, especially small towns and villages, face frequent and long periods of blackouts.[2]

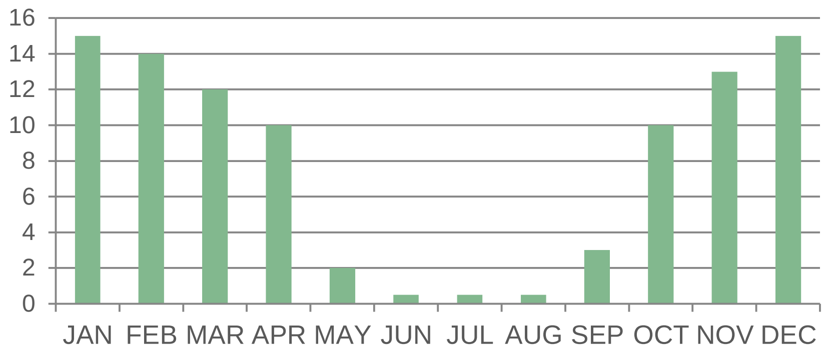
Grid availability in Tajikistan is seasonal and sinusoidal in nature as the primary source of power comes from hydro-plants nationwide triggered by the monsoon and the melting of ice on mountain-tops during the summer time. The average daily power outage (in hours) throughout most of the country is shown in the table below:

[2] http://www.nationsencyclopedia.com/economies/Asia-and-the-Pacific/Tajikistan-INFRASTRUCTURE-POWER-AND-COMMUNICATIONS.html#ixzz1WCP5u8Lk

Tajikistan's Regions have an Average 8 hrs. of Grid Blackout per day

HOMER Simulation Grid Blackout (outage hrs.)

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
15	14	12	10	2	0.5	0.5	0.5	3	10	13	15



Legend:	Severe Outage	High Grid Outage	Low Grid Outage	Stable Grid

Tcell Network – In Brief

Tcell in Tajikistan is represented by two legal companies: CJSC Indigo Tajikistan, operating in RRS, Khatlon and GBAO regions and CJSC JV Somoncom, operating in Sugd region. Both companies share the same values, offer the same products and are owned by the same shareholders. While using services customers of each company feel like they are customers of the same company (regarding services, prices and network coverage perspective).

Tcell is a common brand of CJSC Indigo Tajikistan and CJSC JV Somoncom as of March 2010. CJSC Indigo Tajikistan (South Tajikistan) was established in November 2001. Indigo Tajikistan obtained a GSM-900 license in November 2001 and started commercial operation in July 2002. In 2003, the north and south networks were united through a direct national roaming interconnection and continued working under the common brand Indigo. During 2005-2006, the companies launched automatic international roaming, channel and data transfer (including IP, GSM-900/1800 and telematic service), 3G-UMTS and WAP/GPRS/MMS services. In July 2007, TeliaSonera acquired controlling interest in Indigo Tajikistan and Somoncom, and its ownership in Tcell is 60%.

Tcell – Challenges Faced

- There was a language barrier faced during the information collection and analysis stages, as the main languages spoken by the majority are Russian and Tajik.
- At the time the feasibility study was held, Tcell had two completely separate and independent operations in the North (Khujand) and South (Dushanbe) of the country, which ultimately doubled the work load within the project time allocated for a single operation.

Tcell Network Highlights

The analysis was therefore performed separately for Tcell North and Tcell South. Each of the operations had about 500 operational sites. The north operation has taken a lead in renewable deployment—at the time of the feasibility study it already had eight sites with solar energy and one site with hybrid solar and wind energy. All sites in the Tcell network have grid power connected to them with the exception of the ones with green power already deployed.

For each of the operations, sites were then broken down based on the following: (A) not suitable for renewable, conservative design for renewable may be implemented, and free design of renewable system may be implemented (B) average daily grid power outage in hours / day (C) diesel generator on site.

NORTH SITES BREAKDOWN													
DG On-Site		NO DG			11 kVA			15 kVA			20 kVA		
Average Daily Grid Outage (hrs.)		0	2.5	8	0	2.5	8	0	2.5	8	0	2.5	8
152 Free Design	GF: (144 - 2) = 142	2	4	24	0	5	56	0	0	51	0	1	1
	RT: (8 - 5) = 3	5	0	0	0	0	1	0	0	2	0	0	0
192 Conservative	GF: (174 - 6 -1) = 167	6	3	25	0	2	67	0	1	67	0	0	3
	RT: (17 - 4) = 13	3	0	3	0	0	5	1	1	4	0	0	0
87 Not Suitable	GF: (45 - 18 -1) = 26	13	3	7	5	3	1	0	2	9	0	1	0
	RT: (42 - 28) = 14	21	6	2	2	0	2	3	1	3	2	0	0
Total (429 sites)		**50**	**16**	**61**	**7**	**10**	**132**	**4**	**5**	**136**	**2**	**2**	**4**

Renewable Not Needed	63 = (50 + 7 + 4 + 2)
Consider Battery Bank Expansion	33 = (16 + 10 + 5 + 2)
Need Renewable	333 = (61 + 132 + 136 + 4)
Total	429 = (333+33+63)

SOUTH SITES BREAKDOWN																
DG On-Site		NO DG			11 kVA			15 kVA			20 kVA			40 kVA		
Average Daily Grid Outage (hrs.)		1	4	8	1	4	8	1	4	8	1	4	8	1	4	8
70 Free Design	GF: (68 - 23) = 45	4	2	4	18	7	31	0	0	0	1	0	0			
	RT: (2 - 1) = 1	1	0	0	0	0	1	0	0	0	0	0	0			
174 Conservative	GF: (174 - 6 -1) = 167	45	6	6	13	27	49	0	0	0	2	1	1	1	0	0
	RT: (17 - 4) = 13	9	1	1	0	4	7	0	0	0	1	0	0	0	0	0
318 Not Suitable	GF: (45 - 18 -1) = 26	20	1	39	26	25	202	0	0	0	0	1	0			
	RT: (42 - 28) = 14	0	0	0	0	0	3	0	0	0	1	0	0			
Total (429 sites)		**79**	**10**	**50**	**57**	**63**	**293**	**0**	**0**	**0**	**5**	**2**	**1**	**1**	**0**	**0**

Renewable Not Needed	142 = (79 + 57 + 5 + 1)
Consider Battery Bank Expansion	75 = (10 + 63 + 2)
Need Renewable	344 = (50 + 293 + 1)
Total	561 = (344 + 75 + 142)

As can be observed from the above tables, for Tcell North only 344 sites (152+192) could have some sort of renewable system implemented (based on feedback from the operations team, either due to space limitation or being in government buildings). However, only those that have 8hrs on average daily grid outage (RED Column), would justify having renewable investment as for the sites with 2.5 or 0 hrs of average daily grid outage do not justify having a large investment for a power system. Sites that have 8 hrs of average grid outage, and are not suitable for renewable deployment, could be considered for battery expansion or Deep Cycle Battery deployment as needed. This is in addition to the sites with 2.5hrs average daily grid outage (ORANGE Column). Sites that have 0hrs average grid outage should be kept as is, as the OPEX in maintaining these sites running is quite low to start with.

Likewise for the Tcell South, only 144 sites (70+174) could have renewable systems deployed in them. Of the 144 sites, only 100 sites have 8 hrs of average daily grid outage. All the sites in the ORANGE column – with 4 hrs of average daily grid outage and the sites in the RED column but are not suitable for renewable should be considered for battery expansions or deep cycle battery deployment if needed.

Approach to Financial Analysis & Site Modelling

The financial analysis or business case for renewable energy deployment in operational telecommunication networks aims at comparing Existing CAPEX & OPEX vs. Renewable CAPEX & OPEX. Additionally, if a network experiences severe site outages due to grid power unavailability, the mobile network suffers losses in all the following:

- Revenue: outgoing calls & SMS
- Revenue: incoming calls & SMS interconnection charges
- Revenue: VAS services
- Revenue: subscriber churn
- Brand Image: subscriber dissatisfaction

This lost revenue from severe site outages would not be incurred if correctly dimensioned renewable energy systems were deployed on these sites. For networks with severe site outages – primarily due to power unavailability – the business cases for renewable deployment have to include a value for the lost revenue (i.e. comparing existing CAPEX, OPEX & Lost Revenue vs. renewable CAPEX & OPEX). Since the primary source of revenue for most mobile networks comes from outgoing calls and SMS, only this will be taken into account while calculating revenue losses for a mobile network.

In order to come up with a value for the lost revenue, a dollar value for a minute of outgoing voice traffic and SMS on that network needs to be computed. For that purpose, the following was explored:

- Actual outage time of sites
- Actual traffic volumes of sites
- Calling charging rates
- Estimate revenue model for sites throughout project life

Ultimately, this value was calculated for Tcell, and a project lifetime of 15 years was considered for renewable energy projects.

Furthermore, the discount rate considered for this project in Tajikistan was taken as 12% (provided by the finance team at Tcell and is the average of a bouquet of banks in-country), and the average running hours per diesel generator for sites with 8hrs average daily grid outage was considered as 120hrs per month.

Whilst doing the dimensioning of renewable systems for Tcell sites, the following was taken into account:

- Use FCU / DC Fan for each indoor site:
    - price of FCU was included in business cases for all sites
    - additional load 200W is added to all sites modelling (*since all Tcell sites are indoor*)
    - Some manufacturers of DC Aircons: DC Aircon: DC Airco, Split Cool, Fujitsu General
    - Some manufacturers of Free Cooling Units: BSMC Power, STULZ, ACME Tele power etc.
        - e.g. ACME Telepower: FCU_48VDC-1000CFM (200W) ~ US$1300 DDU Tajikistan
        - e.g. DCAirco: DC 9200HA (672W), DC 10.000HA (770W) ~ US$4700 DDU Tajikistan
- Use battery cooler for each indoor site:
    - Will reduce heat in the room/shelter
    - Will increase the battery life to almost double
    - Cost was not included in business cases *(additional US$3,000 CAPEX)*
- Additional new batteries were included as CAPEX for all sites
- Additional new rectifier was included as CAPEX for all sites where >60 A was needed
- Average transpo & W/H Cost $400 was added to all business cases

- Average diesel cost per liter was estimated at $ 1.46 per liter
- Average O&M Cost for DG was estimated at $ 1.43 per running hour of DG

Renewable Indicators and Pointers

Solar

- Solar patterns do not vary much within a few square kilometres
- Solar Insulation is low during the months where grid power is unreliable Oct-Mar
- Solar Insulation is high during Apr-Sept *(excellent for sites not connected to Grid)*

Monthly Averaged Insulation Incident on a Horizontal Surface (kWh/m^2/day)												
Lat 40.209 Lon 69.666	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
22-year average	1.98	2.85	3.90	5.26	6.64	7.78	7.76	6.90	5.49	3.86	2.40	1.73

Wind

- Wind patterns do vary incredibly within a few meters – especially due to the mountainous and hilly terrain that is 93% of the land
- Wind Speeds must be measured and/or surveyed prior to deploying Wind turbines for any site – as it may either be 100% beneficial or 100% loss if the location of the set-up was mistakenly chosen
- My recommendation is to go for Wind Turbine manufacturers that offer 5 year warranties to avoid risk

Monthly Averaged Wind Speed at 50, 100, 150 and 300 m Above Earth's Surface (m/s)													
Vegetation Type: Rough glacial snow/ice													
Lat 37.23 Lon 71.484	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
50m	7.86	7.43	7.50	7.21	6.67	6.02	6.33	6.50	6.72	7.48	7.77	7.54	7.08

Site Modelling

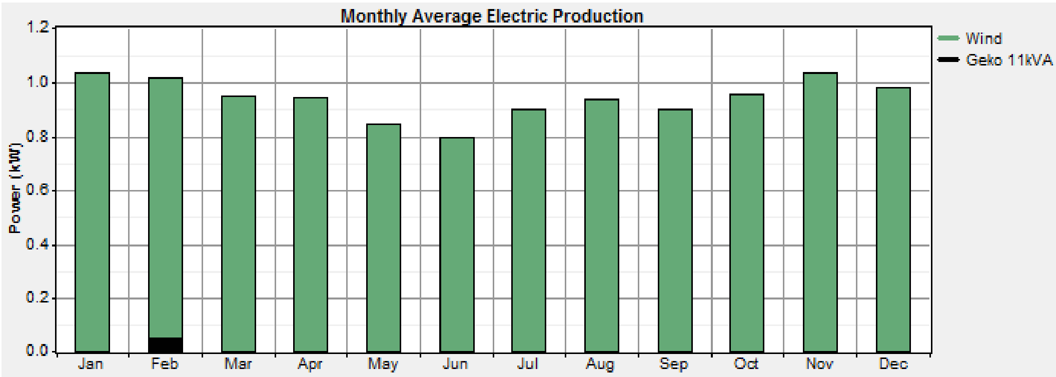
All 309 sites of Tcell North and 100 sites of Tcell South were then grouped into models (13 for the North and 6 for the South) according to the following: 1) average site power requirements, 2) power outages experienced, and 3) DG availability on site.

Sample Results 1: Model 3 – Tcell South (28 indoor sites)

- Average Site Load: 900 W
- DG Status: 11 kVA DG
- Grid Power: Connected with 8 hrs average daily outage throughout the year

Proposed Architecture				Renewable Indicators			Financial Indicators				
Wind Turbine	Charge Controller	Batteries	Rectifier	Autonomy	Excess Electricity	Energy Contribution : Wind Turbine	Payback Period	ROI	IRR	CAPEX	NPV
Proven Energy 7 – 2.5 kW	2* 80A Outback FM80 MPPT Controller	GFMJ-420 Ahr GEL VRLA (1 string)	1.44 KW	44 hrs	65%	99.8 %, DG 0.2 %	3.71 years	27%	30.67%	US$35,137	US$33,068

Tcell South (28 indoor sites)

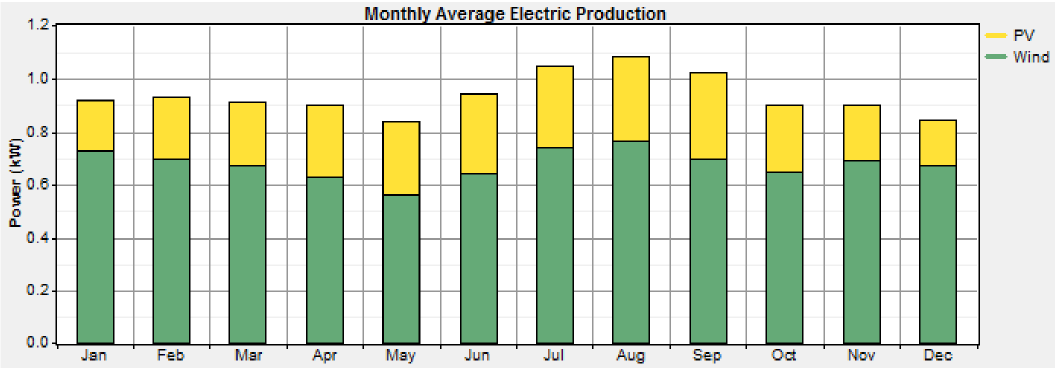


Sample Results 2: Model 1 –Tcell North (30 indoor sites)

- Average Site Load: 1,020 W
- DG Status: N/A
- Grid Power: Connected with 8 hrs average daily outage throughout the year

Proposed Architecture					Renewable Indicators			Financial Indicators				
Solar Power	Wind Turbine	Charge Controller	Batteries	Rectifier	Autonomy	Excess Electricity	Energy Contribution	Payback Period	ROI	IRR	CAPEX	NPV
1.44kW	Proven Energy 7 – 2.5kW	2* 80A Outback FM80 MPPT Controller	GFMJ-420Ahr GEL VRLA (2 string)	Not Needed (all DC system)	82.1 hrs	63%	Wind Turbine 72%, Solar 28%	2.95years	33.9%	41.9%	US$55,941	US$83,509

Tcell North (30 indoor sites)



Financial Analysis

- For the 309 sites of Tcell North that were considered for renewable:
    - On average 299 only are possible and would have an ROI of less than 7.6 years
    - This is budgeted at about US$14.54m
- For the 100 sites of Tcell South that were considered for renewable:
    - On average 82 only are possible and would have an ROI of less than 7.6 years
    - This is budgeted at about US$3.10m

Sites with ROI Priority Significance

	CAPEX	Payback Period (yr)	ROI
0 yrs < Payback < 2 yrs (123 sites)	$4,639,800	1.19	84%
Average per site	$37,722		
2 yrs < Payback < 4 yrs (200 sites)	$9,313,400	3.00	35%
Average per site	$46,567		
4 yrs < Payback < 7 yrs (62 sites)	$3,651,300	5.51	19%
Average per site	$58,892		

Overall Summary

Upon analysis of the entire network the following summarises the results that were outputted:

Green solution can be implemented for	385 on-grid sites
Deep battery cycling recommended for	376 sites above
Total CAPEX for Green solution implementation	US$17.64 million
After Green solution implementation, CO_2 emission will be reduced by > 12,100 tonnes/yr (>60%)	