GEE 21 project and implementation of Goals in Central Asia

Viktor Badaker, UNECE

Second IEEF,

Dushanbe, Tajikistan

14 September 2011

Analysis of Advanced Technologies in Energy Efficiency and Renewable Energy in the Framework of the Global Energy Efficiency 21 Project and Preparation of Recommendations on its Application with Special Emphasis on SPECA Region – new project Sponsored by the Russian Federation

The immediate goal of the project is to conduct appropriate analysis to strengthen the capacity of Governments and other stakeholders in SPECA region to overcome barriers and introduce advanced technologies in energy efficiency and renewable energy to support low-carbon economic and environmental sustainable development.

Project proposal in the framework of the GEE 21 project

Conjunctive Wind/Hydro Energy for Water Management in Kyrgyzstan and Tajikistan.

Purpose

- Strengthen institutional and technical capacity to address emerging challenges in pursuit of sustainable development
- Introduce science based policy, new technologies and international best practices
- Promote cooperation between Central Asian countries in the area of energy and water

Goal

- Climate Change Mitigation and Adaptation along with expanded economic growth
- Reduce use of fossil fuel based energy (~1.6 tCO_2e/MWh)
- Reinforce the hydro system to avoid drought problems and reduce winter water release

Project activities

- Support renewable energy policy development
  - Review of status and barriers
  - Propose Policy and incentives
  - Capacity building

- Technical component
  - Preliminary assessment of wind energy potential
  - Design guidance for measurement program and feasibility studies
  - Encourage and support national private sector wind energy industry in partnership with hydro utilities

- Conjunctive Wind Hydro Power Program
  - Assessment of wind-water interrelation
  - Introduction of case studies for international water trade

Energy-Water problems in CA

- Tajikistan and Kyrgyzstan, which possess about 85% of the region's water resources, are mainly interested in exploiting rivers for electricity production with peak demand in winter. It requires water to be dammed up over the summer and then released from the reservoir late in the year.

- Contrarily, Kazakhstan, Uzbekistan, and Turkmenistan need water resources for irrigation purposes in summer. As a result of power production, large amount of water flows downstream when it's not needed, creating winter flooding and summer shortage in Kazakhstan and Uzbekistan. When the dams run low it takes enormous amounts of water to generate electricity. This problem is aggravated by inefficient irrigation, domestic water use and energy use in these countries.

- A long-term regional water and energy strategy, which should address the differences between electricity producers in Kyrgyzstan and Tajikistan and water consumers in Kazakhstan, Uzbekistan and Turkmenistan and develop a coordinated regional energy/water policy, has not materialized.

- Existing international precedents on sharing water benefits as well as projects aimed on water saving in HPP could assist countries.

Energy-Water problems in Central Asia

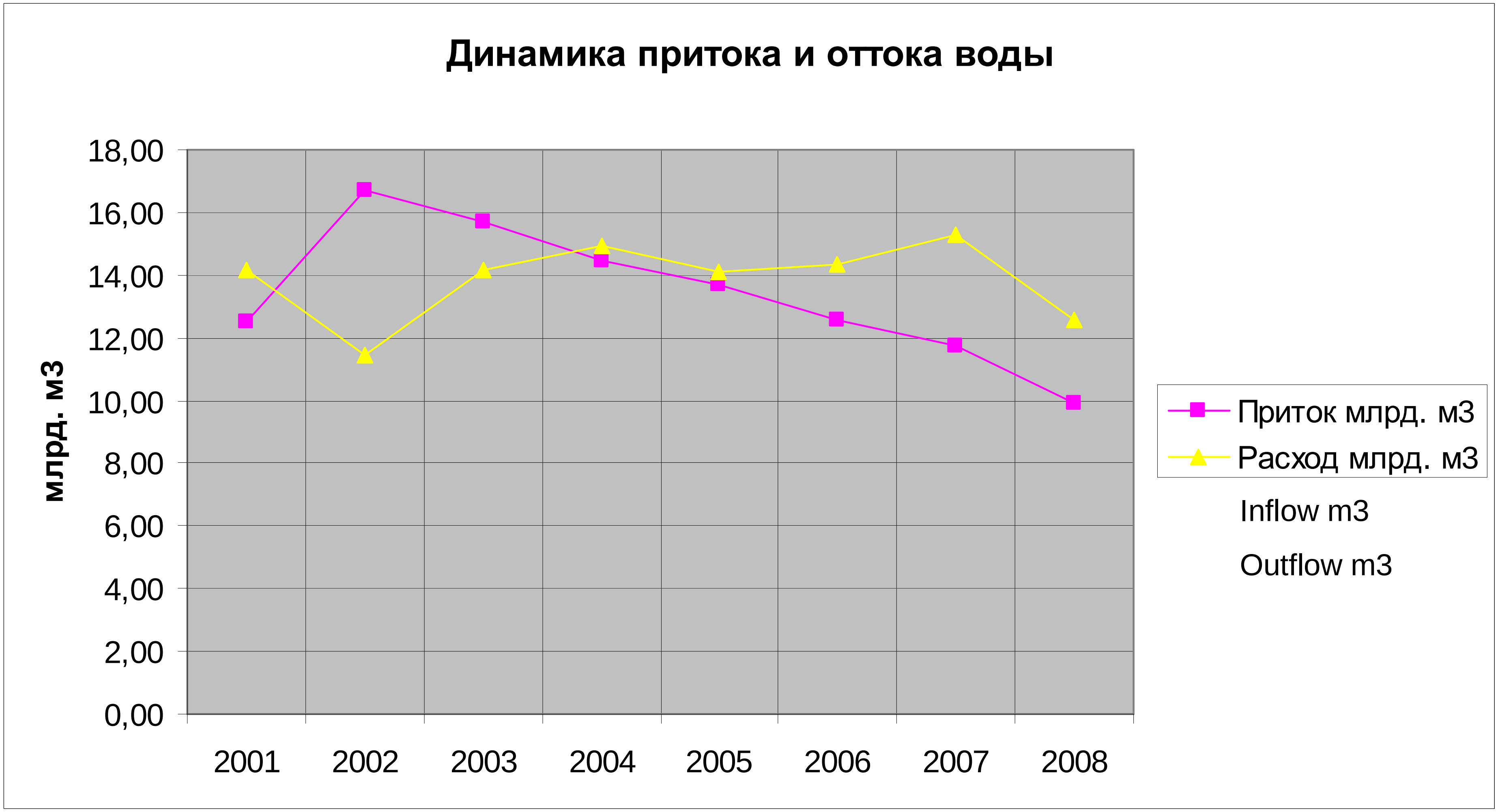
- Central Asia is a self-sufficient energy system: the Region is rich with energy resources though distributed unevenly among the countries. While Kyrgyzstan and Tajikistan have great potential of hydropower resources, Kazakhstan, Uzbekistan and Turkmenistan are producers and considerable exporters of gas and oil.

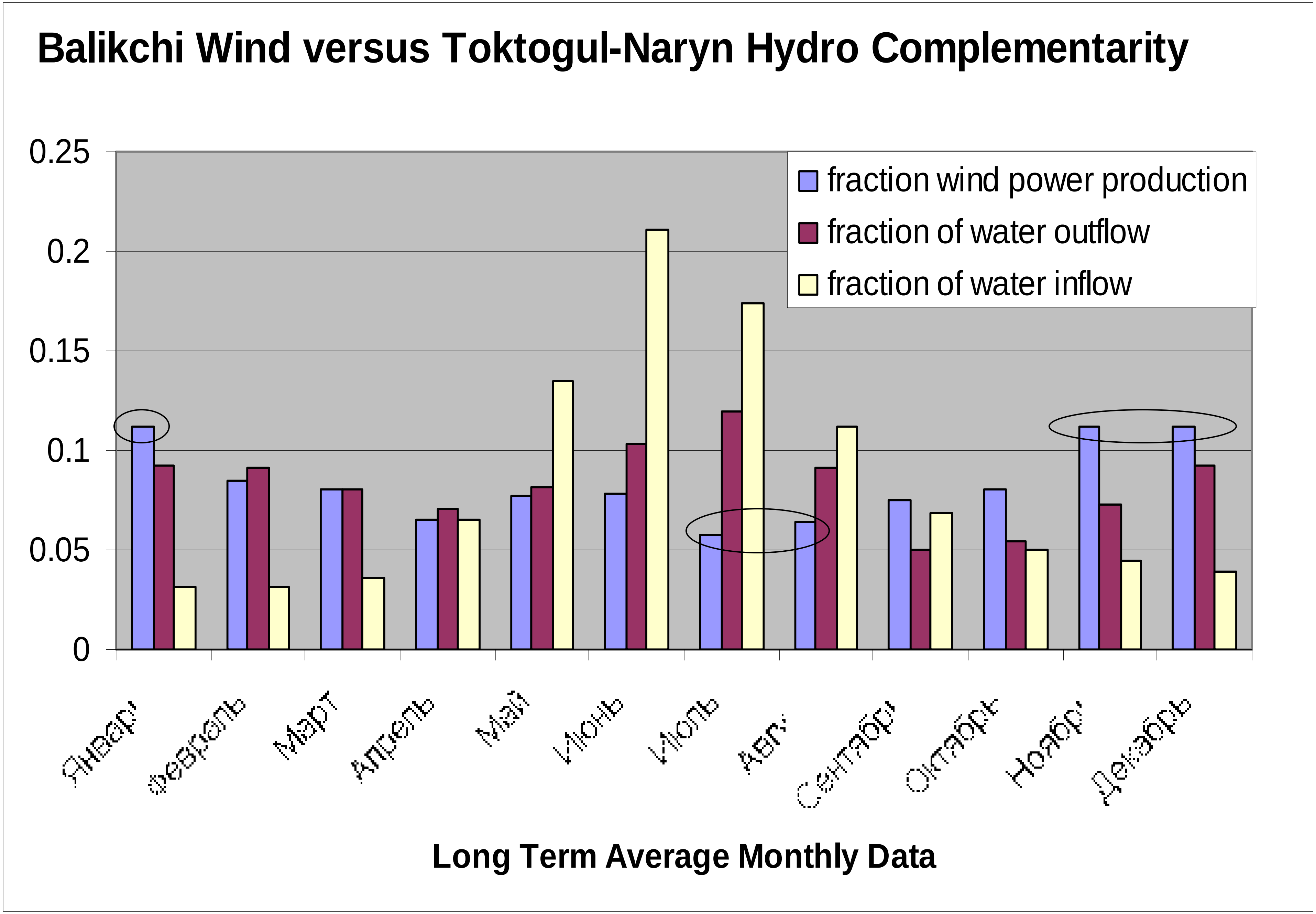
- The emphasis on hydro power energy production in Kyrgyzstan and Tajikistan exposed another problem. The existing hydro system was created during Soviet period when power was generated when there was water demand, which was priority of the constructed hydro stations. Aluminum smelting is done in summer to use the excess electricity.

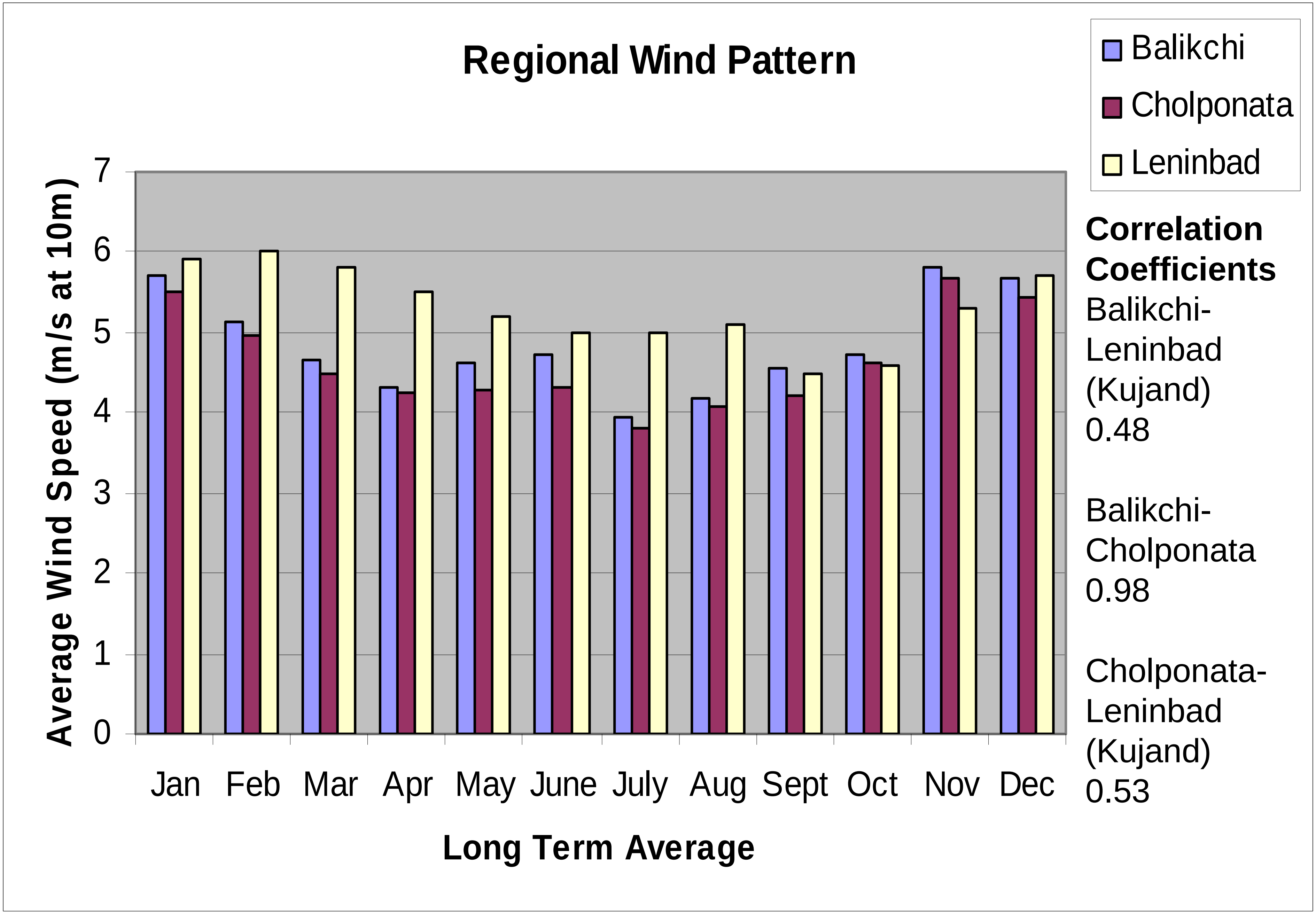
- Since the supply of fossil fuels became problematic after 1991, these nations had to change their priorities and exploit hydro to meet its their needs for heat and light which contradicts interests of downstream countries (Kazakhstan and Uzbekistan).

Toktogul Reservoir

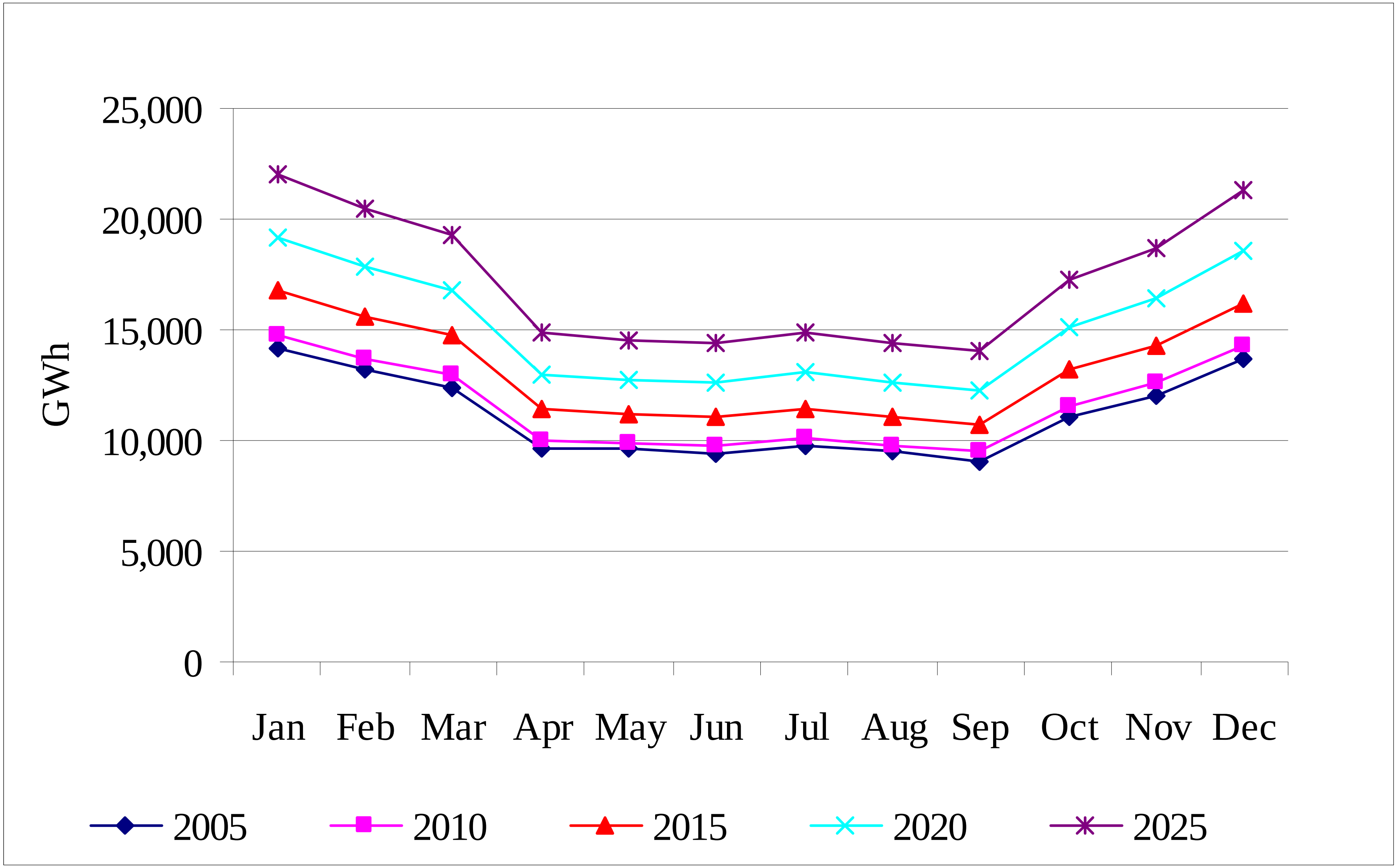
(data provided by Ministry of Industry, Energy and Fuel Resources, Kyrgyzstan)




Balikchi Wind versus Toktogul-Naryn Hydro Complementarity
0.25
0.2
0.15
0.1
0.05
0
fraction wind power production
fraction of water outflow
fraction of water inflow
Январ
Февраль
Март
Апрель
Май
Июнь
Июль
Авг
Сентябр
Октябрь
Ноябр
Декабрь
Long Term Average Monthly Data


Regional Wind Pattern
Balikchi
Cholponata
Leninbad
Correlation Coefficients
Balikchi-Leninbad (Kujand) 0.48
Balikchi-Cholponata 0.98
Cholponata-Leninbad (Kujand) 0.53
Average Wind Speed (m/s at 10m)
0
1
2
3
4
5
6
7
Jan
Feb
Mar
Apr
May
June
July
Aug
Sept
Oct
Nov
Dec
Long Term Average

Projected Gross Electricity Demand for Central Asian Republics (World Bank)



Main factors for estimating wind power

- Wind Power Density in watts/m^2

WPD = ½ ρ $(speed)^3$

ρ = air density corrected for pressure (altitude, temperature)

- Wind speed shear (roughness, orography, obstacles)

$S_H = S_{10} (H/10)^{\sim 0.2}$

- Weibull distribution (curve fit to the speed readings)
- Turbine power curve

~3 or 4 m/s cut in

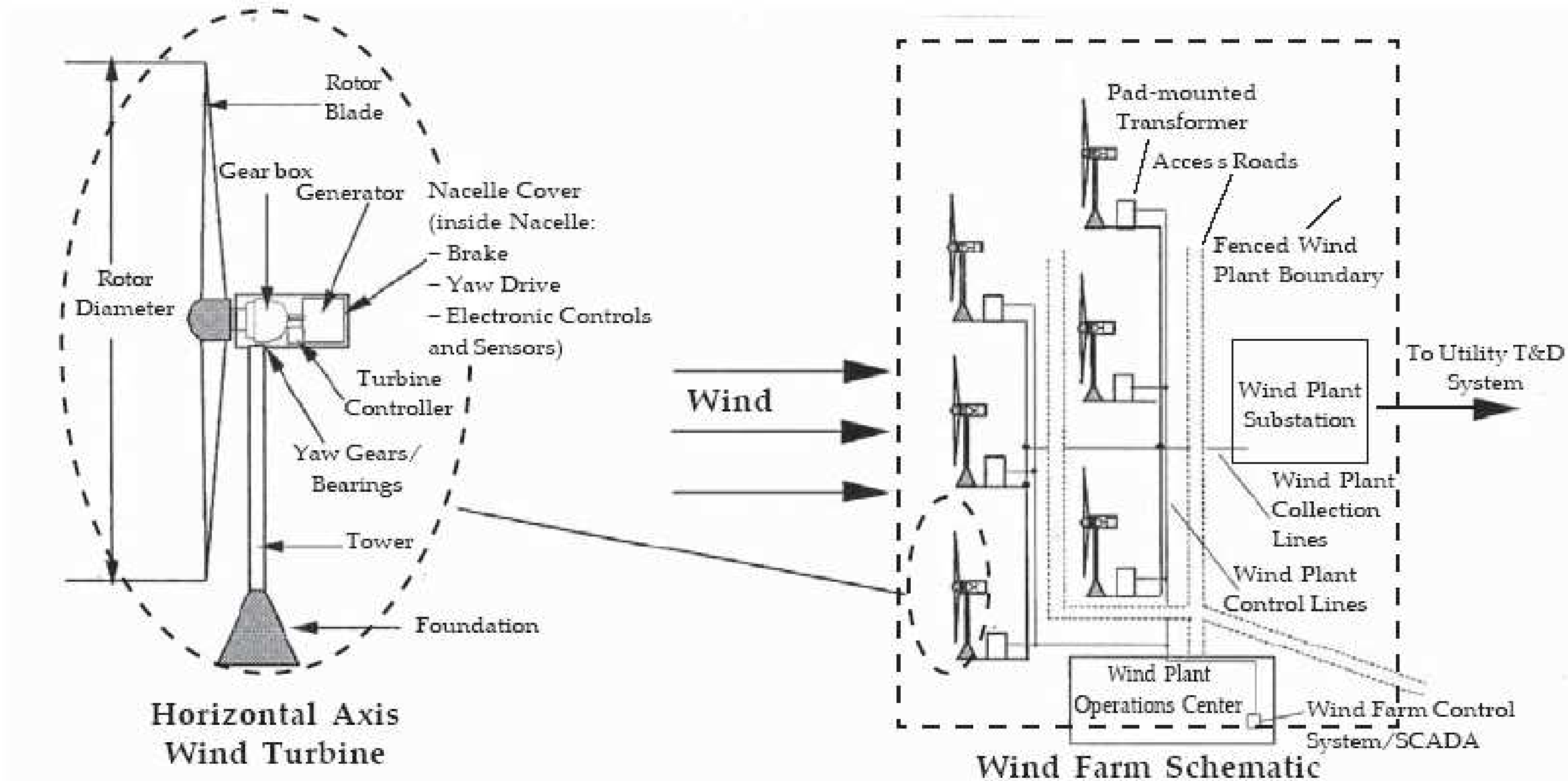
~12 m/s full rated power

>~25 m/s cut out

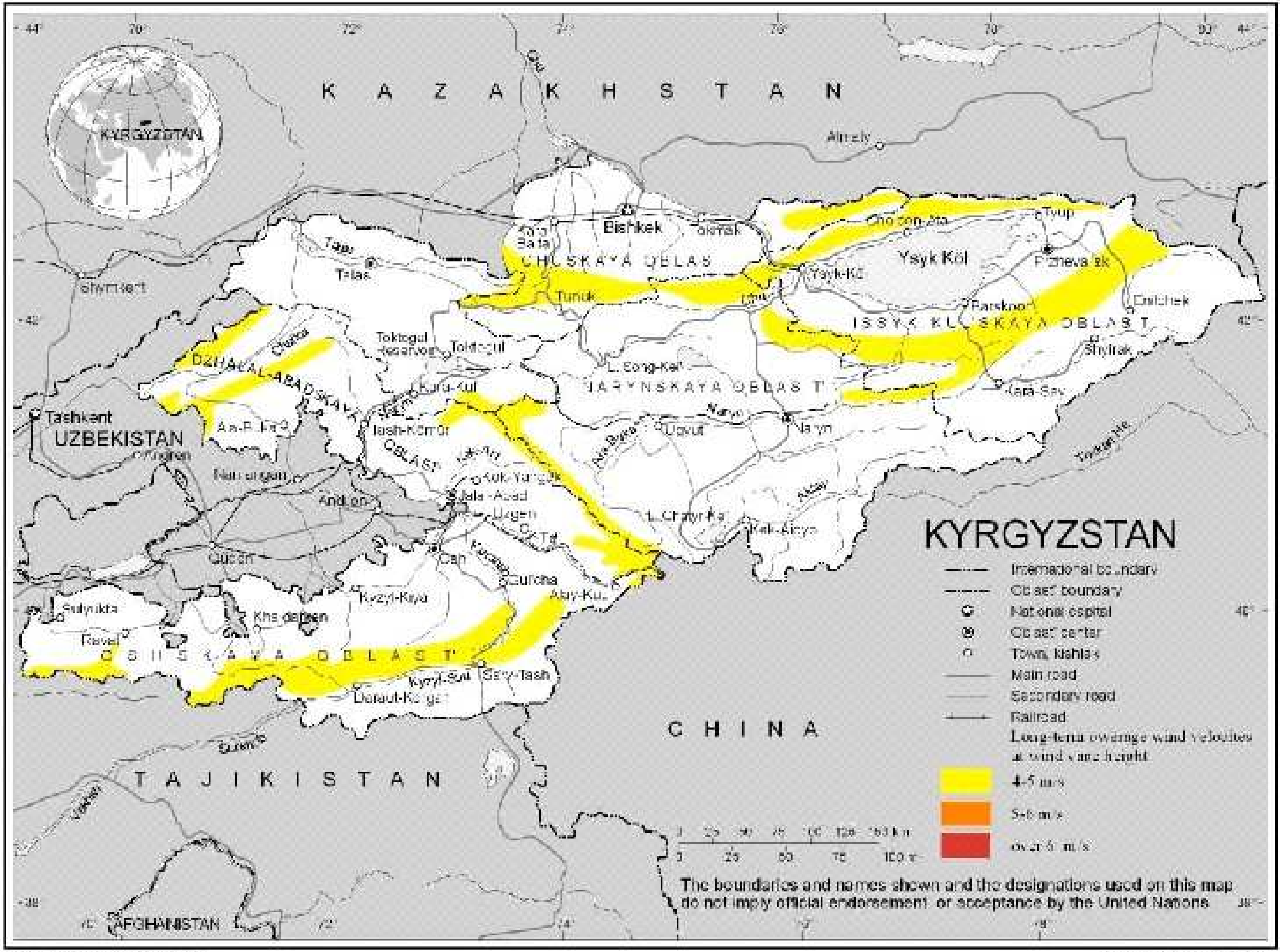
Common data deficiencies

- New buildings and construction
- Growing trees or shrubs, added fences, new road works
- Instrument wear, drifting out of calibration, damage or corrosion
- Measurements not regular through the day, through the year

Figure A2.1: Wind Turbine Schematics



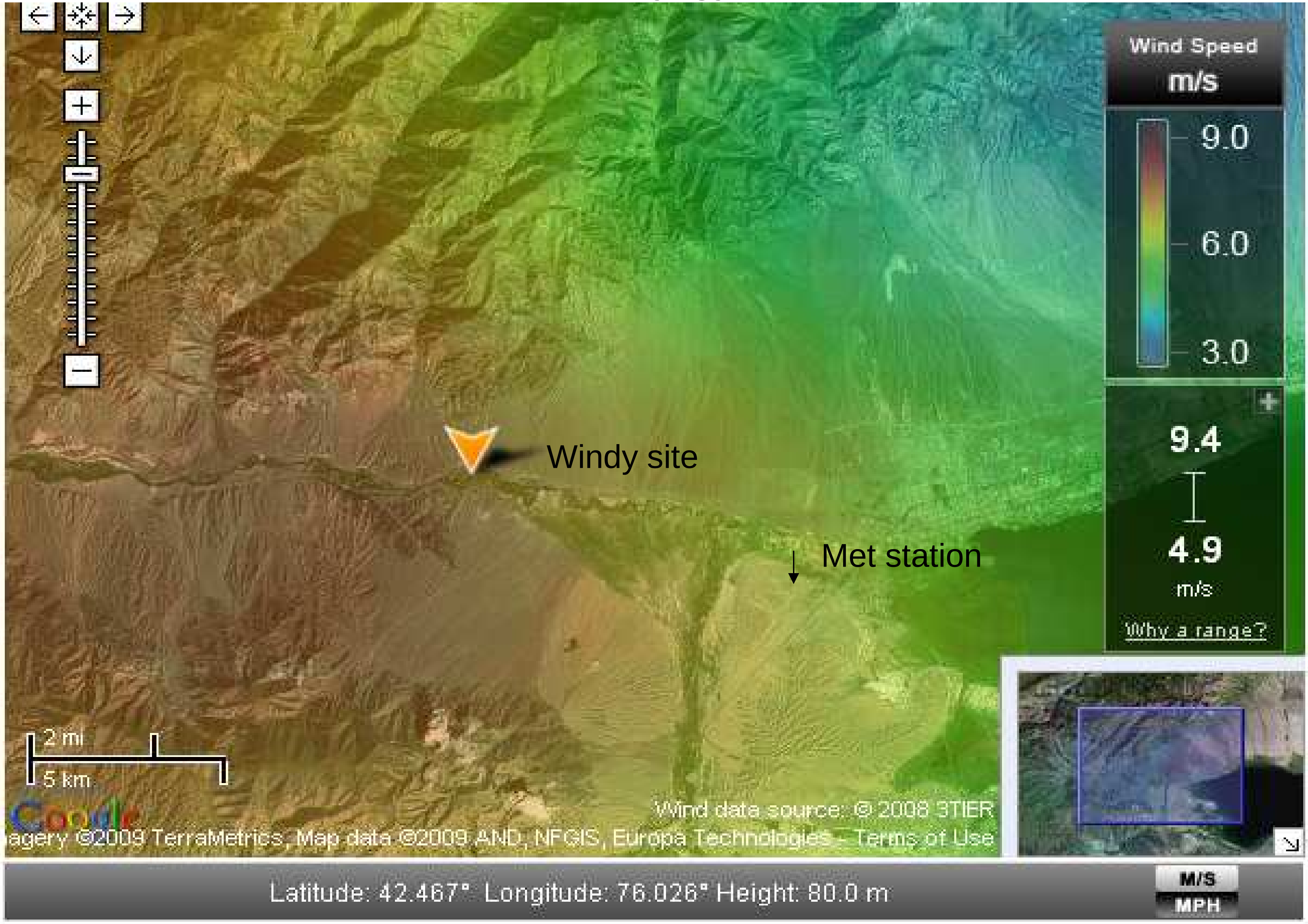
Source: DOE/EPRI.

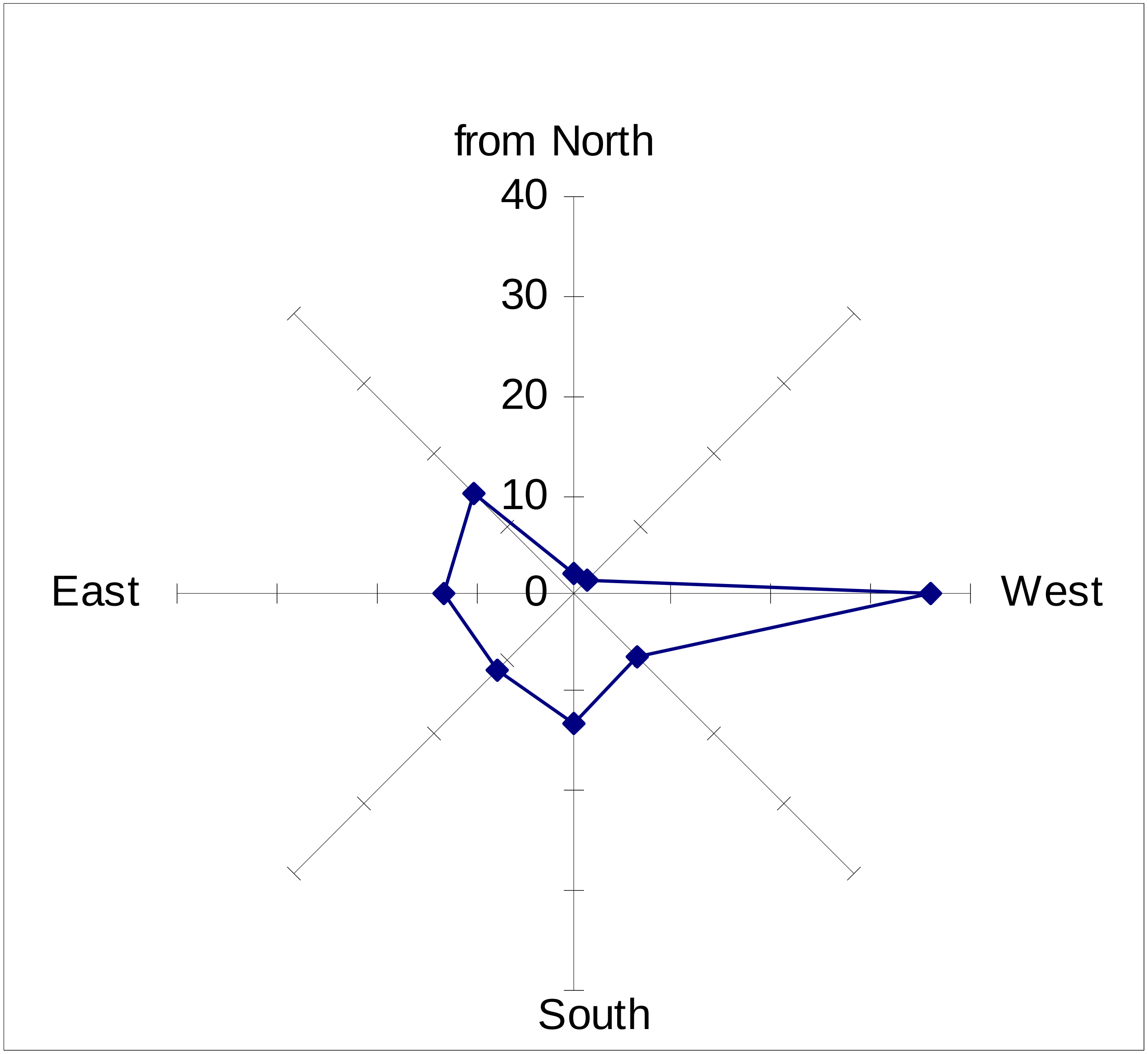


Map No. 3770 Rev. 3 UNITED NATIONS
August 1998

Department of Public Information
Cartographic Section

Balikchi Kyrgyzstan

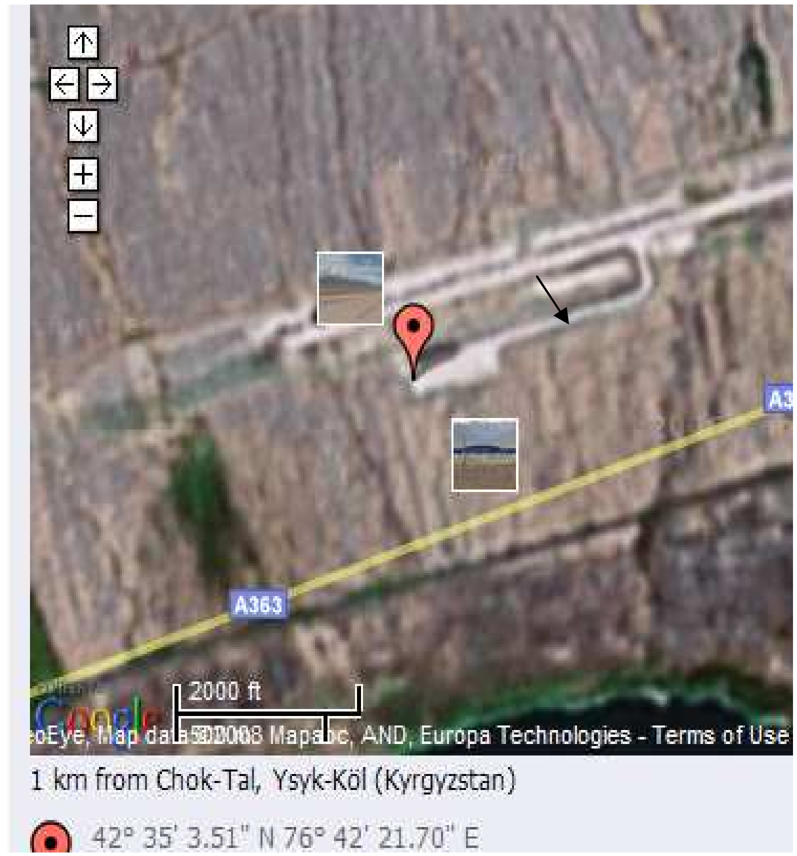




Wind Direction Distribution (%) Balikchi (Rybacje)

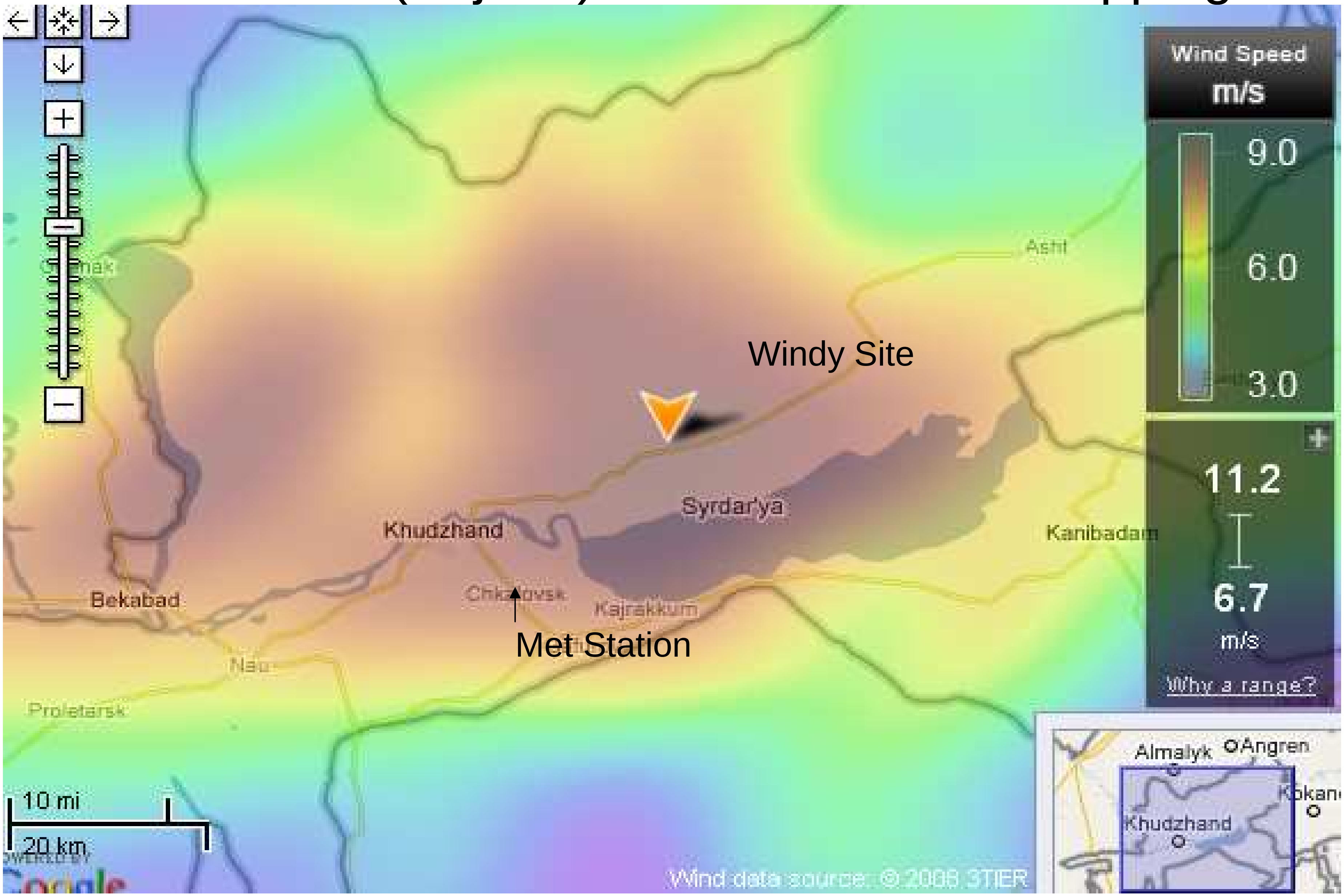
All Speed and Direction pairs of data needed

Tampchi Airport met tower



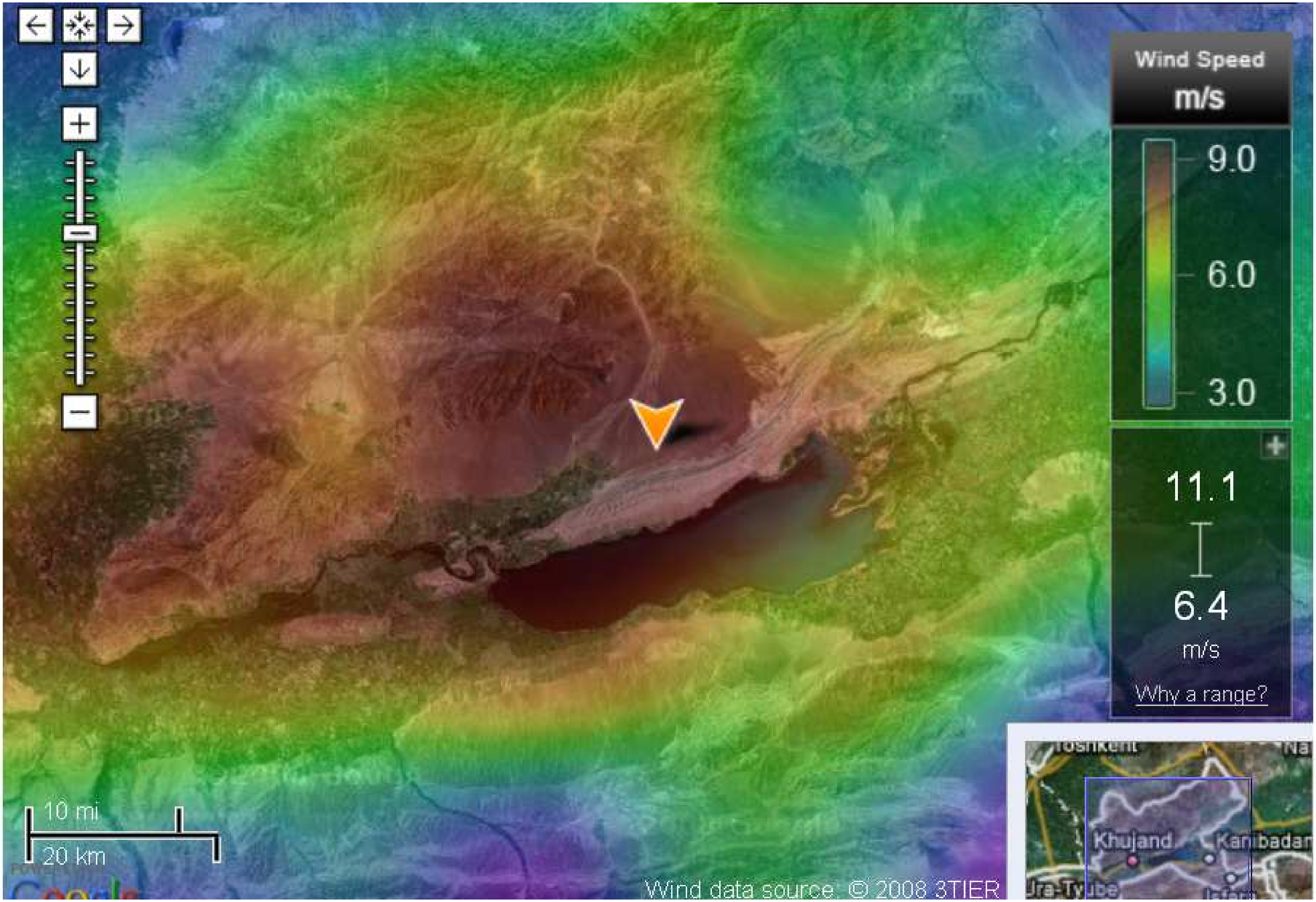

Kairakum 126 MW
54% average power capacity factor

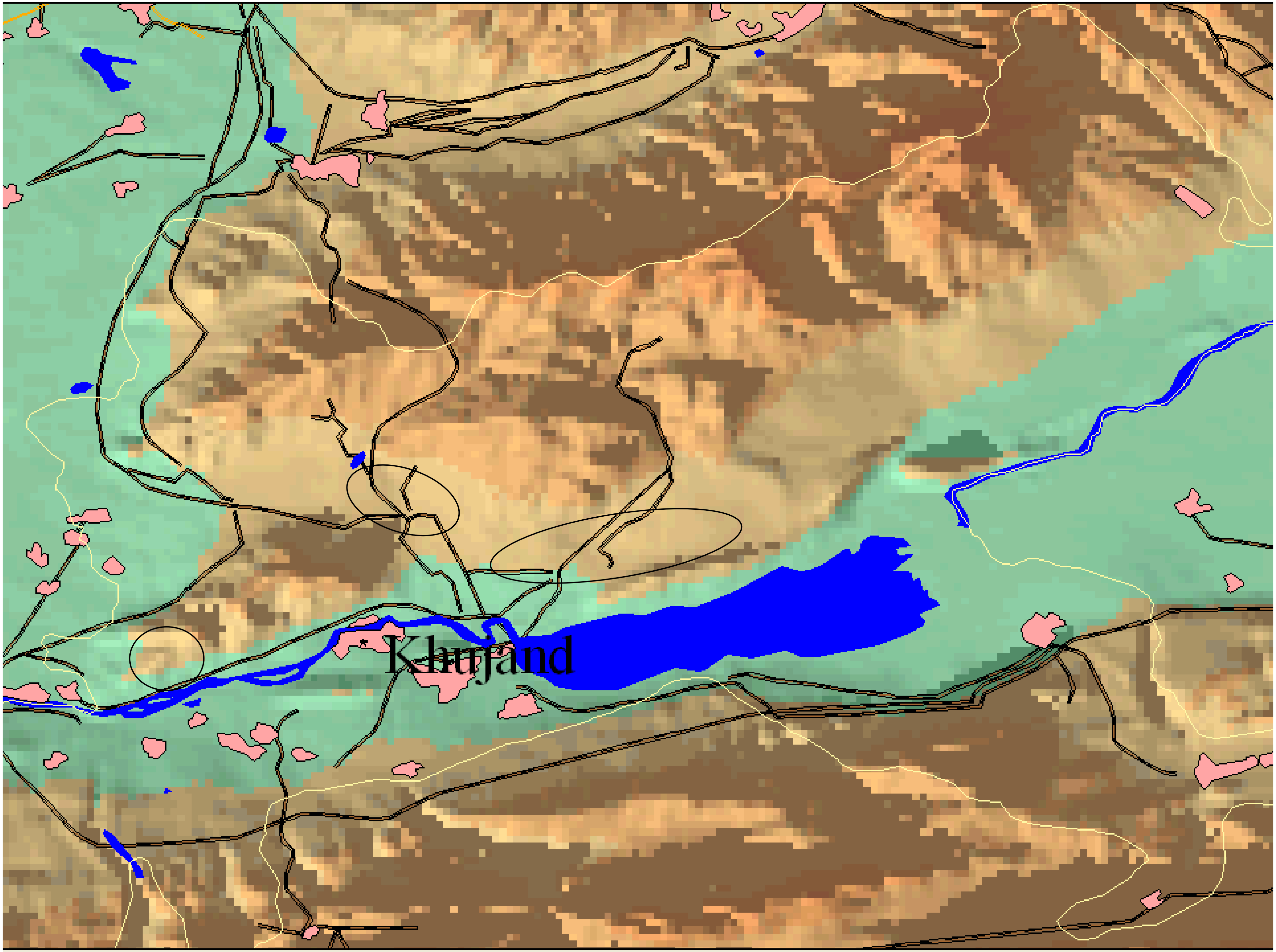
Khudzhand (Kujand) Mesoscale Wind Mapping



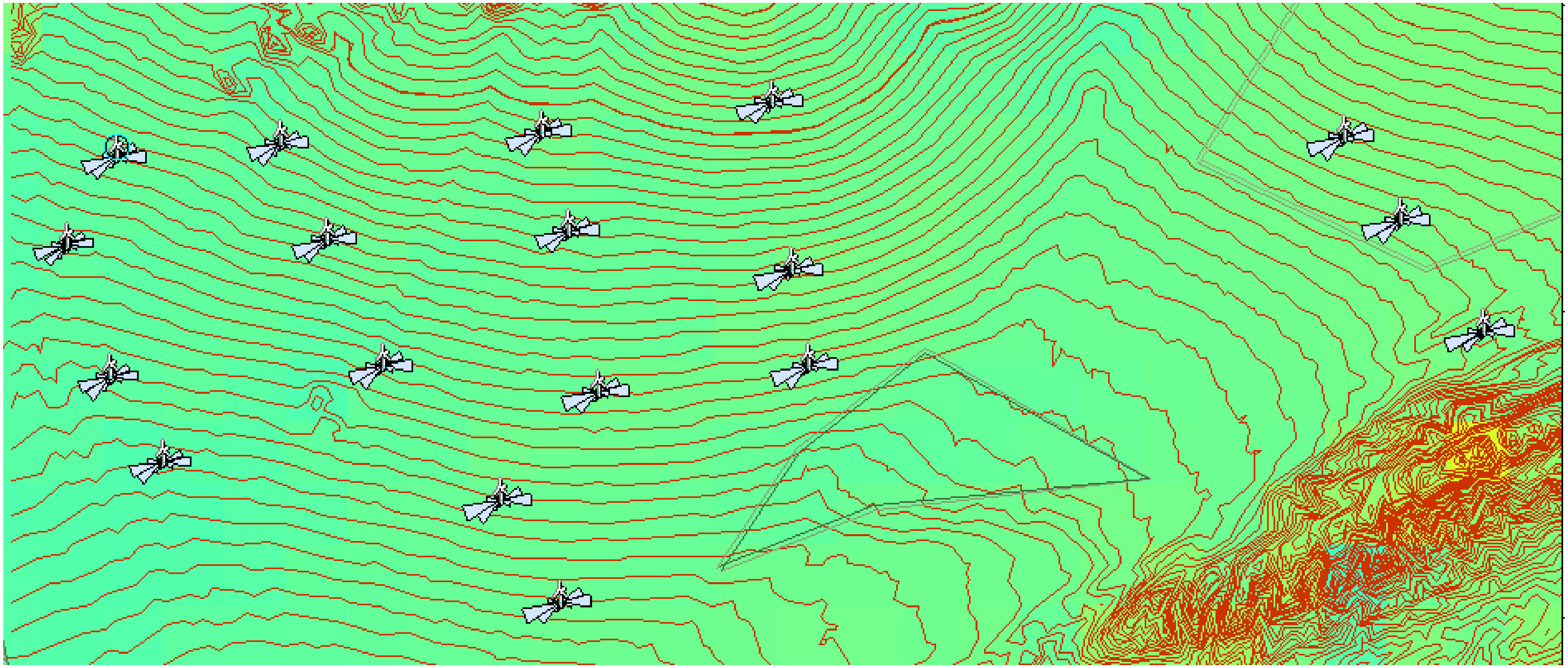
Tupolev-154 refuelling at Khujand airport - Ту-154 на заправке в аэропорту Худжанда

Khudzhand Tajikistan




Khujand

Wind Atlas Assessment and Application Program (WA^{S}P) analysis for Khudzhand NASA Shuttle Radar Topographic Measurements, RosHydromet wind data 1936-1991



Summary results for 15 MW

Annual Energy Production 47 GWh

Wake loss 0.15 %

Where are the problems? Which are the challenges ahead?

While engineering technicalities for hydropower energy are well established and proven to work, after the USSR collapsed, the lack of a proper legislative framework and other “new” challenges emerged abruptly. This also means that the concept of International Water Resource Management (IWRM) has not been properly designed and implemented.

Present challenges are:

- Lack of investment in infrastructure (new+maintenance)
- Poor Water governance;
- Trans-boundary water issues;
- Climate change

Conjunctive Wind Hydro Program:
EBRD Estimated Mid Term Technical Potential by 2020

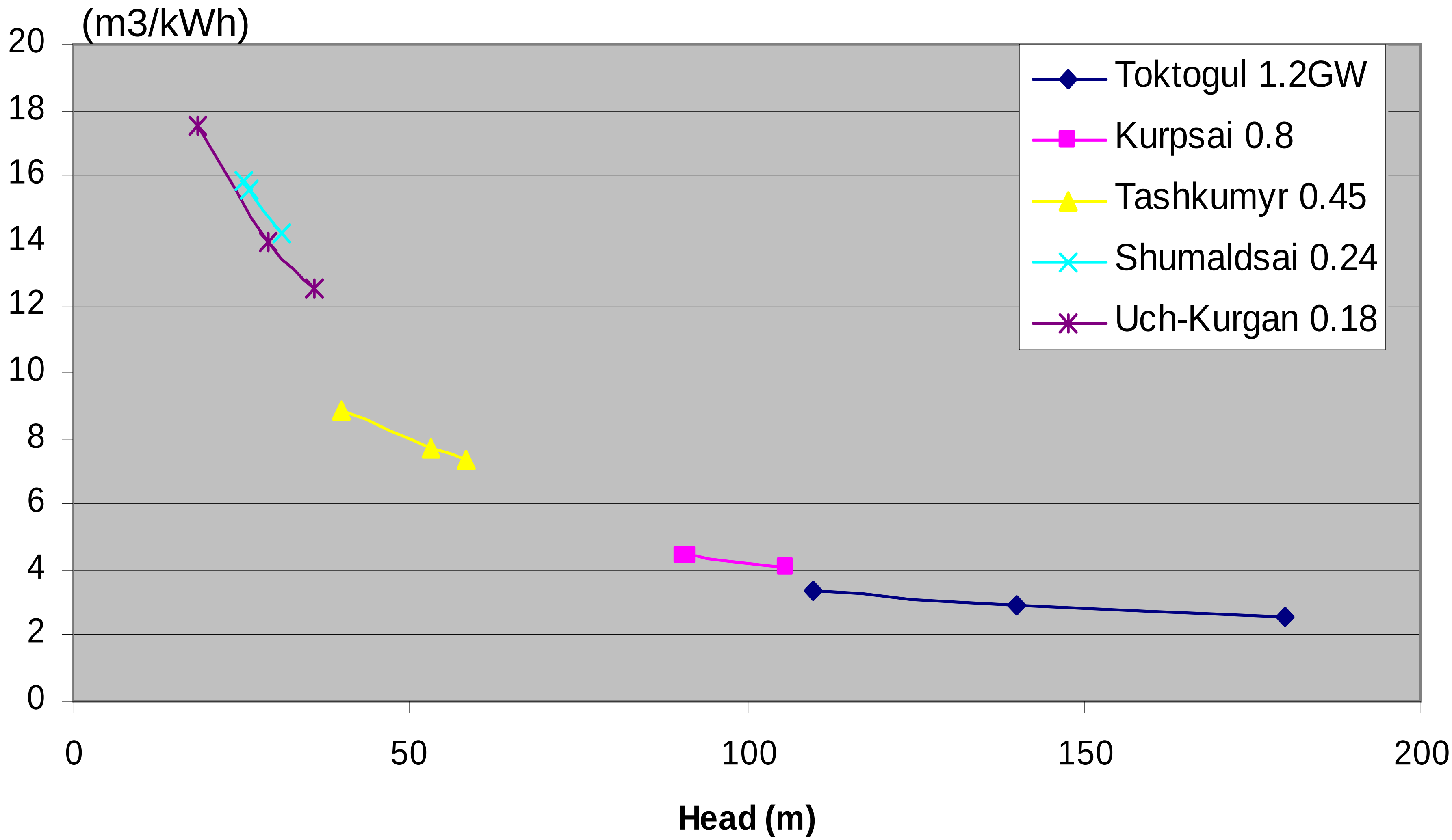
- Tajikistan: 1 GW (~100 km2 area)
- Kyrgyzstan: 1.5 GW (~150 km2 area)
- Enough to build a Wind Turbine manufacturing industry in the region – towers, blades, etc.

Initial installations:

- ~30 to 100 MW each to be commercial scale for imported equipment with available cranes and civil engineering
- Grid integration and general experience

Average Hydro Production Kyrgyzstan 2001 – 2007	12,800	GWh
10% of Hydro Production	1,280,000	MWh
Wind Power Capacity to meet 10% Hydro Production	370	MW at 40% Capacity Factor
Average Annual Water Saving from Wind	1.5	km^3 at 1.2 m3/kwh (Naryn Cascade)
European Bank for Reconstruction and Development - Renewable Energy Initiative Mid Term Technical Potential 2020	Kyrgyzstan	
Wind Power	1,500	MW
	5,300	GWh at 40% Capacity Factor
Annual Water Savings	6.3	km^3 (Toktogul)

Without Toktogul operating there is 40% less power available and a 70% increase in specific water use



"Optimisation of Syr Darya Water and Energy Uses" WARMAP project 2002

Antipova et al 2002

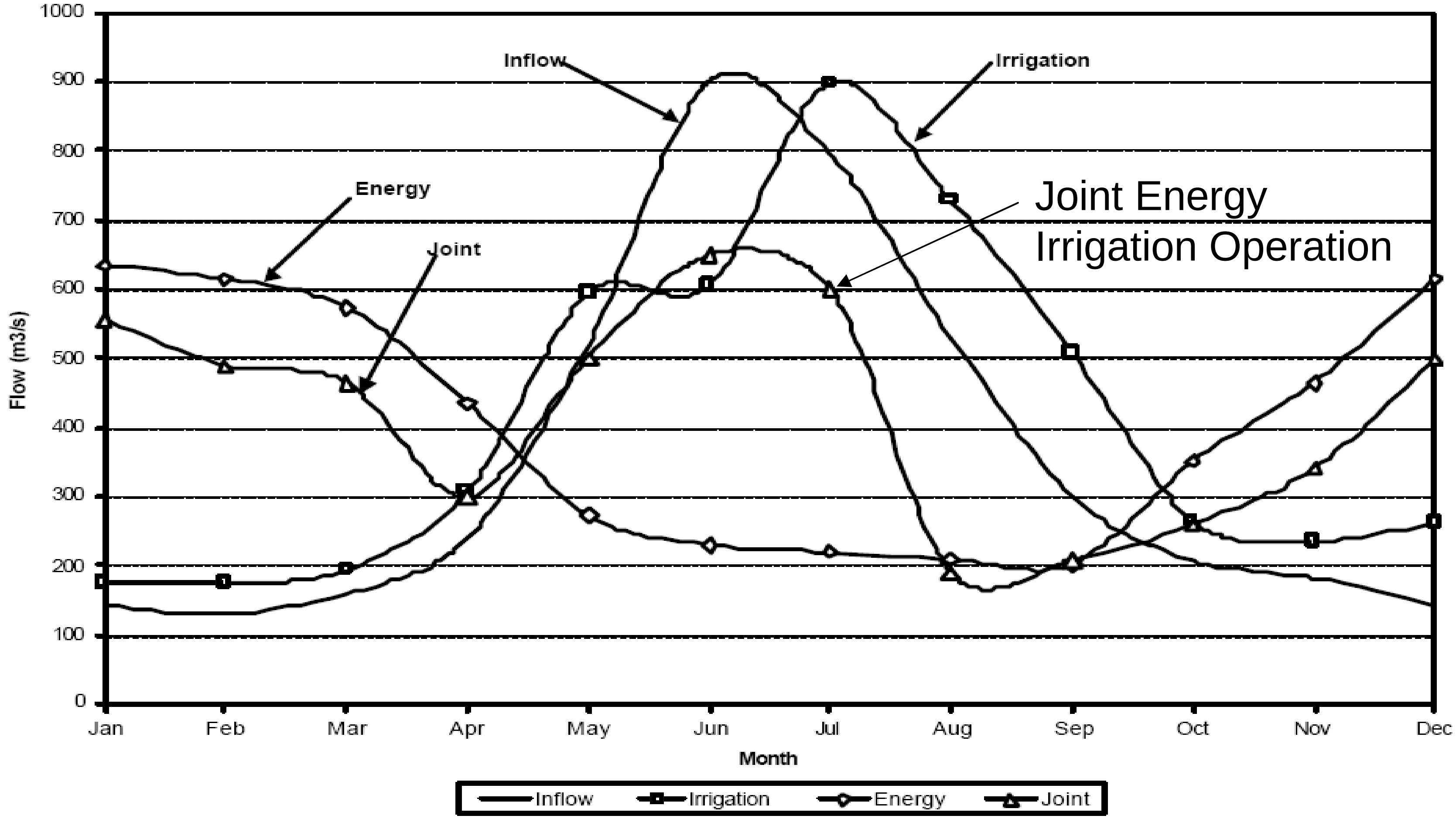
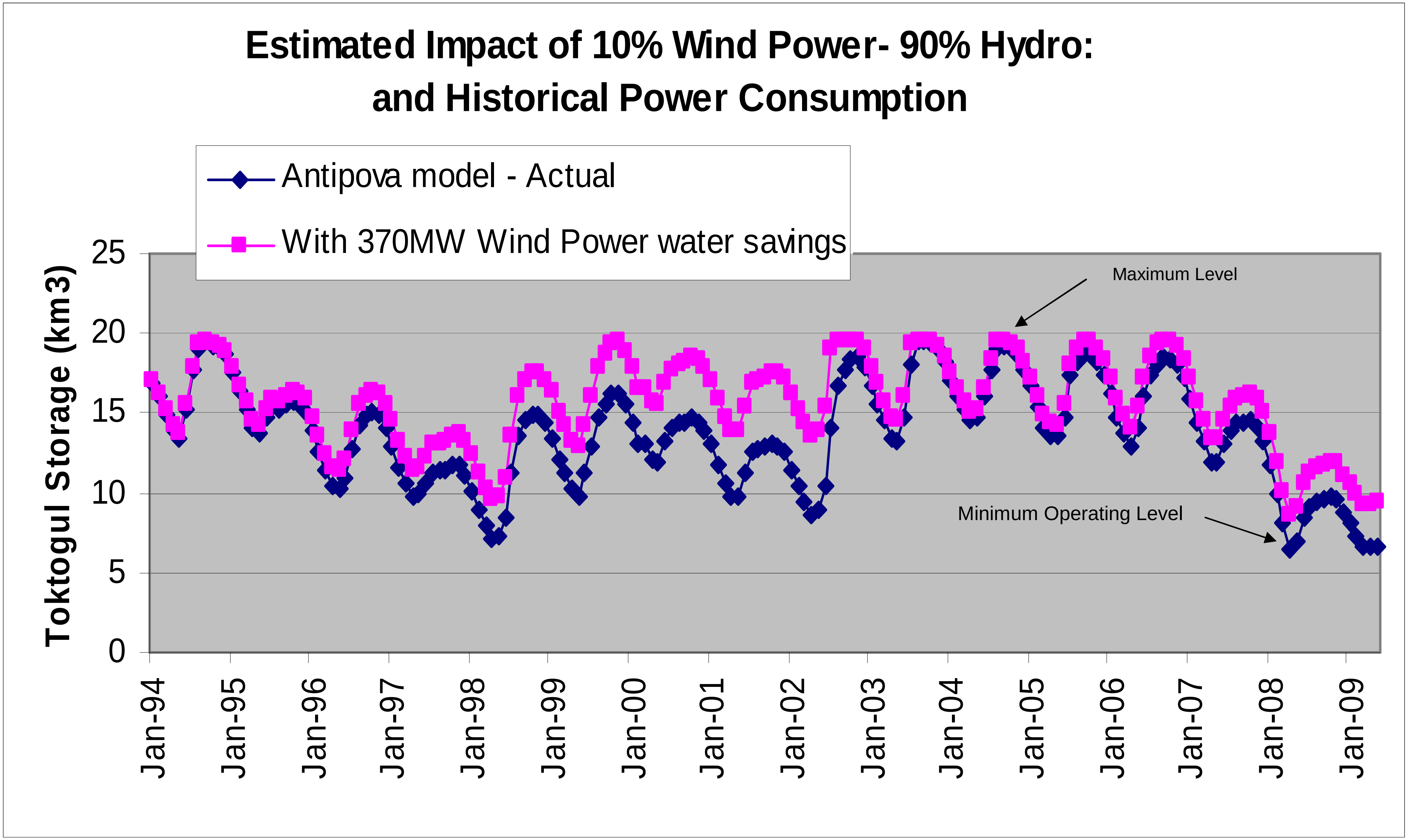


Figure 2. Toktogul reservoir operation under different regimes.

Kyrgyzstan
Estimated Impact of 10% Wind/ 90% Hydro Conjunctive Operation with **No** Wind Power Dispatch During Irrigation May-July



Wind can be part of the solution to avoid minimum operating level

- ~10% wind power

Combined with

- Water efficiency & Integrated Water Resource Management
- Energy efficiency
- Cascaded Seasonal Hydro Reservoirs
- Regional electricity trade

All needed to Adapt to Climate Change

Technical and Economic Costs of Off-Grid, Mini-Grid and Grid Electrification Technologies – ESMAP 2007

Table A2.4: Present and Projected Wind Turbine Capital Costs (US$/kW)

Capacity	*2005*			*2010*			*2015*		
	Min	*Probable*	*Max*	*Min*	*Probable*	*Max*	*Min*	*Probable*	*Max*
300 W	4,820	5,370	5,930	4,160	4,850	5,430	3,700	4,450	5,050
100 kW	2,460	2,780	3,100	2,090	2,500	2,850	1,830	2,300	2,650
10 MW	1,270	1,440	1,610	1,040	1,260	1,440	870	1,120	1,300
100 MW	1,090	1,240	1,390	890	1,080	1,230	750	960	1,110

Table A2.5: Present and Projected Wind Turbine Generation Costs (US¢/kWh)

Capacity	*2005*			*2010*			*2015*		
	Min	*Probable*	*Max*	*Min*	*Probable*	*Max*	*Min*	*Probable*	*Max*
300 W	30.1	34.6	40.4	27.3	32.0	37.3	25.2	30.1	35.1
100 kW	17.2	19.7	22.9	15.6	18.3	21.3	14.4	17.4	20.2
10 MW	5.8	6.8	8.0	5.0	6.0	7.1	4.3	5.5	6.5
100 MW	5.0	5.8	6.8	4.2	5.1	6.1	3.7	4.7	5.5

File Edit View Insert Format Tools Data Window Help RETScreen

Type a question for help

Link_CA_Start

Анализ затрат RETScreen - Проект электростанции

Настройки

Метод 1	Примечания/диапазон		
Метод 2	Вторая валюта	Примечания/диапазон	Нет
	Распределение затрат		

Первоначальные затраты (кредиты)	**Единица**	**Количество**	**Цена за единицу**	**Сумма**	**Отн. Затраты**
ТЭО - технико-экономическое обоснование					
ТЭО - технико-экономическое обоснование	Стоимость	1	$ 100,000	$ 100,000	
Под-итог:				$ **100,000**	0.2%
Разработка проекта					
Разработка проекта	Стоимость	50,150	$ 80	$ 4,012,000	
Под-итог:				$ **4,012,000**	6.2%
Инженерно-технические работы					
Инженерно-технические работы	Стоимость	50,150	$ 40	$ 2,006,000	
Под-итог:				$ **2,006,000**	3.1%
Энергосистема					
Ветровая турбина	кВт	50,150.00	$ 940	$ 47,141,000	
Строительство дорог	км			$ -	
Линия электропередачи	км	15	$ 28,177	$ 422,655	
Подстанция	проект			$ -	
Мероприятия по энергосбережению	проект			$ -	
Заданный пользователем	Стоимость			$ -	
				$ -	
Под-итог:				$ **47,563,655**	73.6%
Баланс системы и прочее					
Запасные части	%	10.0%	$ 47,141,000	$ 4,714,100	
Транспортировка	проект	59	$ 3,000	$ 177,000	
Обучение и сдача в эксплуатацию	в день			$ -	
Заданный пользователем	Стоимость	50,150	$ 120	$ 6,018,000	
Непредвиденные расходы	%		$ 64,590,755	$ -	
Проценты во время строительства		0 месяц(ы)	$ 64,590,755	$ -	
Под-итог:				$ **10,909,100**	16.9%
Общие первоначальные затраты				$ **64,590,755**	100.0%

Ежегодные затраты (кредиты)	**Единица**	**Количество**	**Цена за единицу**	**Сумма**
Эксплуатация и обслуживание				
Запчасти и рабочая сила	проект			$ -
Заданный пользователем	Стоимость	2	$ 471,410	$ 942,820
Непредвиденные расходы	%		$ 942,820	$ -
Под-итог:				$ **942,820**

Периодические затраты (кредиты)	**Единица**	**Год**	**Цена за единицу**	**Сумма**
Заданный пользователем	Стоимость	10	$ 9,428,200	$ 9,428,200
				$ -
Окончание срока реализации проекта	Стоимость			$ -

Перейдите к листу Анализ выбросов

Стимулирование и гранты	$	
Коэффициент задолженности	%	65.0%
Заёмный капитал	$	41,983,991
Акционерный капитал	$	22,606,764
Процентная ставка по кредиту	%	4.00%
Срок погашения кредита	г.	15
Выплата заемного капитала	$/год	3,776,086

Анализ подоходного налога

Ежегодный доход

Доход от экспорта электроэнергии		
Электроэнергия, передаваемая в сеть	МВт·ч	88,012
Цена на экспортируемую электроэнергию	$/МВт·ч	54.85
Доход от экспорта электроэнергии	$	4,827,574
Темп роста экспорта электроэнергии	%	5.0%
Доход за счет снижения выбросов ПГ		
Чистое уменьшение выбросов ПГ	тCO2/г	114,638
Чистое уменьшение выбросов ПГ - 25 гг.	тCO2	2,865,954
Ставка кредита на уменьшение выбросов ПГ	$/тCO2	5.00
Доход за счет снижения выбросов ПГ	$	573,191
Срок кредита на уменьшение выбросов ПГ	г.	15
Чистое уменьшение выбросов ПГ - 15 гг.	тCO2	1,719,572
Темп роста ставки кредита на уменьшение выбросов ПГ	%	

Премиальный доход потребителя (возврат средств)

Прочий доход (стоимость)

Доход от производства Чистой Энергии (ЧЭ)

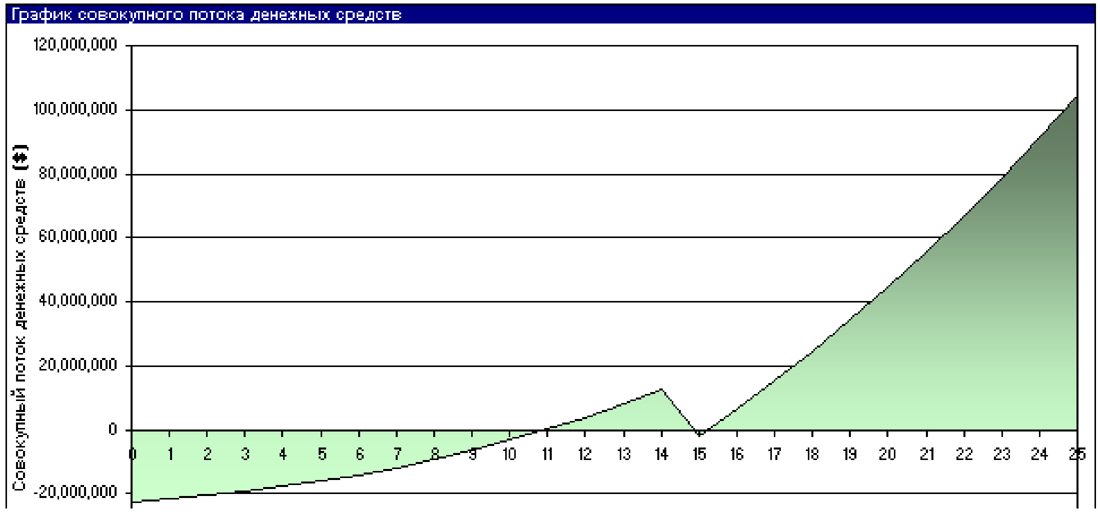
Баланс системы и прочее	16.9%	$	10,909,100
Общие первоначальные затраты	**100.0%**	**$**	**64,590,755**
Ежегодные затраты и выплата заемного капитала			
Эксплуатация и обслуживание		$	942,820
Цена на топливо - Предлагаемый случай		$	0
Выплата заемного капитала - 15 гг.		$	3,776,086
Итого ежегодные затраты		**$**	**4,718,906**
Периодические затраты (кредиты)			
Заданный пользователем - 15 гг.		$	9,428,200
Ежегодная экономия и доход			
Цена на топливо - Базовый случай		$	0
Доход от экспорта электроэнергии		$	4,827,574
Доход за счет снижения выбросов ПГ - 15 гг.		$	573,191
Итоговая ежегодная экономия и доход		**$**	**5,400,764**

Экономическая целесообразность

ВНР до уплаты налогов - капитал	%	11.5%
ВНР перед уплатой налогов - активы	%	3.9%
ВНР после уплаты налогов - капитал	%	11.5%
ВНР после уплаты налогов - активы	%	3.9%
Простой срок окупаемости	г.	14.5
Возврат капитала	г.	11.0
Чистая существующая стоимость (ЧСС)	$	52,483,053
Ежегодная экономия за срок службы	$/год	3,013,990
Коэффициент рентабельности (КР)		3.32
Обслуживание кредита		1.23
Стоимость производства энергии	$/МВт·ч	36.45
Затраты на снижение выбросов ПГ	$/тCO2	(26)

5	1,755,144	1,755,144	-16,082,241
6	2,003,046	2,003,046	-14,079,195
7	2,263,343	2,263,343	-11,815,853
8	2,536,655	2,536,655	-9,279,198
9	2,823,632	2,823,632	-6,455,566
10	3,124,959	3,124,959	-3,330,607
11	3,441,351	3,441,351	110,744
12	3,773,564	3,773,564	3,884,308
13	4,122,387	4,122,387	8,006,694
14	4,488,651	4,488,651	12,495,345
15	-14,727,323	-14,727,323	-2,231,978
16	8,479,930	8,479,930	6,247,952
17	8,903,926	8,903,926	15,151,878
18	9,349,123	9,349,123	24,501,001
19	9,816,579	9,816,579	34,317,579
20	10,307,408	10,307,408	44,624,987
21	10,822,778	10,822,778	55,447,765
22	11,363,917	11,363,917	66,811,682
23	11,932,113	11,932,113	78,743,794
24	12,528,718	12,528,718	91,272,513
25	13,155,154	13,155,154	104,427,667

График совокупного потока денежных средств



Preliminary Estimated Feed-in Price: 5.0 to 6.5 cents/kwh with Internal Rate of Return ~13% to project developer

- Wind Resource
  - Average Wind speed at 65m: 7.0 m/s
  - Capacity factor ~40%
- Capital cost – volume purchasing and installation
  - World Bank ESMAP cost survey 2005: 1240 $/kW
- Financing terms – favourable terms ~
- Regional electricity trading ~5.0 cents/kWh (ADB study)
- Add value of water saved and reduced vulnerability to climate change (regional water benefits proceeds could be invested in wind energy as a hedge against drought)
- Subtract Carbon Credit?
  - Coal, heavy fuel oil and gas mix ~1.5 t CO_2/MWh

National wind resource measurement and prefeasibility studies

- Minimum 1 year data on site near turbine hub height ~60m above ground level, several masts needed
  - Locally produced lattice towers?
  - Instrument packages ~ 10,000 US$ each
  - Must correlate to meteorological station data or extend to 3 years data gathering
- Wind Energy Assessment and Feasibility Study ~250,000 to 500,000 US$
- Training and analysis ~
  - WA^{S}P micro-siting and wind farm analysis
  - RETScreen prefeasibility and risk analysis
- Policy and Planning Support
  - Feed-in tariffs, public private partnership, resource royalties

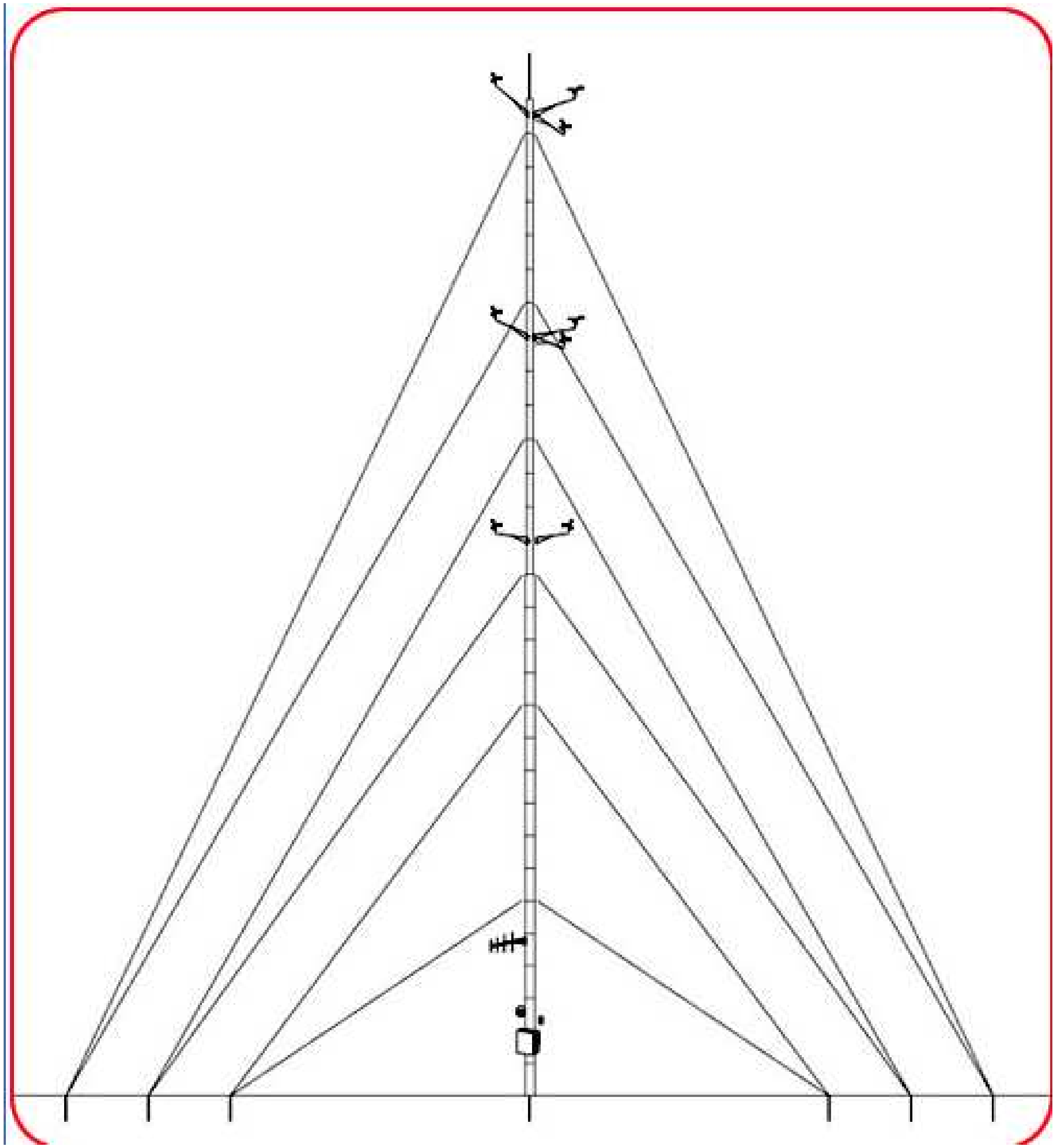
Typical Measurement Tower

-redundant sensors each level

-wind shear from 3 levels

-cellphone & PV panel internet data transfer

-lattice or tube



Thank you
and may the
wind blow to
help refill the
reservoirs!