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Wind Power + BESS in Uzbekistan
Technical perspective

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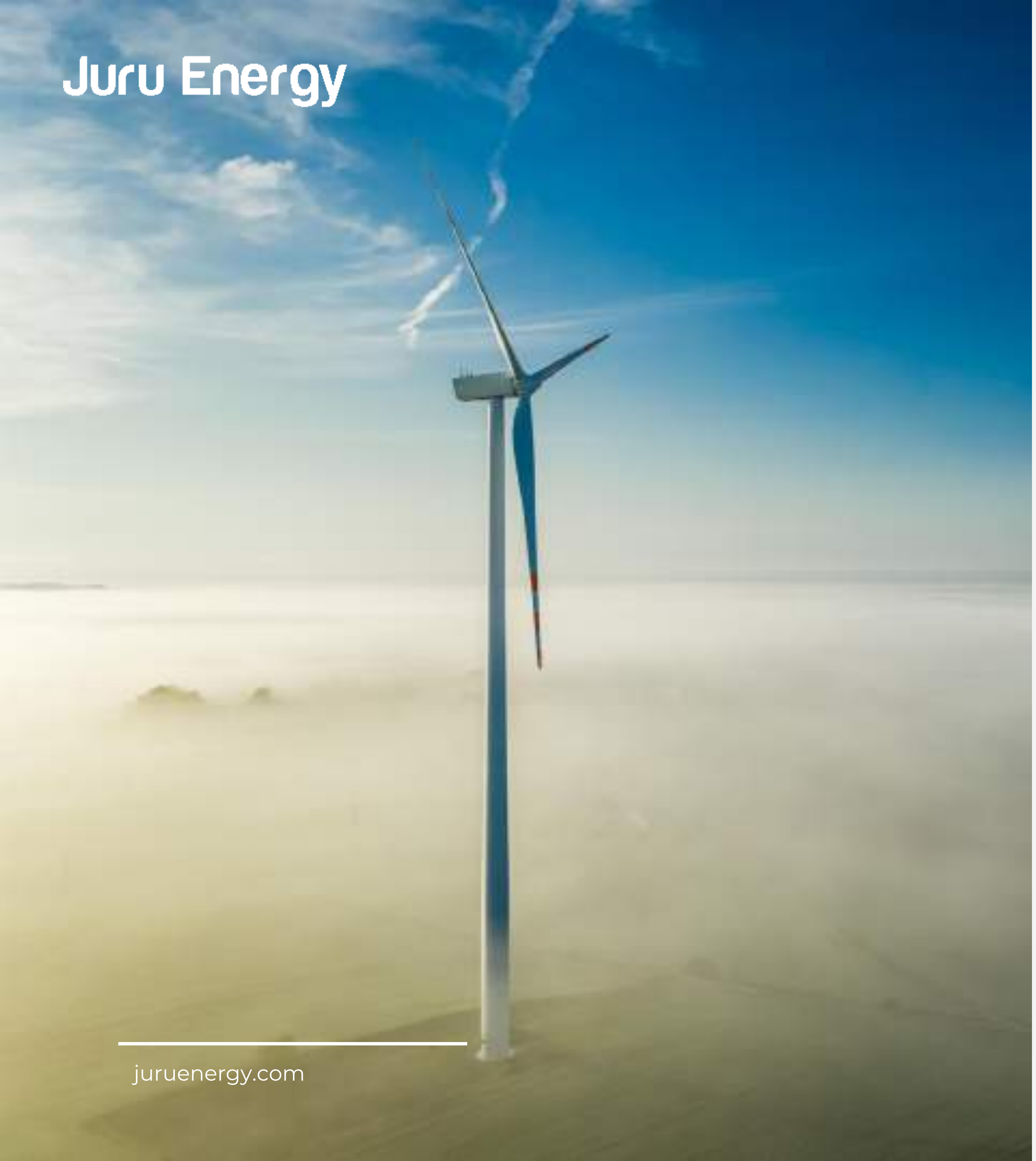

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The story of Juru is the story of renewables in Central Asia

juruenergy.com

Founded by Botir Gafurov 2015, Juru Energy is an energy and sustainability consultancy focused on Central Asia.

Key Facts

80
Number of projects

120
Experts headcount

70
Full time Staff

9
Countries worked

Core Business and Expertise

Consulting

- Energy systems Advisory
- Sustainable Buildings and Cities

Engineering

- Heat & Power Generation
- Transmission & Distribution
- Smart Power Systems
- Automation & Control

Sustainability

- Environmental & Climate
- Social Performance
- Engineering Surveys

Project Development:
Key Stages

Stage 1

Site Selection and Concept Development

Stage 2

Pre-feasibility Study

Stage 3

Feasibility Study

Stage 4

Permitting, financing and contracts

Stage 5

Engineering, construction and commercial operation

Project Development: Site Selection

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Wind Resource Assessment

Potential sites are compared from the perspective of wind speed based on the existing information such as Wind resource map.

Negotiations with Stakeholders

The suitability of the proposed sites is discussed with regulatory and relevant stakeholders.

E&S Screening

Sites are assessed from the E&S point of view to ensure the absence of red flags e.g. critical habitat, proximity to social infrastructure, etc.

Grid Connection Assessment

Local grid infrastructure data in the vicinity of each site is collected and analyzed. The feasibility of grid connection is tentatively assessed.

Site Assessment

The sites are assessed on a high level in terms of accessibility and terrain conditions.

Site Ranking and Selecting the Best Site

After considering all the aspects, the sites are ranked and the most suitable site for WPP construction is selected.

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Project Development: Key Documents and Permits

Power Purchase Agreement

Power Purchase Agreement should be concluded between the Project Developer and the National Electric Grid of Uzbekistan.

Planning & Land Use Consents

Geological and archaeological clearance shall be taken from State Geological and Archaeological committees. Then State Cadastral Committee provides boundaries and labels the land as under industrial use. Right of Way (RoW) is provided based on prelim and permanent technical conditions for connection to the infrastructure.

Environmental Permits

National Environmental Impact Assessment (EIA) for construction and operation of industrial enterprises consist of 3 stages. Preliminary EIA (Stage 1) is sufficient to start construction.

Land Lease Agreement

Implementation of utility scale Wind Plant on PPP base require Presidential Decree (PD) to be issued. PD serves as a base for land allocation by Khokimiyats (municipalities). Land lease agreements are concluded between project developer and local municipalities.

Construction Permits

Regional affairs of Ministry of Construction provides construction permit based on land permit, environmental permits and Basic Design Docs (site general layout, topographical map).

Grid Connection Application

Technical Conditions for connection to the grid is obtained from National Electric Grid of Uzbekistan.

Project Development:
Grid Connection Regulatory Procedure

1	**IPP**	Application to the grid owner for the issuance of Technical Conditions for connection and ToR for Power Evacuations Studies.
2	**System Operator (NEGU)**	Review of the IPP's application & ToR for the Grid Studies
3	**Specialized organization**	Carrying out a Power Evacuation Study for: 1. Defining grid hosting capacity (optional); 2. Defining Interconnection Options; 3.Conducting studies for approved capacity and connection scheme; 4. Developing conceptual design of Electrical Interconnection Facilities
4	**NEGU**	Coordination with the IPP on connection options based on the results of the study or assessment & study approval. Issuance of technical conditions for connection.
5	**Specialized project institution**	1. Development of a project (basic and detailed design phases) for connecting IPP to power grids under an agreement with the producer. 2. Approval of the connection project by the organization that issued the Technical Conditions and UzEnergoInspektsiya
6	**Producer or organization that will operate the connected IPP**	1. Design of commissioning scheme. 2. Alignment on commissioning scheme with the system operator. 3. Construction, installation and commissioning. Request to Uzenergoinspektsiya and the grid owner to verify compliance with the Technical Conditions and with established rules and regulations during installation and commissioning
7	**IPP or specialized organization, grid owner and UzEnegoInspektsiya**	Testing and commissioning Registration of the commissioning act in the predefined form

Project Development:
Grid Connection Required Grid Studies

General Studies

- Load Flow Studies;
- Contingency Studies;
- Short circuit Studies;
- Steady-state and dynamic stability studies;
- Electrical infrastructure conceptual design approval prior to commencement of basic design phase.

RE Generation only

- Grid compliance studies:
- Reactive power compensation study;
- Voltage and frequency ride through studies;
- Voltage and rotor angle stability studies;
- Power Quality Studies

500kV Connection

- Transient switching studies.

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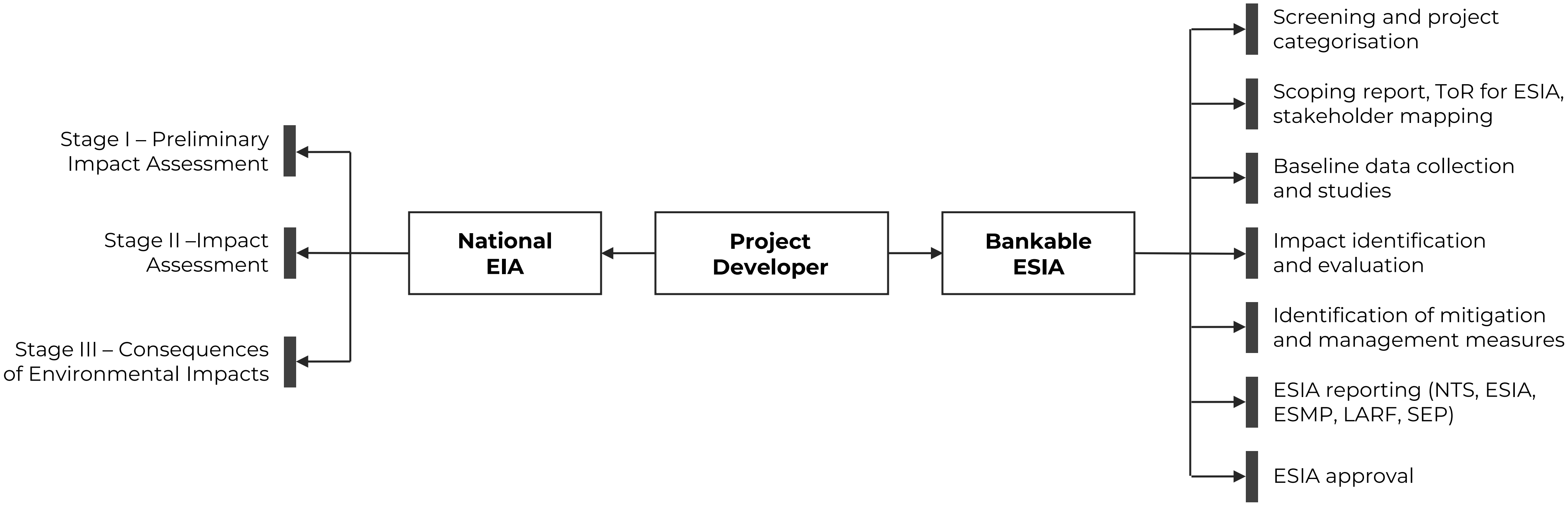
Project Development:
Environmental and Social Assessment



Committed and Planned Large Scale RE Projects

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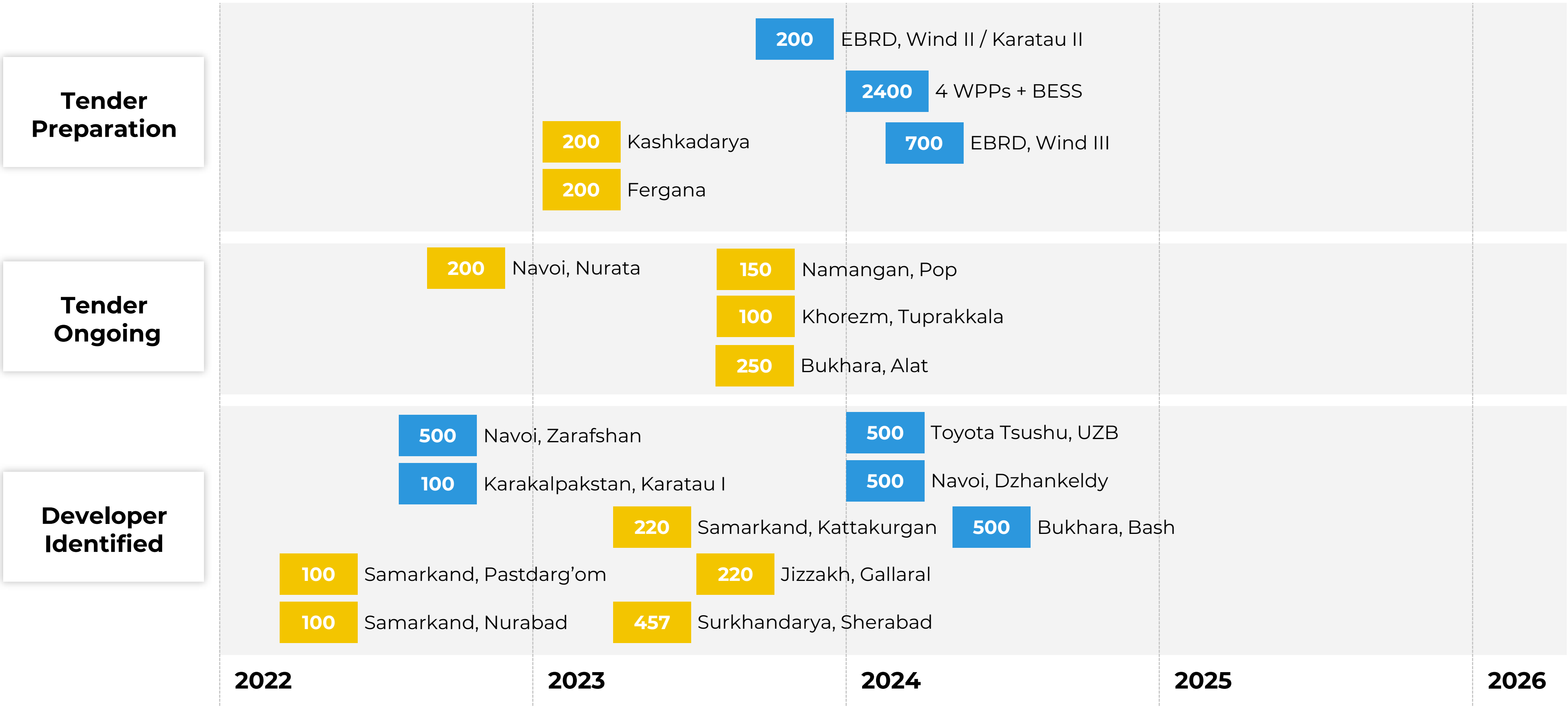


Total - 3700 MW

- 400 Solar PV Power Plants
- 3300 Wind Power Plants

Total - 700 MW

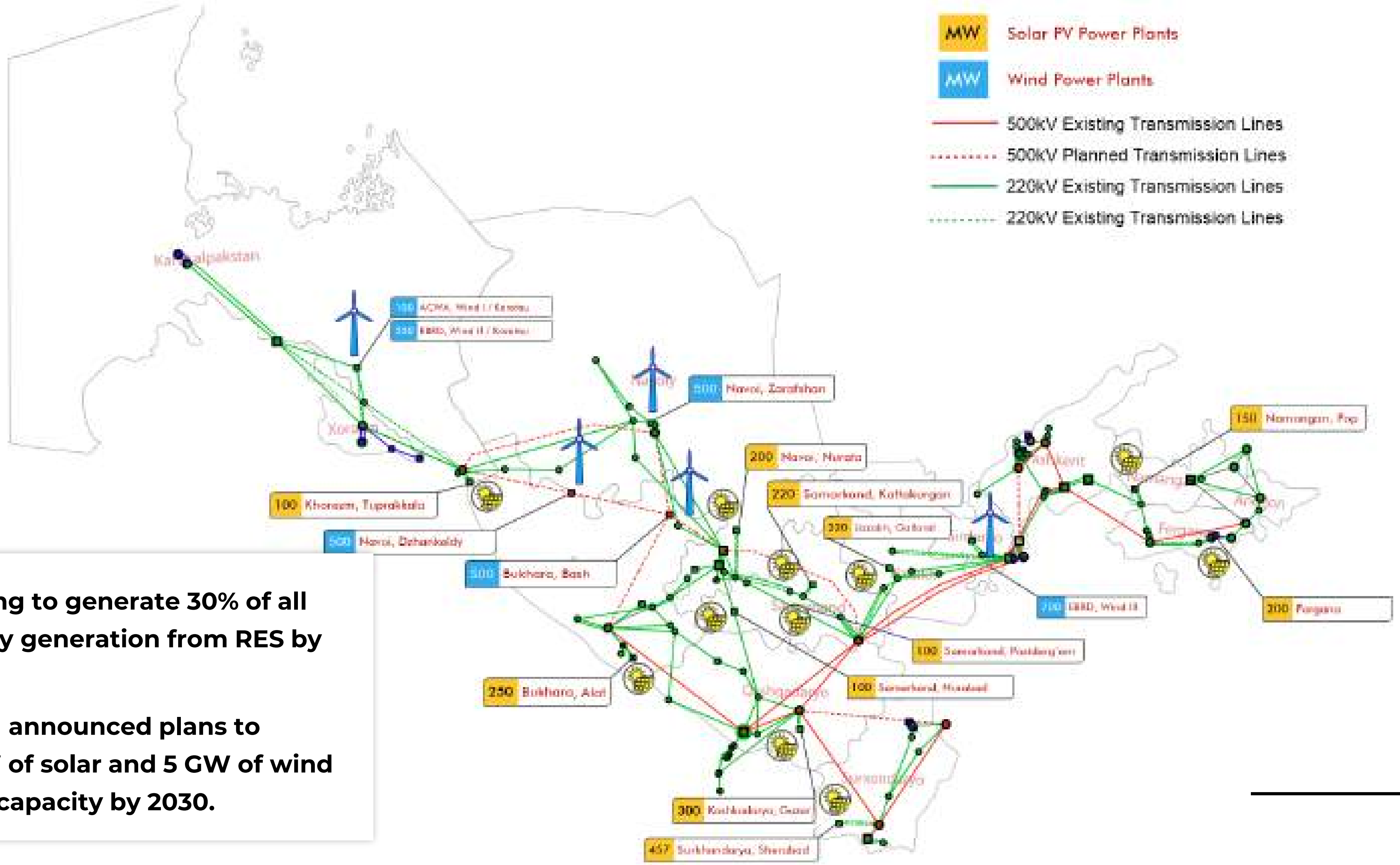
- 700 Solar PV Power Plants
- 0 Wind Power Plants

Total - 3197 MW

- 1097 Solar PV Power Plants
- 2100 Wind Power Plants

Source:
1. minenergy.uz/en/lists/view/77
2. minenergy.uz/en/news/view/1389
3. minenergy.uz/ru/news/view/1448
4. minenergy.uz/ru/news/view/1263
5. uzdaily.uz/en/post/71154

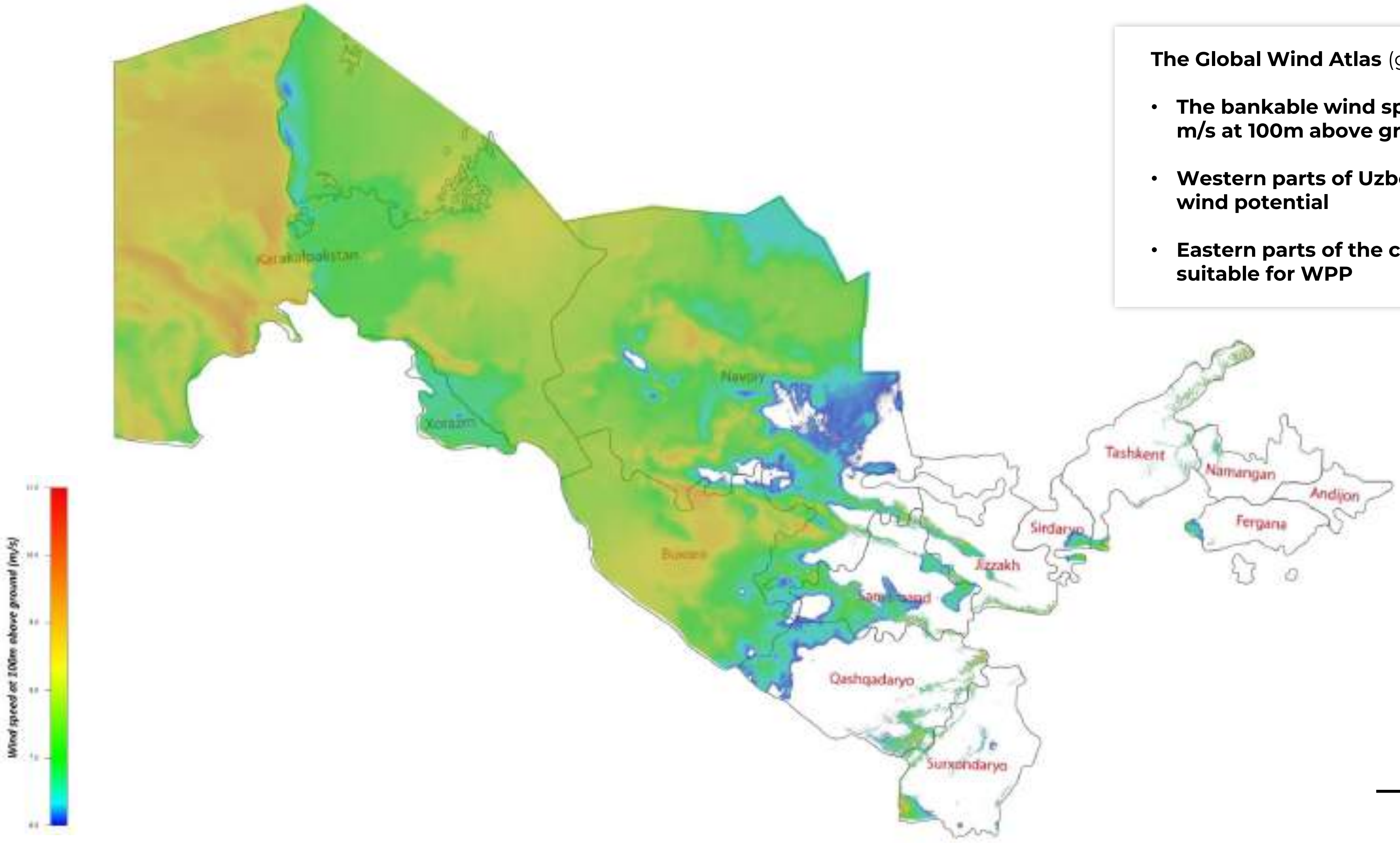
Committed and Planned Large Scale RE Projects – Geographic Spread



GoU is aiming to generate 30% of all its electricity generation from RES by 2030.

In 2021, GoU announced plans to install 7 GW of solar and 5 GW of wind generation capacity by 2030.

Wind Atlas of Uzbekistan



The Global Wind Atlas (globalwindatlas.info)

- **The bankable wind speeds are above 6-6.5 m/s at 100m above ground**
- **Western parts of Uzbekistan have stronger wind potential**
- **Eastern parts of the country is generally not suitable for WPP**

Electricity Generation Profile: Existing Power Plants

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Total installed capacity ca. 15 GW

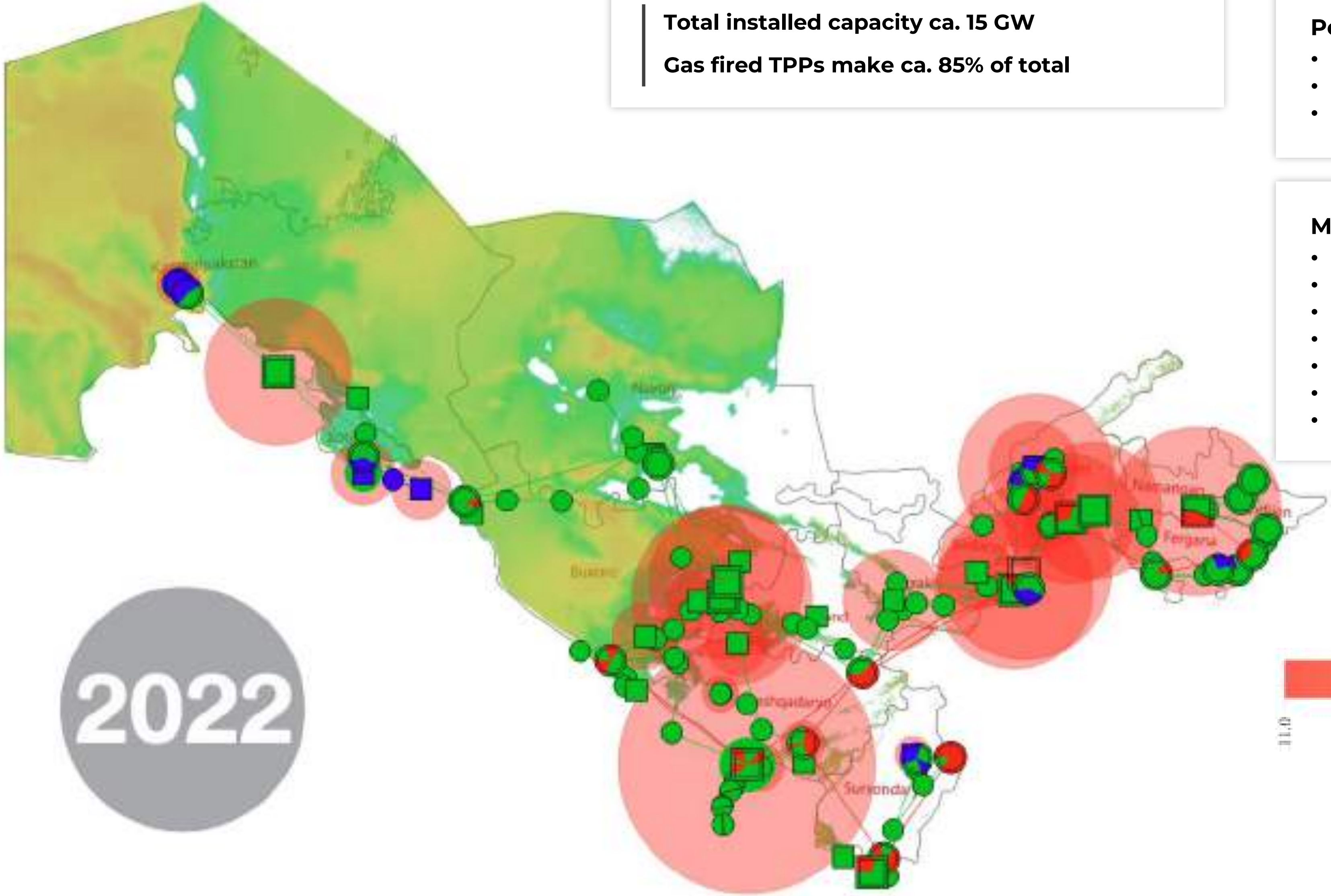
Gas fired TPPs make ca. 85% of total

Peaker Plants:

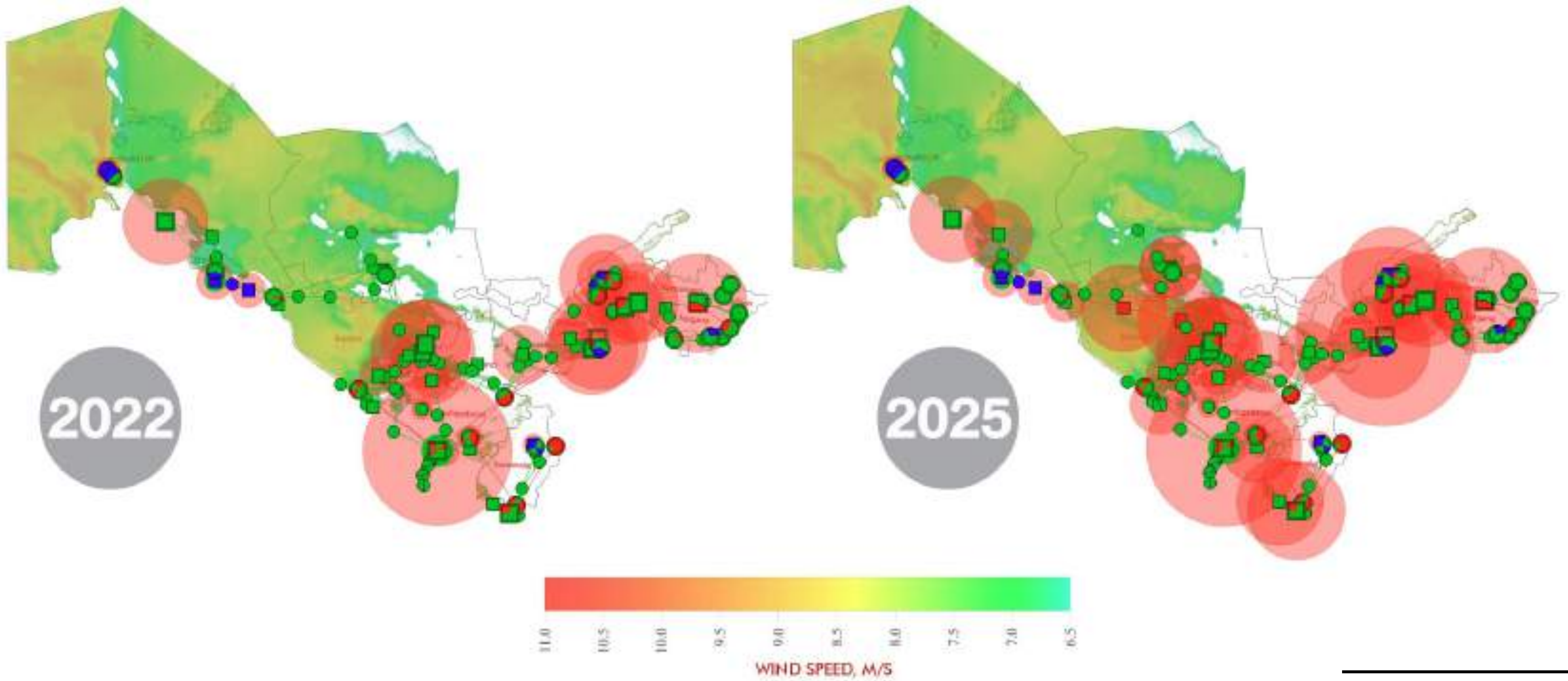
- Gas Piston Plant in Bukhara - 270MW
- Gas Piston Plant in Tashkent - 240MW
- Gas Piston Plant in Khorezm - 174MW

Main Generation Sources:

- Syrdarya TPP – 3000MW
- New Angren TPP – 2400MW
- Navoi TPP – 1935MW
- Talimarjan TPP – 1800MW
- Tashkent TPP – 1800MW
- Takhiatash TPP - 920MW
- Turakurghan TPP- 900MW



Electricity Generation Profile: Existing vs. Planned Capacity



Electricity Demand Growth Forecast 2022-2025

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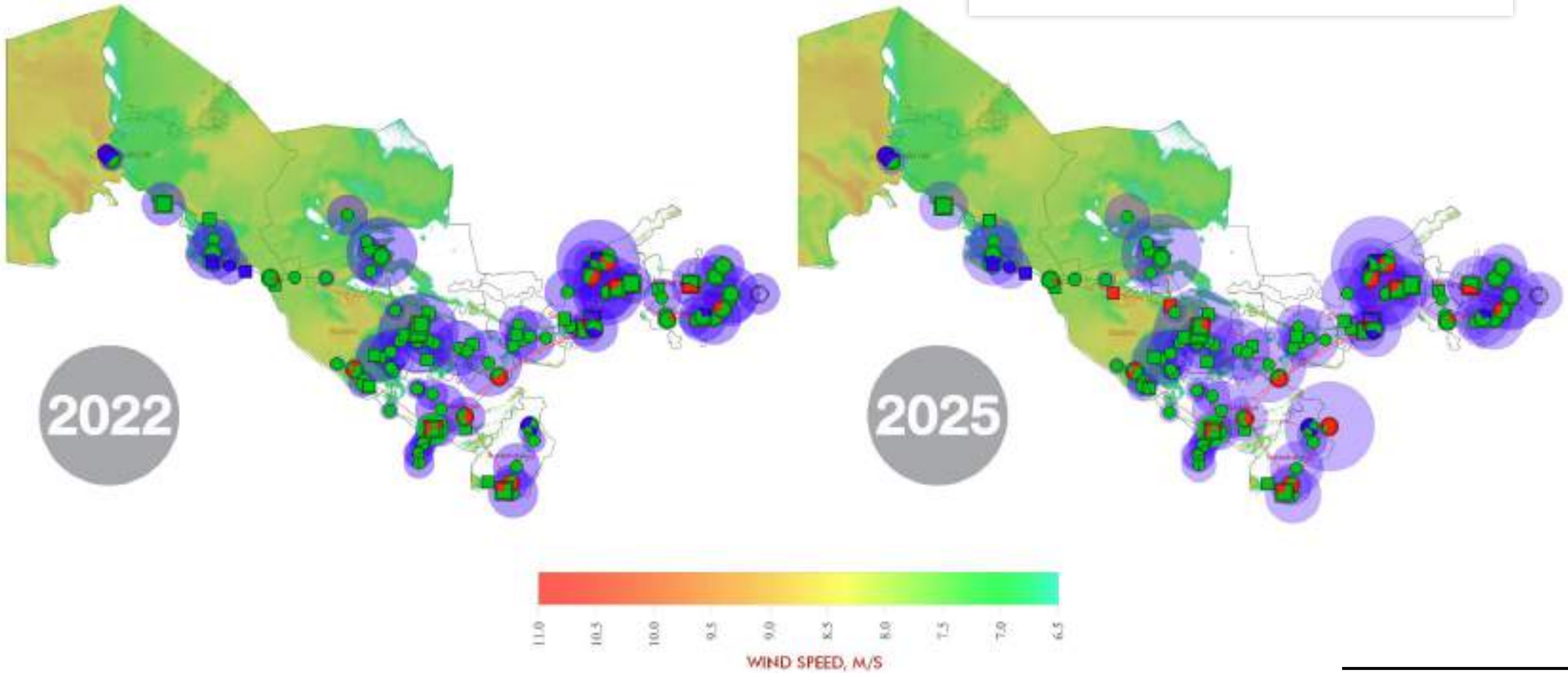
Demand has been increasing 5% a year on average.



Theoretical Wind Potential vs Demand Centers

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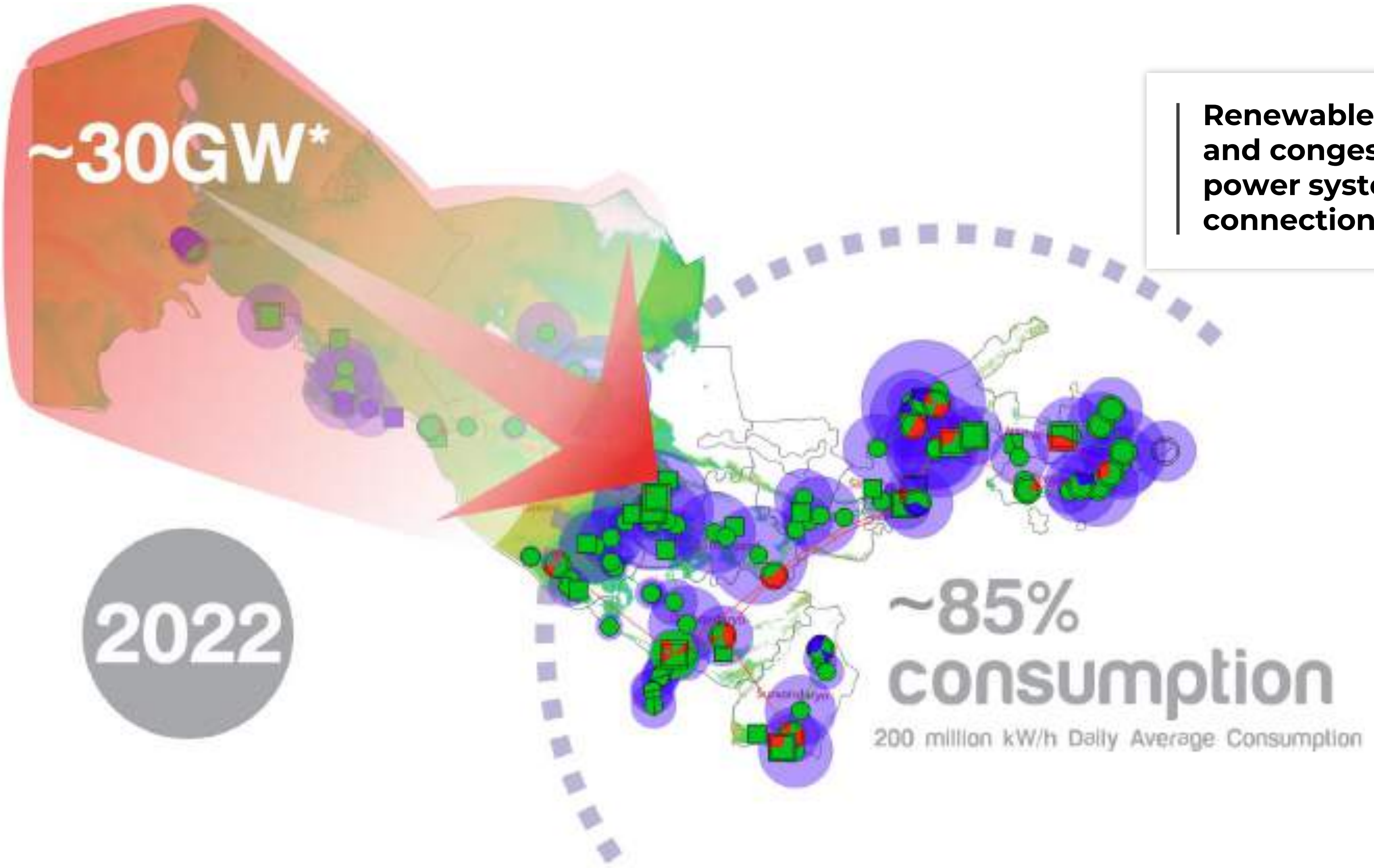

Renewable generation in remote and congested parts of the power system impact grid connection assessments

*- Juru Energy's estimation based on wind resource map (WindPro) data

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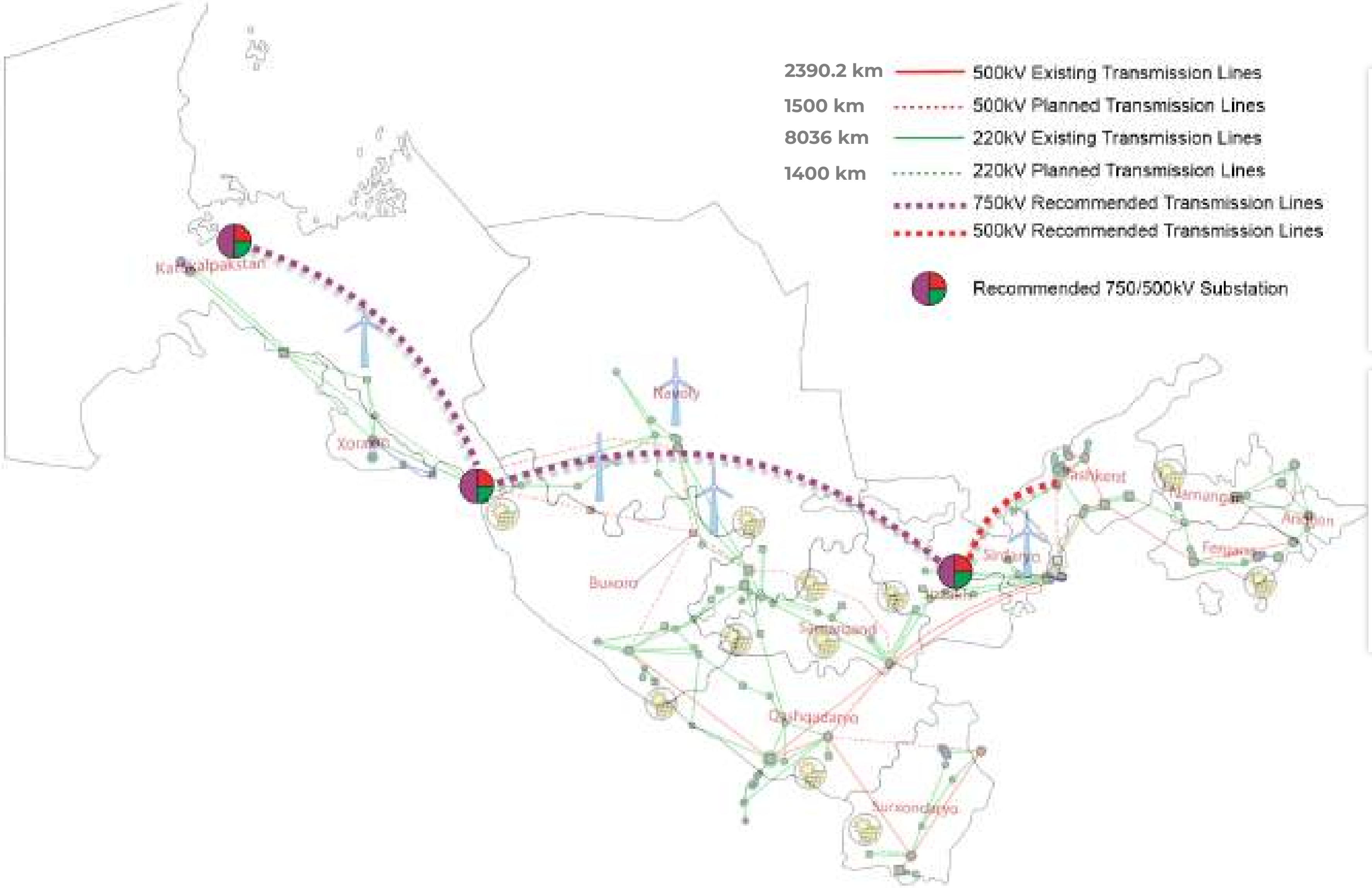
Future Power System Reinforcement



The future power system will need to support increasingly complex dynamics in the transition from mainly synchronous to inverter-based resources (IBR) and balance increasing volumes of variable renewable energy (VRE).

The North Western Region is experiencing significant renewable generation development.

Transmission infrastructure in this region is insufficient.

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Role of BESS

in mitigating the adverse impact of RE on the grid

> *"... large solar PV plants (with overall capacity of over 300MW) shall be gradually equipped with industrial scale power storage systems to ensure stabilisation of intermittent generation and regulate peak loads."*
>
> Extract from Chapter 5, Paragraph 2. of
>
> **Concept Note for Ensuring Electricity Supply in Uzbekistan in 2020-2030**

Potential Applications of BESS

in Uzbekistan and other CA Power Systems

VRE Smoothing / Firming
relevant for both WF and Solar PV
Considered.

Flexible Ramping
relevant for both WF and Solar PV
Considered.

Peak Shaving
could be coupled with RE or as a standalone project
Large capacity requirement = Expensive!

Frequency-response reserves
could be coupled with RE or as a standalone project
Large capacity requirement = Expensive!

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Case 1. Smoothing WF Output

The wind farm is coupled with a 25 MW / 52 MWh Li-ion BESS.
The Lake Bonney BESS operates to smooth the wind farm output

The wind farm and BESS are registered in the National Electricity Ancillary Services Market providing frequency control services

Source: https://arena.gov.au/projects/lake-bonney-battery-energy-storage-system/

The Lake Bonney Wind Farm
South Australia, 278.5 MW

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Case 2. WF Ramp Management

Requirement:
reduce ramps to 1% of the installed capacity, i.e. 1.4 MW / minute.

A ramping constraint of 1.4 MW / minute is very strict and as a consequence it was found that the BESS needed to have a high energy capacity. The BESS was sized at 80 MW / 480 MWh, with a E:P ratio of 6, i.e. 6 hours storage duration.

This storage time can only be met by a NaS battery at a high cost. The following figure shows the simulated ramp reduction.

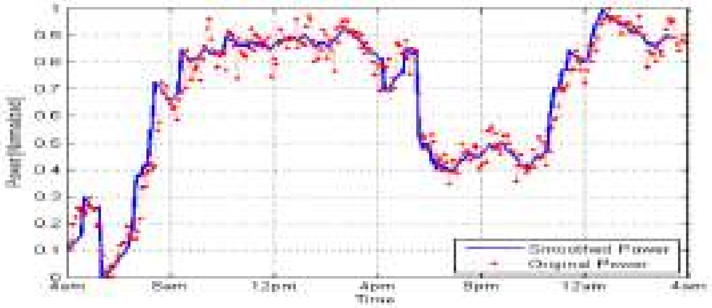
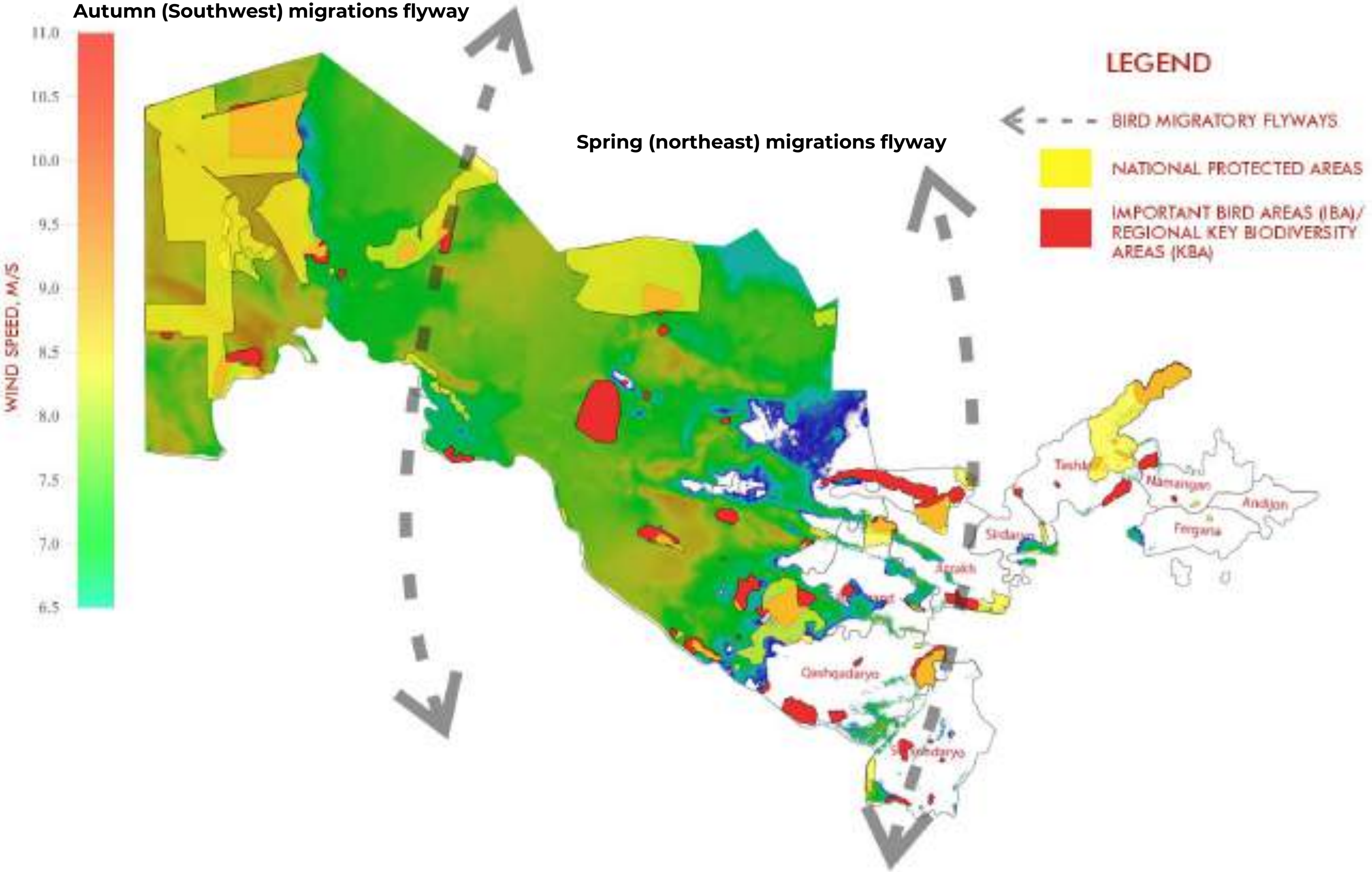


Figure. Woolnorth Wind Farm + BESS

Woolnorth Wind Farm
Tasmania, Australia, 81 MW

E&S Considerations: Bird Migration and Conservation Areas



WPP can have adverse environmental impacts, including the potential to reduce, fragment, or degrade habitat for wildlife, fish, and plants.

Spinning turbine blades can pose a threat to flying wildlife like birds and bats.

Uzbekistan lies on the Central Asian Flyway

Protected areas for sustainable conservation of biodiversity <**5,77%** of the territory of Uzbekistan.

Important bird areas (IBAs)
52 areas
2,462,782 ha total area

Currently, the national system of protected areas in Uzbekistan includes:

- 7 state nature reserves
- 3 state national natural parks
- 12 state wildlife sanctuaries
- 2 state biosphere reserves
- 6 state natural monuments, one state national park
- 1 natural nursery
- 1 state complex (landscape) reserve

E&S Considerations: Wind Farm

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Problem	Solution	Outcome
Proximity of the Project site to the IBA/KBA	Screening against proximity to IBA/KBAs, nationally protected areas, Ramsar sites, etc on the early stage of the site selection	Expensive mitigation measures
Seasonality of the terrestrial biodiversity surveys in the desert areas of Uzbekistan	Survey design at the scoping stage of the project	Extended overall timeline of the Project
Presence of the archaeological artefacts on the Project site	Consultations with the Archaeological Centre at the site selection stage/scoping stage of the project	- Additional Archaeological surveys - Extended overall timeline of the Project - Budget increase
Mining potential for the priority minerals such as gold	Consultations with Ministry of Geology at the site selection stage	Change of the Project location
Absence of the final OHTL design at the ESIA stage of the Project	Inclusion of the bird monitoring for the associated OHTLs	Extended overall timeline of the Project

E&S Considerations: BESS

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Environmental impacts

The life-cycle global warming emissions
Less of 5% of Li-Ion batteries are currently recycled, and production of new cells involves large use of energy and water

Use of land
A 10 MW battery facility will occupy roughly 700 m^2 and part of the soil will be sealed by the construction of concrete platforms

The visual impact
A 10 MW battery can lead to the installation of concrete platforms and up to 10 40ft containers plus auxiliaries systems

Use of hazardous materials
Li-ion batteries contain hazardous materials like Lithium, Cobalt and Nickel. In conditions of correct decommissioning, no contamination will take place

Safety Issues

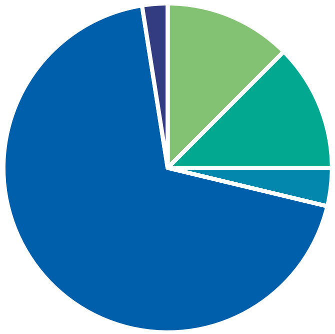
Thermal runaway
The major risk for a battery is a cycle in which excessive heat keeps creating more heat and finally leads to fire

Uncontrolled and disruptive fire
It is a very rare occurrence, with 3 cases reported to date, thanks to the effective and redundant automatic fire extinguishing systems within the modern containerised battery systems.

Toxic fumes
Battery fire extinguishing has to be performed with unconventional means, and the fumes present toxicity even if limited.

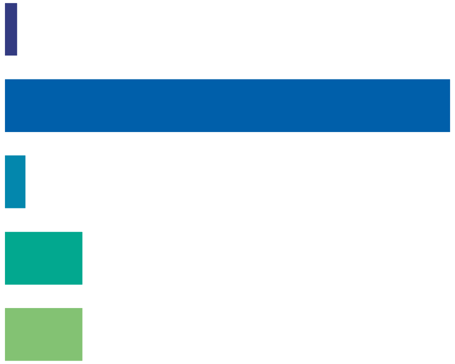
Cost Breakdown

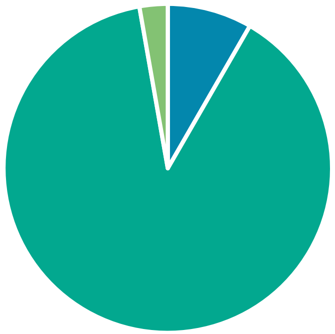
EPC - 100 MW Wind + 25 MW / 50 MWh BESS + Grid Infrastructure



EPC - WPP — USD **80M**

Planning and documentation	USD **2M**
Procurement – Wind Turbines, MW switchgear, cabling	USD **55M**
Procurement – Wind Farm Substation	USD **3M**
Transportation	USD **10M**
Construction	USD **10M**





EPC – Grid Connection — USD **18.0M**

Engineering	USD **0.5M**
Procurement	USD **16.0M**
Construction	USD **1.5M**

EPC - BESS — USD **28M**

BESS 25 MW / 50 MWh (lifetime - 15 years)	USD **28M**

Grid connection infrastructure cost is substantial, which is pushing project sizes to mega wind projects in order to keep the tariff low

Lithium - Ion Batteries

Capital and Operating Expenditure

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CAPEX Costs

	10 MW / 7.5 MWh (45 m)	10 MW / 20 MWh (2 h)
Ex works cost	**4.00** M$	**8.55** M$
Shipping	**0.10** M$	**0.25** M$
Installation	**0.50** M$	**1.20** M$
Total	**4.60** M$	**10.00** M$

OPEX Costs

	10 MW / 7.5 MWh (45 m)	10 MW / 20 MWh (2 h)
Maintenance	**45** k$/year	**75** k$/year
Ext. warranty	**50** k$/year	**90** k$/year
Elect. Losses*	**65** k$/year	**100** k$/year
Total	**155** k$/year	**265** k$/year

Li-Ion batteries have seen in the last years a reduction in cost in the order of 25-30 %/year.

Batteries usually have limited maintenance costs

OPEX costs can increase if stringent performance-based warranties or long term warranties (>5 years) are required

Li-ion battery overall lifetime average electric efficiency is in the order of 82%

Concluding remarks

Wind market

IPCC Report 2022 on Mitigation of Climate Change concludes that in the energy sector, wind as well as solar energy have the highest potential to reduce net emissions

Uzbekistan wind market is an interesting market with total of 5 GW market size until 2030

Northwest part of Uzbekistan has high wind potential, whereas main load centres are in the South East. This requires HV or EHV OHTL to connect key wind centres with load centres

Role of BESS

Energy storage can be applied to 'smooth' the wind farm production so that the variability is reduced

BESS is still expensive and therefore financial case for BESS is based on the benefits of BESS in terms of avoided penalties for breaching Grid Code requirement or the degree of curtailment

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