GREEN HYDROGEN IN TURKMENISTAN – PROSPECTS AND CHALLENGES

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OUTLINE

* **Analysis of international studies**
* **Main conditions for the development of renewable energy**
* **Pilot project for hydrogen production in Turkmenistan**

UNITED NATIONS ECONOMIC COMMISSION FOR EUROPE

Low-carbon hydrogen production in the CIS countries and its role in the development of the hydrogen ecosystem and export potential

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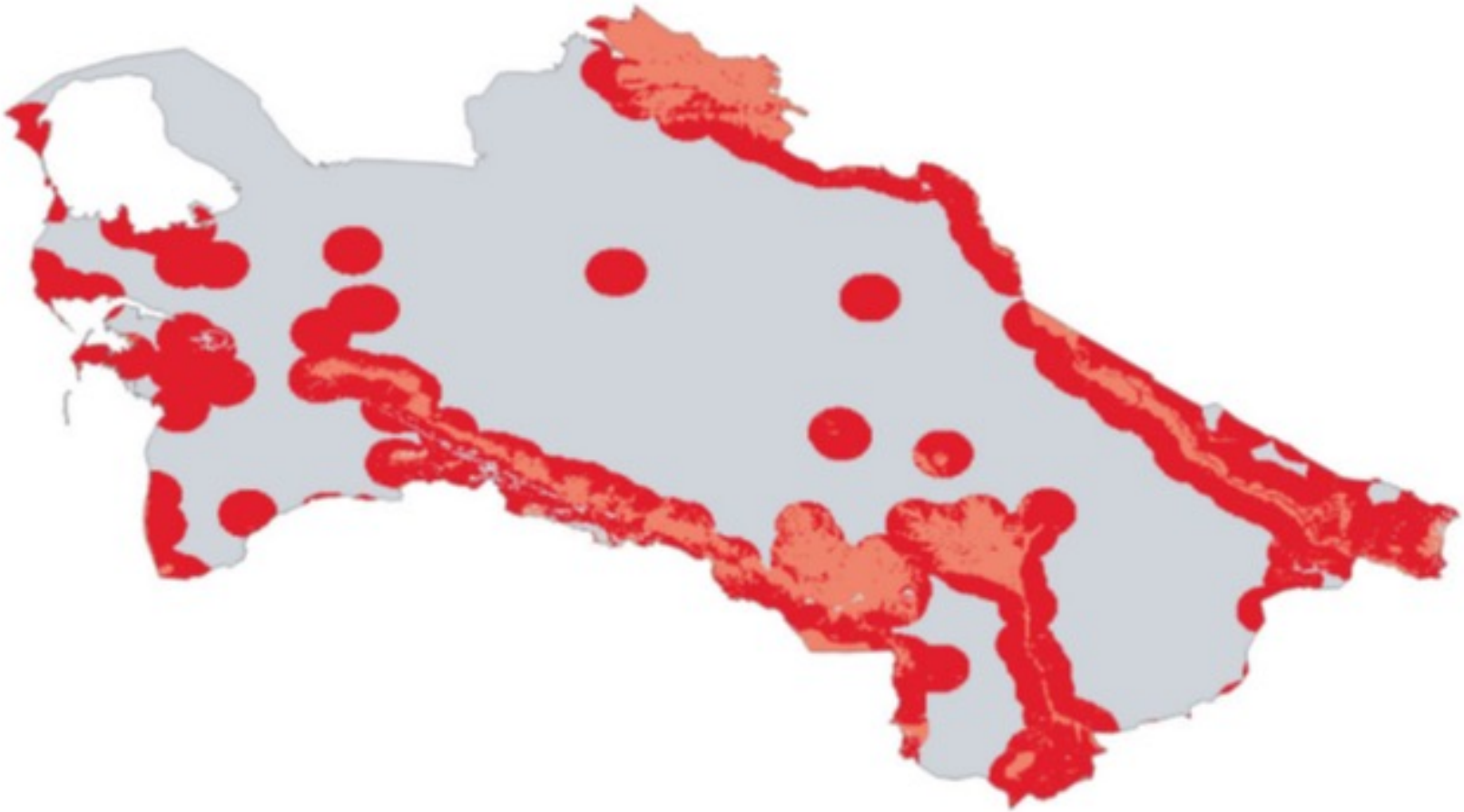
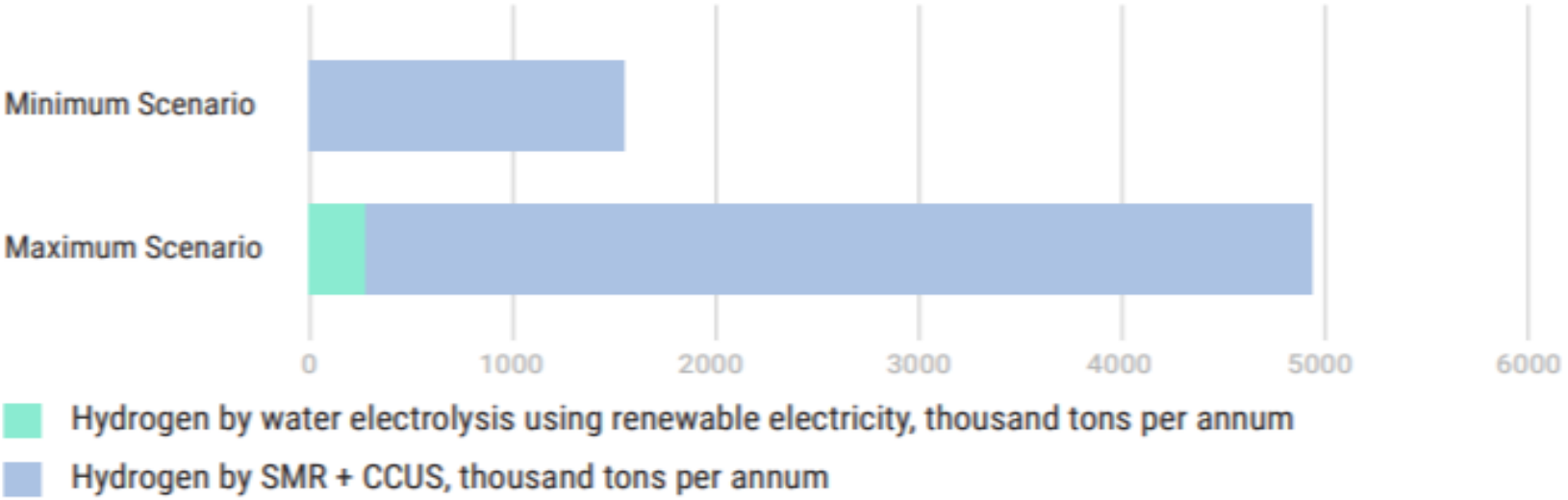
Model of the Turkmenistan's territory with solar PV practical potential zonation



Red color stands for a territory convenient for locating utility-scale PV plants without any land-use constraints (possibly under land use regulations due to nature and cropland protection); pink stands for a territory convenient for locating utility-scale PV plants with some land-use constraints, gray is an area inconvenient for utility-scale PV plants due to identifiable physical obstacles.

Source: *ESMAP (2021)*

Resource potential of hydrogen production in Turkmenistan by 2040, thousand tons per year



This is determined by the significant proven natural gas reserves in place and the growth rate of its production. The key constraint and condition in this case is the outstripping development of CCUS industry – even in the minimum scenario, it is necessary to create CCUS facilities with a total capacity of 18 $MtCO_2$ per annum.

Resource potential of hydrogen production in Turkmenistan by 2040

	MINIMUM SCENARIO	MAXIMUM SCENARIO
Renewable electricity for hydrogen, GWh per year	306.6	17630
Natural gas for hydrogen, bcm per annum	9.609	28.827
Hydrogen by water electrolysis using solar and wind electricity, thousand tons per annum	6	321
Hydrogen from methane by SMR + CCUS, thousand tons per annum	1813	5439
Hydrogen total, thousand tons per annum	**1819**	**5760**
Required capacity of CCUS systems, $MtCO_2$ per annum	18	54

* At the current level of uncertainty, it is not possible to calculate these parameters, but it is possible to assess the resource potential by taking them at the minimum and maximum levels. In this study, two scenarios are adopted:

1) Minimum scenario

10% of the increase in solar and wind electricity generation during 2020-2040 is used for hydrogen production;

increase in renewable energy capacity by 2040 – 1 GW;

10% of the increase in natural gas production by 2040 is used for hydrogen production.

2) Maximum scenario

50% of the increase in solar and wind electricity generation is used for hydrogen production;

in Turkmenistan, 25% of the technical potential for offshore wind on a fixed foundation is realized (17.5 GW);

renewables capacity factor is – 35%

30% of the increase in natural gas production by 2040 is used for hydrogen production.

In both scenarios, it is assumed that hydrogen production by electrolysis of water will require 55 kWh/kg H_2 of electricity, and hydrogen production by steam methane reforming will require 5.3 m3 /kg H_2 of electricity. The amount of CO_2 released during the reforming process, which must be stored, is estimated as 10 kg CO_2 / 1 kg H_2.

Main conditions for the development of renewable energy

* Solar energy potential in Turkmenistan
* Regulatory framework

Solar energy potential in Turkmenistan

Согласно этого кадастра в территории Туркменистана выделяются 5 зон с соответствующими распределением годовых величин суммарной солнечной энергии, т.е.

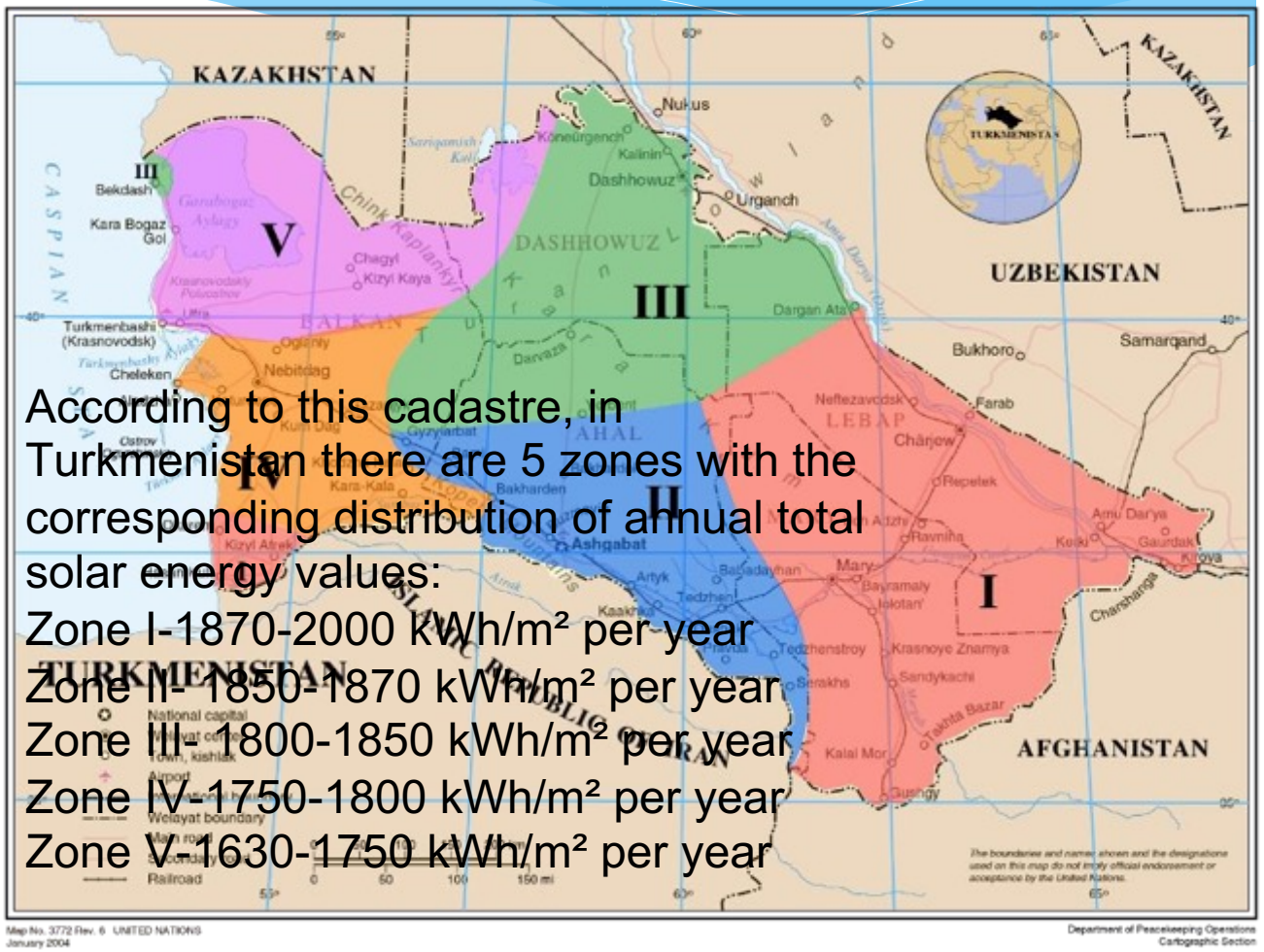
I-зона с 1870-2000 кВт·ч/м^2 год,

II-зона с 1850-1870 кВт·ч/м^2 год,

III-зона с 1800-1850 кВт·ч/м^2 год,

IV-зона с 1750-1800 кВт·ч/м^2 год,

V-зона с 1630-1750 кВт·ч/м^2 год.



According to this cadastre, in Turkmenistan there are 5 zones with the corresponding distribution of annual total solar energy values:

Zone I-1870-2000 kWh/m² per year

Zone II- 1850-1870 kWh/m² per year

Zone III- 1800-1850 kWh/m² per year

Zone IV-1750-1800 kWh/m² per year

Zone V-1630-1750 kWh/m² per year

Regulatory framework

* **"State Energy Saving Program for 2018-2024." Resolution of the President of Turkmenistan dated February 21, 2018.**
* **The program for the development of energy diplomacy of Turkmenistan for 2021-2025. Resolution of the President of Turkmenistan dated December 4, 2020.**
* **National Strategy for the development of renewable energy in Turkmenistan until 2030. Resolution of the President of Turkmenistan dated December 4, 2020.**
* **Law “On Renewable Energy Sources”.13/03/2021**

Pilot project for hydrogen production in Turkmenistan

Purpose of the pilot project:

* - Analyze the current state and prospects for the development of hydrogen energy;
* - Consider the possibility of implementing a pilot project on hydrogen production in Turkmenistan;
* - Select a suitable location for the construction of the facility;
* - Provide for the use of renewable sources to supply consumers of the facility with electricity;
* - Study existing methods for producing hydrogen in order to select suitable ones to be used in Turkmenistan;
* - Calculate the volume of electricity generated by the selected source and consumed by the elements of the hydrogen production system;
* - Determine the cost of the pilot project implementation and its payback period.

Pilot project for hydrogen production in Turkmenistan

* **Methods used in the project:**
* - To achieve the set goals, the volume of electricity generated by the source, as well as the cost of implementing a pilot project and a payback period were calculated using data from open sources;
* - In the framework of the project, a facility was modelled. It consists of an electricity source – a PV power plant with an installed capacity of 100 MW; a hydrogen production system- an electrolyzer with a capacity of 50 MW; a water desalination system - a reverse osmosis system with a capacity of 80 tons of water per day;
* - Electrolyzers of various types were analyzed.

Pilot project for hydrogen production in Turkmenistan

* **Advantages of hydrogen energy:**
* - It will help solve a number of energy problems, the main one of which is the decarbonization of a number of sectors: transport, chemical industry, ferrous metallurgy. In addition, it will allow increasing the flexibility of the energy system;
* - hydrogen can be produced in several ways, using a range of energy sources;
* - will solve renewable energy storage problems, which improves its efficiency.

Pilot project for hydrogen production in Turkmenistan

* **Turkmenistan has great hydrogen energy potential.**
* The pilot project considers the construction of two solar photovoltaic power plants (PV) with an installed capacity of 100 MW each in Mary and Lebap velayats in the settlements of Serhetabat and Kerki. They can become energy sources for the production of “green hydrogen”. If electrolyzers are used for this purpose together with PV, then there is no need to use special equipment either to convert the generated current (generators, inverters) or to synchronize with the electrical grid.

Pilot project for hydrogen production in Turkmenistan

In addition to electrical energy, water can be the source for producing hydrogen using an electrolyzer. Efficiency and reliability of electrolyzer operation directly depends on the degree of its purification. In the technological process of producing hydrogen, it is possible to use non-fresh water, which requires the use of desalination plants. This could increase the cost of hydrogen production. On average, the impact of water treatment activities is estimated to be USD 1/m3 or about USD 0.01/kg of hydrogen. The electrolysis process ideally requires 9 kg of water to produce 1 kg of hydrogen.

Pilot project for hydrogen production in Turkmenistan

* **Calculation method:**
* To analyze the prospects for the joint operation of renewable sources and an electrolyzer for the production of hydrogen in Turkmenistan, a PV power plant with a capacity of 100 MW in the settlement of Kerki and a PV power plant with a capacity of 100 MW in the settlement of Kushki were selected as a source of electrical energy.
* It was believed that only the electrolyzer and the desalination plant were PV power plant consumers. An approximate calculation of the volume of electrical energy generated by such a PV power plant per year was carried out.

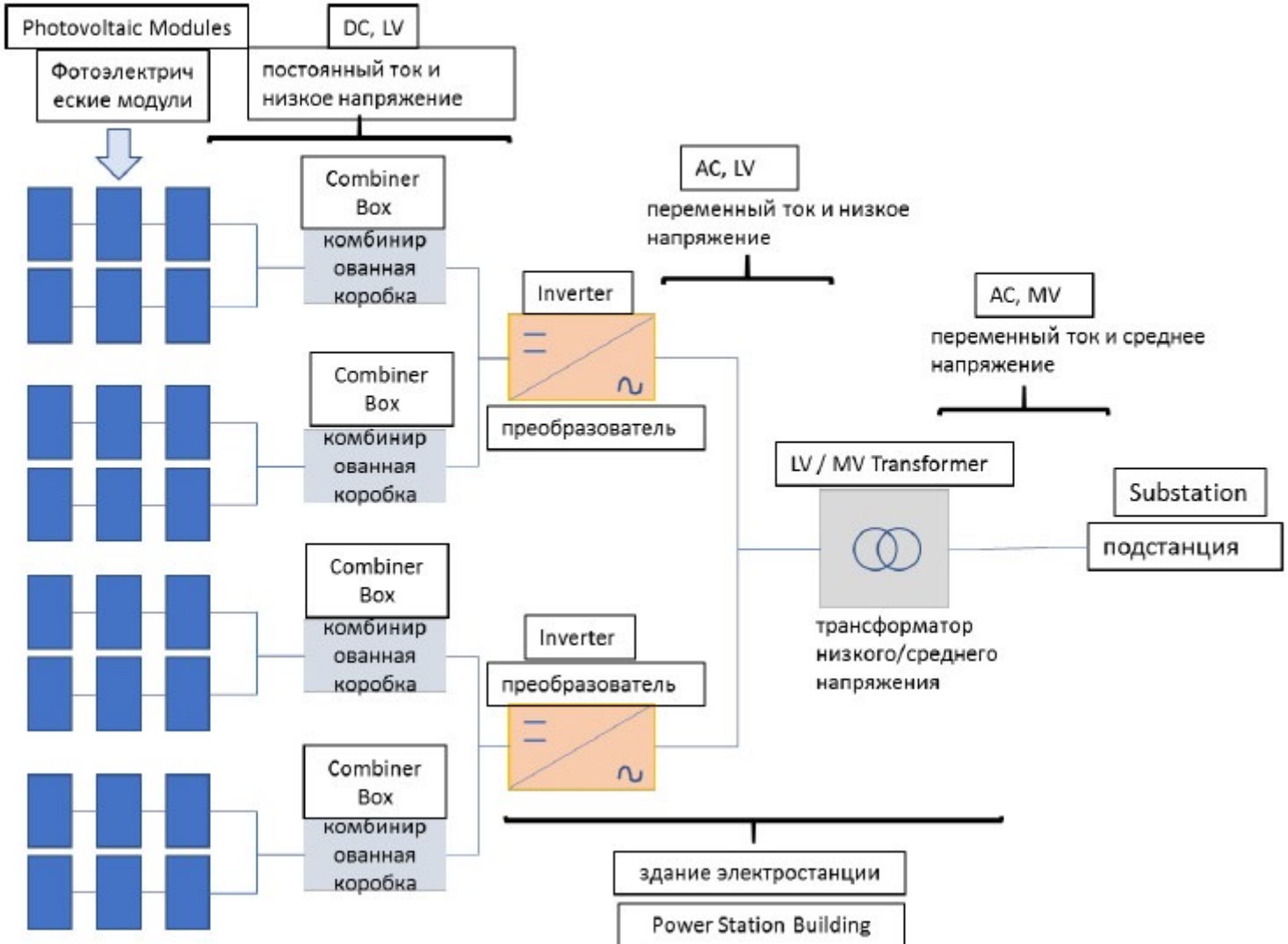
Pilot project for hydrogen production in Turkmenistan

1	**PV power plant capacity, main base unit**	**2745x2=5490,0 kW**
2	Photovoltaic panel capacity	380 W
3	Number of photovoltaic panels	7224x2=14448
4	Number of photovoltaic panels connected in a row	28
5	Number of rows	258x2=516
6	Photovoltaic panel area	28578 m^2
7	Number of inverters	2
8	$P_{отн}$	-
9	Inverter rated power	2841 kVA

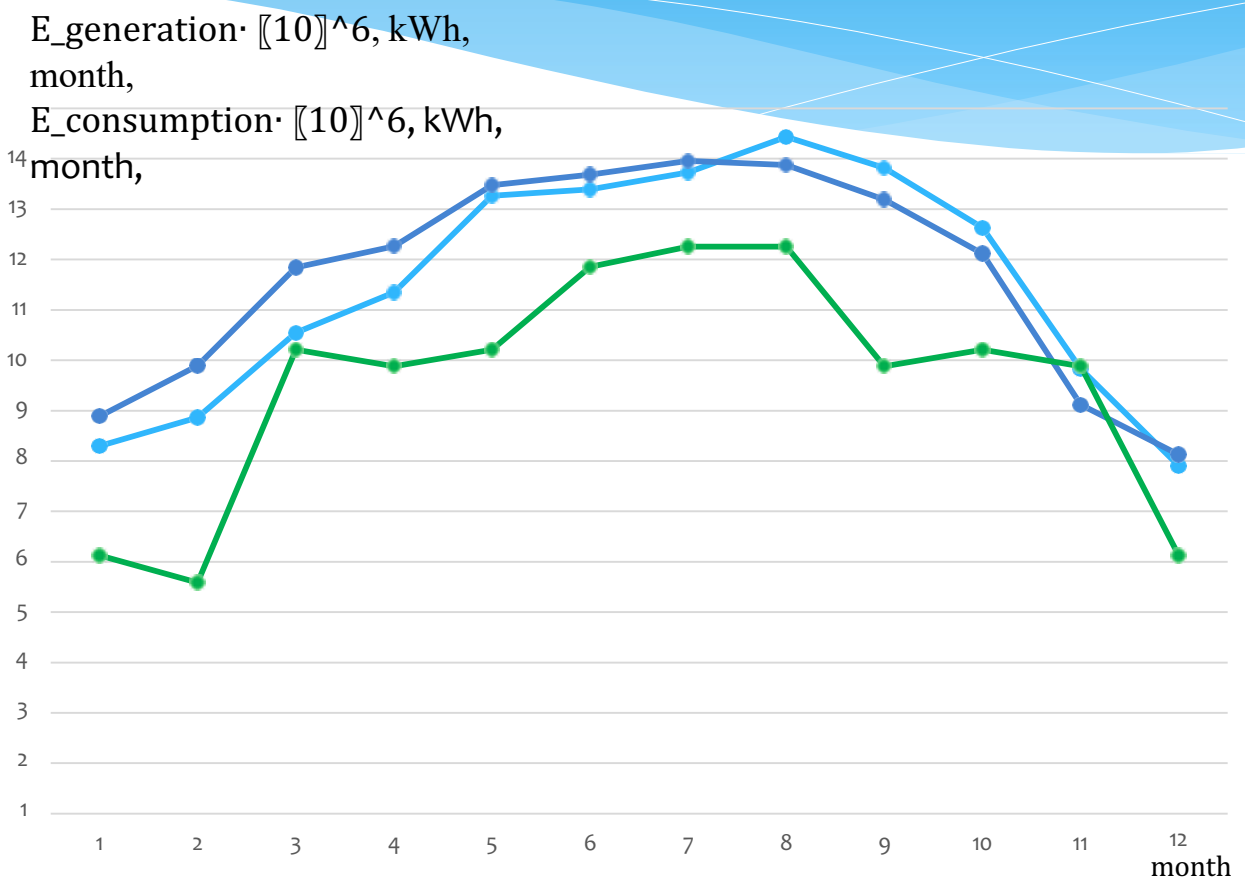
Pilot project for hydrogen production in Turkmenistan

1	**PV power plant capacity**	**100 MW**
	Number of main base units	18
	PV power plant capacity, main base unit	5490 kW
2	Photovoltaic panel capacity	380 W
3	Number of photovoltaic panels	260064
4	Number of photovoltaic panels connected in a row	28
5	Number of rows	9288
6	Photovoltaic panel area	514406 m^2
7	Number of inverters	36
8	Electricity production per year	138.538·106 kWh

Pilot project for hydrogen production in Turkmenistan



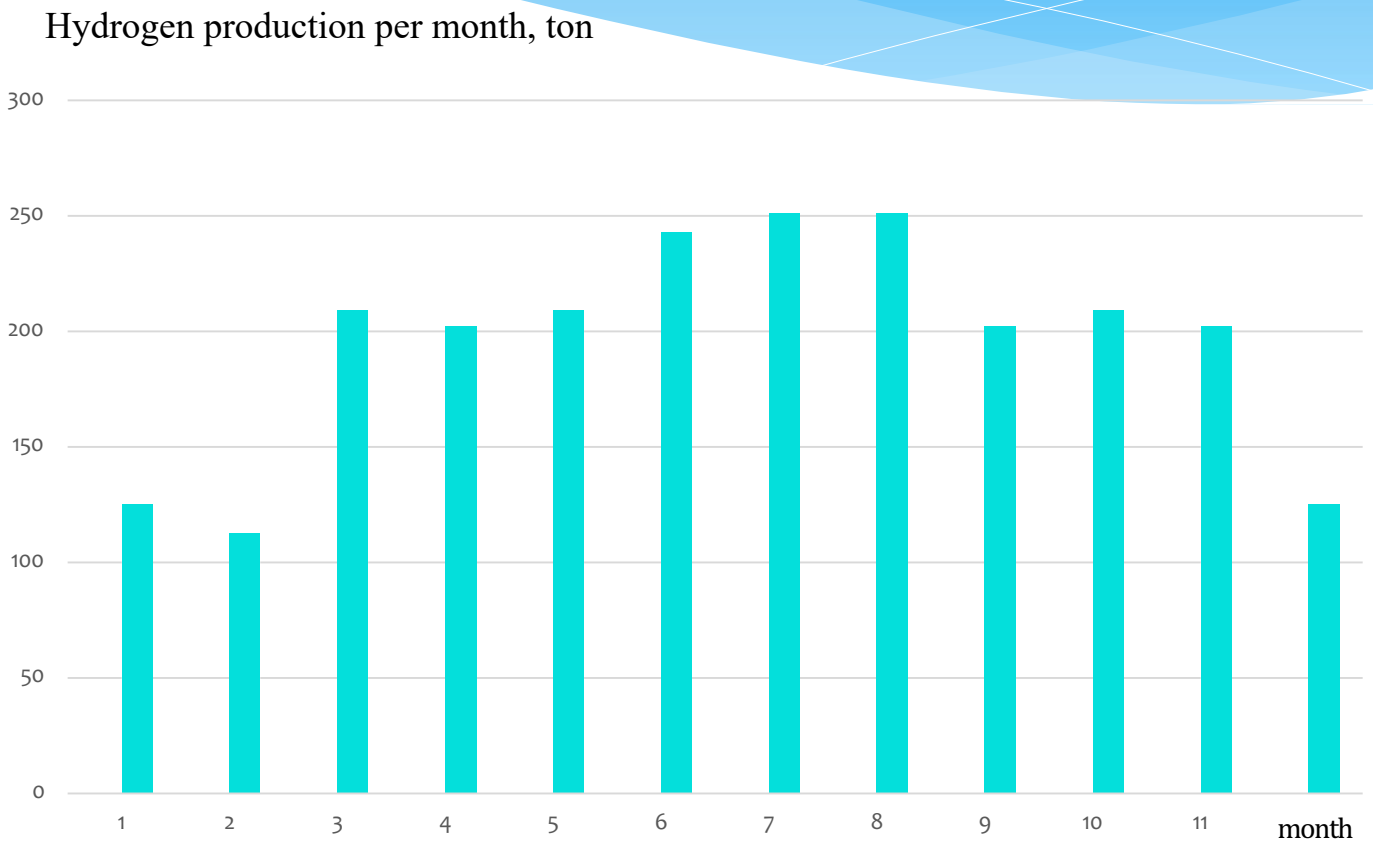
Pilot project for hydrogen production in Turkmenistan



Pilot project (electrolyzer with a capacity of 1.0 MW)

Technical parameters	Value and unit of measurement
Rated power	1 MWh
Производительность по водороду	300 ncm/h, 27kg/h
Hydrogen production control	15-100%
Specific energy consumption	4.4 kWh/ncm, 48.88 kWh/kg
Hydrogen outlet pressure	30-200 kgf/cm2
Hydrogen specific density	0.08988 kg/ncm
Net calorific value	119.96 MJ/kg (i.e. 33.32 kWh/kg or 3.00 kWh/ncm)

Pilot project for hydrogen production in Turkmenistan



RESULTS OF THE PILOT PROJECT

Technical parameters and information	Value and unit of measurement
Locality, coordinates	Atamyrat (Kerki): N 37.8°; E 65.2°
	Serhetabat (Kushki): N 35.2°; E 62.4°
The amount of total solar energy arriving at the surface of a solar panel located in the settlememt at an inclination angle β=36° south orientation	Atamyrat (Kerki): 1919.328 kWh/m2 year
	Serhetabat (Kushki): 1892.972 kWh/m2 year
Electricity generation by PV power plant per year	Atamyrat (Kerki): 140,467·106 kW·h
	Serhetabat (Kushki): 138,538 ·106 kWh
Hydrogen production	2344.45 t
Energy consumption in hydrogen production	114.443·106 kWh
Water consumption in hydrogen production	21104,550 t