ANCHOR PROJECTS OF THE SPECIAL INDUSTRIAL ZONE “CHORNOBYL”

The state has adopted a "Strategy for the development of the exclusion zone and the zone of unconditional (compulsory) resettlement affected by radioactive contamination as a result of the Chornobyl disaster for 2021-2030" on the organization of the Special Industrial Zone "Chornobyl" (SIZ "Chornobyl"), on the territory of which objects of economic activity, research centers should be created, infrastructure projects should be implemented.

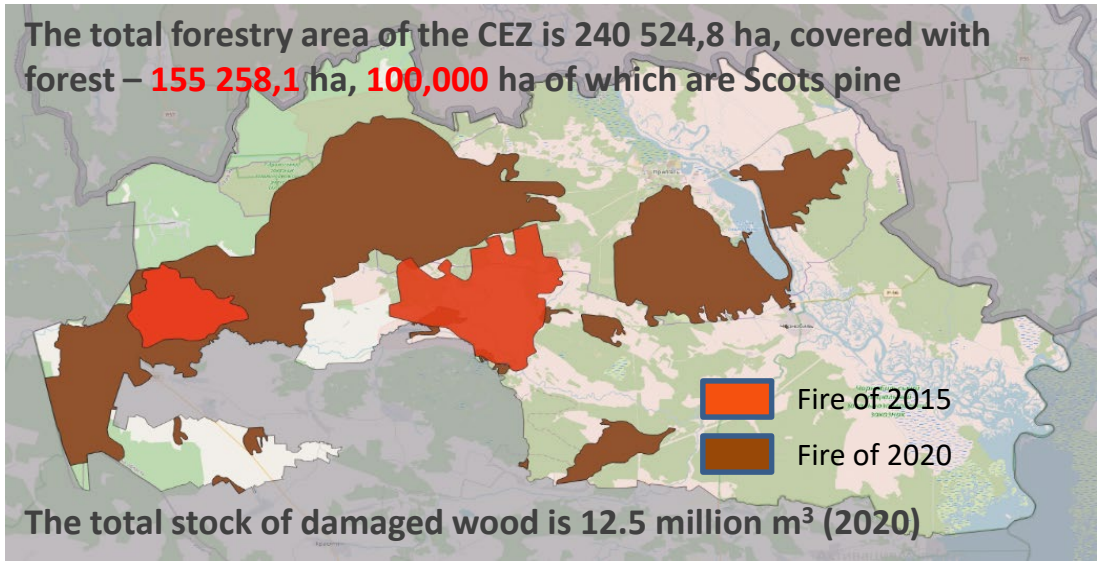
PREREQUISITES FOR THE ESTABLISHMENT OF A SPECIAL INDUSTRIAL ZONE "CHORNOBYL"

The main task of the project is to restore the degraded ecosystems of the Chornobyl Exclusion Zone (CEZ). The ways to achieve this goal would be to unite the efforts of the state of Ukraine with the world community through UN programs and structures, with donor countries of the relevant Chornobyl Funds, involving specialized (environmental, climate and other) structural funds of the EU, IAEA, attracting state and international investments in a form of public-private partnership.

At present, the existing forest ecosystems do not perform the main barrier function - the accumulation and retention of radionuclides, mainly because:

- artificial pine plantations created in the early years after the accident fulfilled their role and became unviable;
- mass fires occurred (1800 fires for the period 1993-2020);
- failure to provide adequate care for forest ecosystems;
- in the conditions of climate change forests die en masse due to low resistance to fires, pests, forest diseases.

As a result of fires, 137Cs deposited with wood was released : in 2015 - 130 GBq, in 2020 - 700 GBq.



The formed radioactive ash is included in the geochemical migration of elements in ecosystems, carrying out secondary radioactive contamination. According to research, burnt forest floor and ash contain from 6,600 to 180,000 Bq / kg Sr-90, from 4,100 to 270,000 Cs-137.

PROJECT OF PREPARATION OF DEGRADED ECOSYSTEMS FOR RECOVERY

To restore degraded forest ecosystems to the state of initiating the beginning of natural biodiversity renewal with the formation of a mosaic landscape, it is necessary to use sustainable forestry practices - continuous sanitary felling to eliminate the effects of fires and fire prevention felling to remove large areas of forest.

The estimated volume of wood contaminated with radionuclides, which decomposes into radioactive waste now and will be formed over a period of 5-10 years from the start of urgent work, is not less than 25 million m^3. This is a complex key issue, both in terms of volume (scope) and given the use of best international practices, taking into account modern radiological, environmental, climatic, social and economic requirements. At the same time, in the freed areas, as they are cleared, natural plantations will be grown with a high level of natural fire protection, resistant to climate change, which will be able to exist independently and perform a barrier function indefinitely.

The project solves the following tasks:

1. To prevent the occurrence of the largest forest fire in the history of Ukraine in radioactively contaminated areas of CEZ, the consequences of which will be unpredictably catastrophic.
2. To assist the restoration of natural ecosystems to replace artificially created, degraded and radioactively contaminated.

PREPARATION OF ECOSYSTEMS FOR RECOVERY

The project is of exceptional importance as a unique practice of liquidation of the consequences of radioactive contamination in CEZ and provides the solution for a unique set of technical tasks for the removal of radioactively contaminated wood and making extraordinary management decisions to abandon total forest planting in favor of natural regeneration and bringing the forest cover of the territory to 80%, restoration of wetland ecosystems, etc. Execution of large-scale works in a short period of 8 years is due to the high ability of radioactive ash to migrate. The problem of dust suppression during work and protection of workers from radiation needs a separate solution. The experience gained is important for the world community and can be used to solve similar problems.

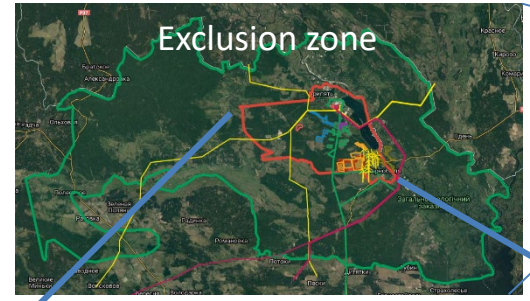
The total cost of removing 1 ton of radioactively contaminated wood for further disposal is 10 EUR.

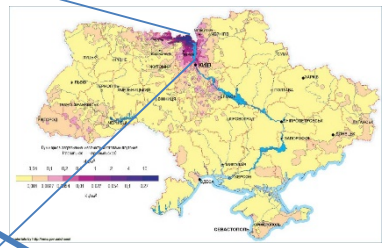
Types of work	Amounts	Productivity of machinery and equipment, quantity	CAPEX, thousand $
Removal of fire-damaged and dry wood	**25 million m^3**	**300 m3/h or 60 thousand m3/year, 94 machinery units**	**46 000**
Storing and processing of the removed wood : - Lower timber landing arrangement - Arrangement of wood chips warehouse - Wood chipping	**12,5 million tones (project time frame – 8 years)**	**3 million m3/year (1,5 million t)**	**63 250** 28 750 11 500 23 000
Assisting the natural regeneration of forests	**10 thousand ha**	**1,25 thousand ha/year**	**1 500**
Restoration of wetland ecosystems	**1295 km**	**200 km/year**	**9 200**
TOTAL			**120 000**

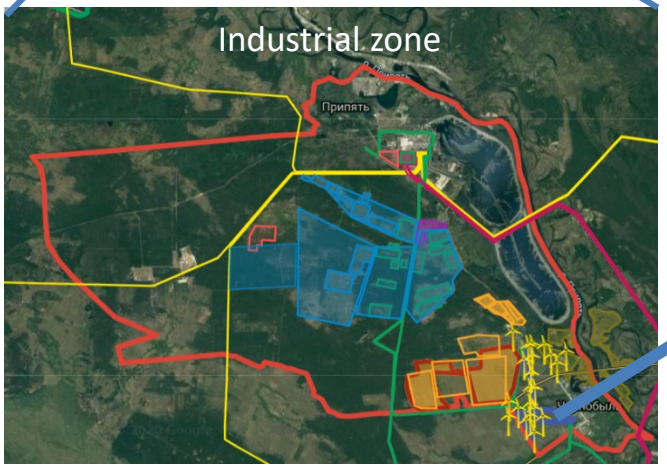
PORTFOLIO OF SIZ “CHORNOBYL” PROJECTS AND GENERAL CHARACTERISTICS

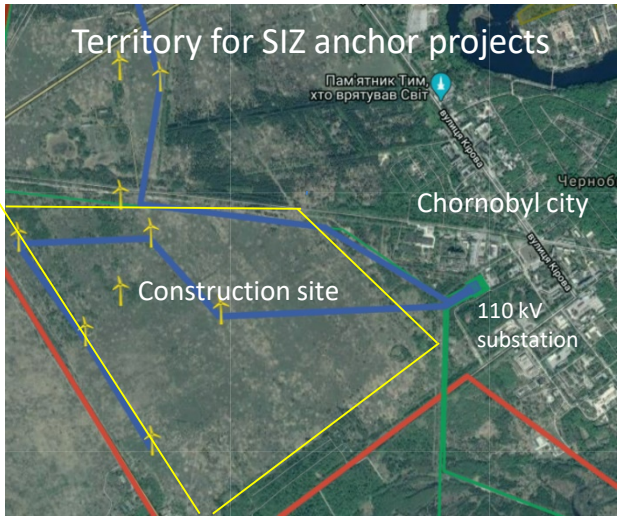
This portfolio of projects should solve a key task **- the utilization of wood contaminated with radionuclides.** To do this, it is proposed to create a cluster consisting of three objects:

1. Plant for utilization of contaminated wood and production of pure synthesis gas (H2 + CO).
2. Power plant that should provide the cluster with electricity and heat.
3. A chemical plant using pure synthesis gas as a raw material.









<u>Characteristics of the selected site:</u>

Availability of territory for construction and further development - more than 350 hectares.

Availability of engineering infrastructure:

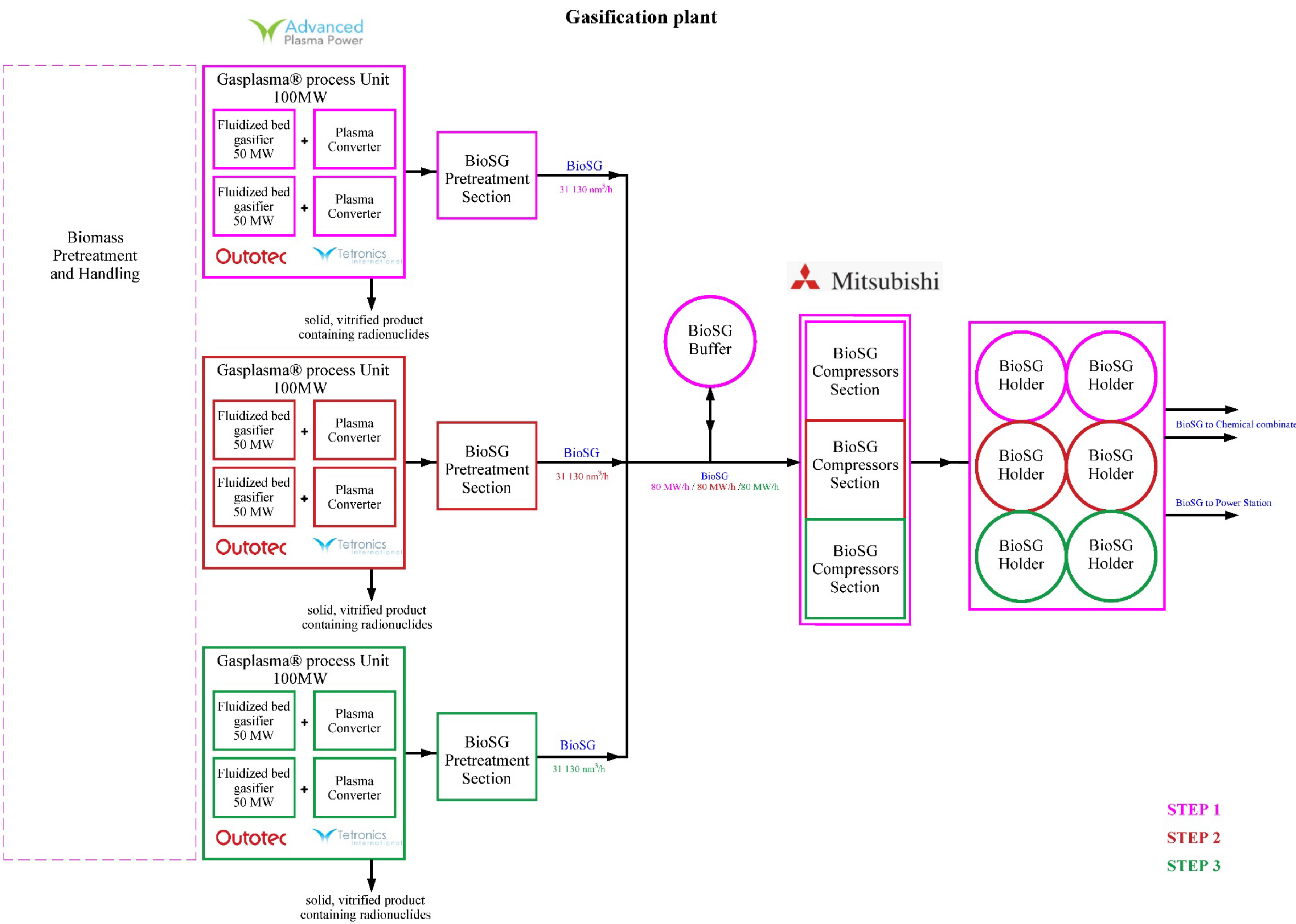
- two independent power sources
- water source for technological and domestic needs
- developed network of highways
- construction of a railway station, the completion of which is scheduled for 2023

PLANT FOR UTILIZATION OF CONTAMINATED WOOD AND PRODUCTION OF CLEAN SYNTHESIS GAS

- Gasplasma® process, as the main technology that will allow to obtain synthesis gas and immobilize radionuclides:
  - BFB gasifier from Outotec
  - plasma converter from Tetronics, which has the ability to dispose all types of radioactive waste
- The synthesis gas cooling and purification system includes the world's most advanced technologies of leading companies
- The total project volume will be 2,000 GW / 800 thousand nm^3 of pure synthesis gas per year, in case of full development

Stages of project implementation			
Stage I	Construction of two Gasplasma® lines with a total capacity of 100 MW, construction of a line for cooling and purification of synthesis gas, as well as facilities for the full development of the plant composed of: intermediate buffer; compressor station; storage of pure synthesis gas; general production facilities	2021-2024	CAPEX - $ 200 million
Stage II	Increasing the total capacity to 200 MW	2022-2024	CAPEX - $ 150 million
Stage III	Increasing the total capacity to 300 MW	2023-2025	CAPEX - $ 150 million

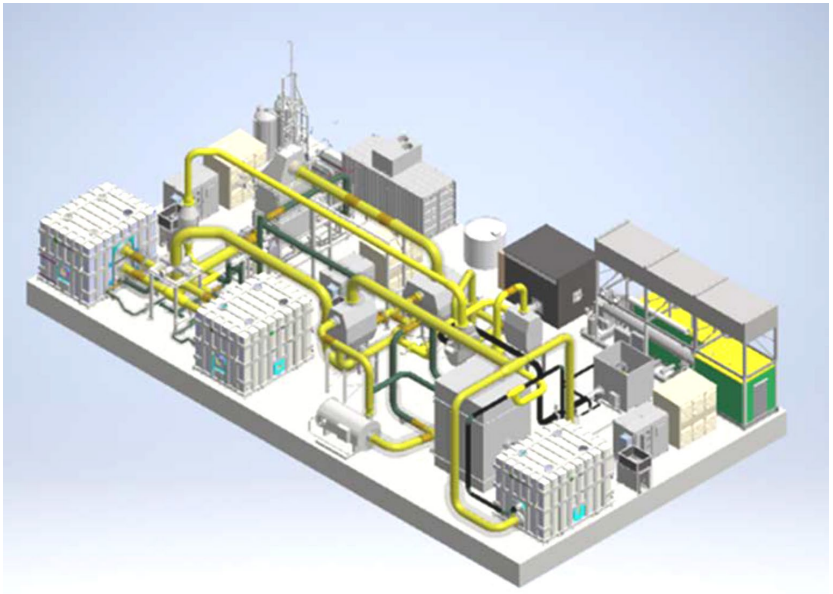
SCHEMATIC LAYOUT OF GASIFICATION PLANT



Power Station

1 General data

- Power Station provides **green** electricity and **green** heat to meet the needs of CIZ consumers as well as nuclear facilities of CEZ industrial zone
- The combination of technologies in a consequent cycle allows to receive the general electrical efficiency at the rate of 60%
- Direct current is consumed by CIZ industrial facilities without inversion that allows to avoid losses during conversion



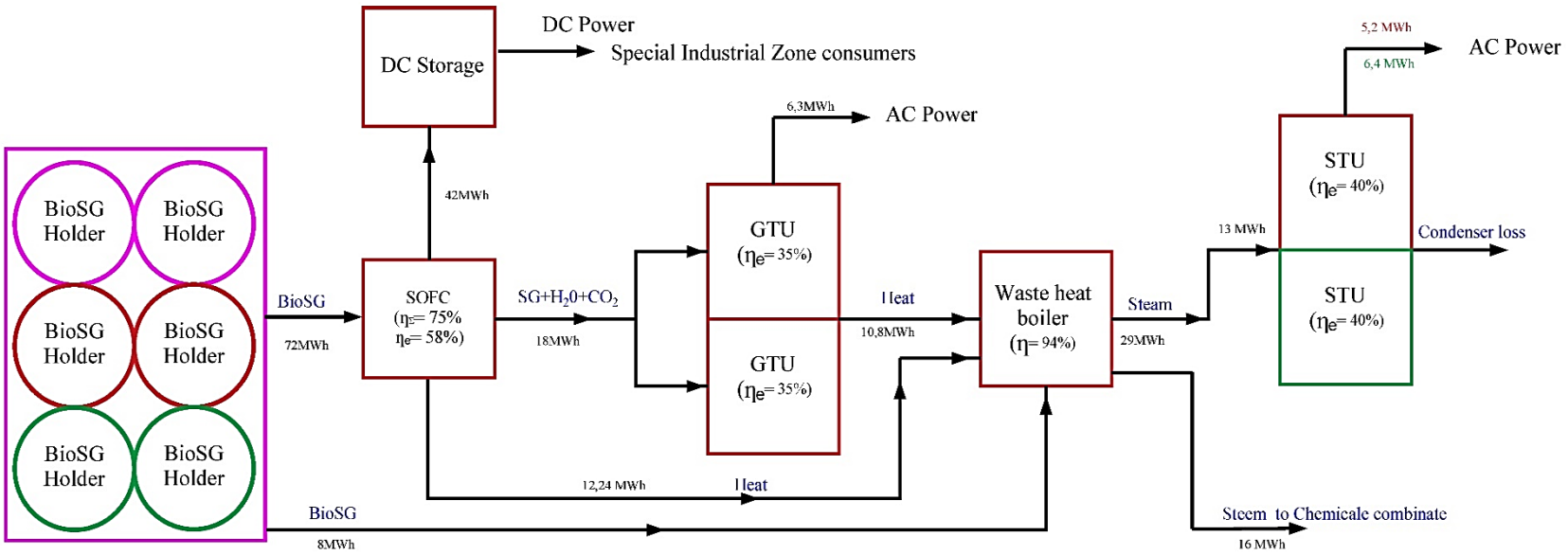
2 Technology description

- Pure synthesis gas enters the fuel cells (SOFC - Solid Oxide Fuel Cell), which produce direct current and heat.
- Subsequent to SOFC the mixture of gases (unreacted synthesis gas + H_2O + CO_2) enters the gas turbine, which produces alternating current, and the remaining heat is transferred to the waste heat recovery boiler
- In the waste heat recovery boiler:
  - ✓ the existing heat is being reheated to the required technological parameters by burning pure synthesis gas
  - ✓ heat is being distributed between the consumers (chemical plant, domestic use, etc.)
- The remaining hot steam is fed to a steam turbine, which extracts the remaining energy, producing alternating current

3 Project indicators

Capacity	DC – 42 MW AC – 11,5/12,7 MW Thermal – 16 MW
CAPEX	**146 $ million**

SCHEMATIC LAYOUT OF POWER STATION

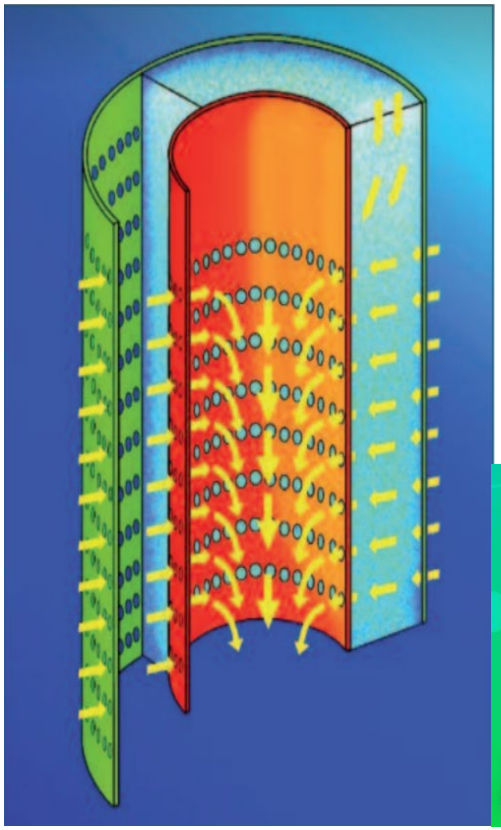


STEP 1

STEP 2

STEP 3

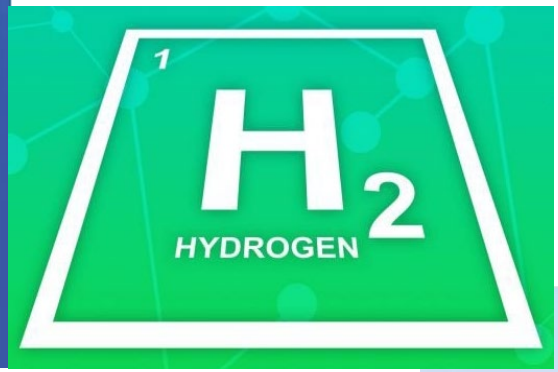
STEP 1 Chemical Cluster Project for the Pure SynGas Processing



Production of "green" industrial hydrogen

At the first stage of the project's development it is planned to produce technical hydrogen with 97.9% H2 and CO2 content as an industrial end-product in accordance with the import substitution program for sale at the market.

Capacity	187 MMNm3a H2 97.9% 250 kta CO2
CAPEX	**16 $ mln**



CASALE

1 CO Conversion

- Axial-radial technology by Casale SA is widely used in ammonia and methanol plants and being used in more than 500 catalyst beds.

2 CO_2 removal

- OASE® technology (BASF) makes it possible to purify gases containing hydrogen and/or carbon monoxide for further purification and composition adjustment for use in green methanol, ammonia, etc. production processes.

STEP 2 **Chemical Cluster Project for the Pure SynGas Processing**

Pure hydrogen and hydrogen peroxide (HP) production

MAHLER ADVANCED GAS SYSTEMS

Economic indicators

Capacity	15 kta H2O2 158 MMNm3a H2 (99.999%) 250 kta CO2
CAPEX	**$25 million (HP Production)** **$5 million (PSA Unit)**

1 Production of hydrogen appropriate for synthesis

- In the second step, technical hydrogen

is fed into the HYDROSWING by Mahler AGS GmbH, which consists of four or five adsorbers filled with different adsorbents. The purification process is based on short-cycle adsorption, where impurities are separated to produce extremely pure hydrogen with a purity up to 99.999% vol. including 11.0 million nm3 / year for HP synthesis.

2 H_2O_2 Production

- The world's leading licensors of anthraquinone PH production are the following companies: Chematur Engineering AB (Sweden), Evonik Industries AG (Germany), Solvay S.A. (Belgium).
- The anthraquinone method is based on two processes: restoration of carbonyl groups of anthraquinone compounds and oxidation of the created hydroxyl groups. Hydrogenation is performed with hydrogen in the presence of a catalyst, oxidation is performed with pure oxygen or air.

Chematur Engineering

STEP 3

Synthesis gas processing

Biomethanol production

Capacity	83 kta MeOH grade AA 130 kta CO_2
CAPEX	**100 $ million**

MeOH TO-GO™

HALDOR TOPSOE

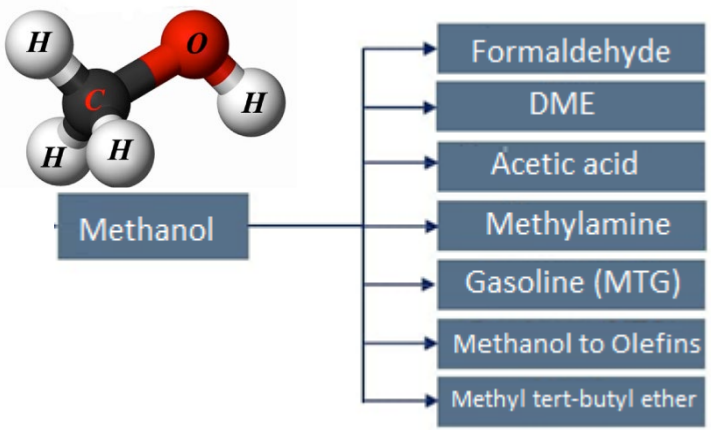
2 Product Methanol of Grade AA

- **MeOH**-To-**Go**™ - it is a small modular methanol plant designed for field operation anywhere in the world. At the moment, the most optimal and effective solution for projects of methanol production plants with a capacity of 70 ÷ 85 thousand tons per year is the supply of plants in a modular design from the company Haldor Topsoe AS (on the terms of EPC).

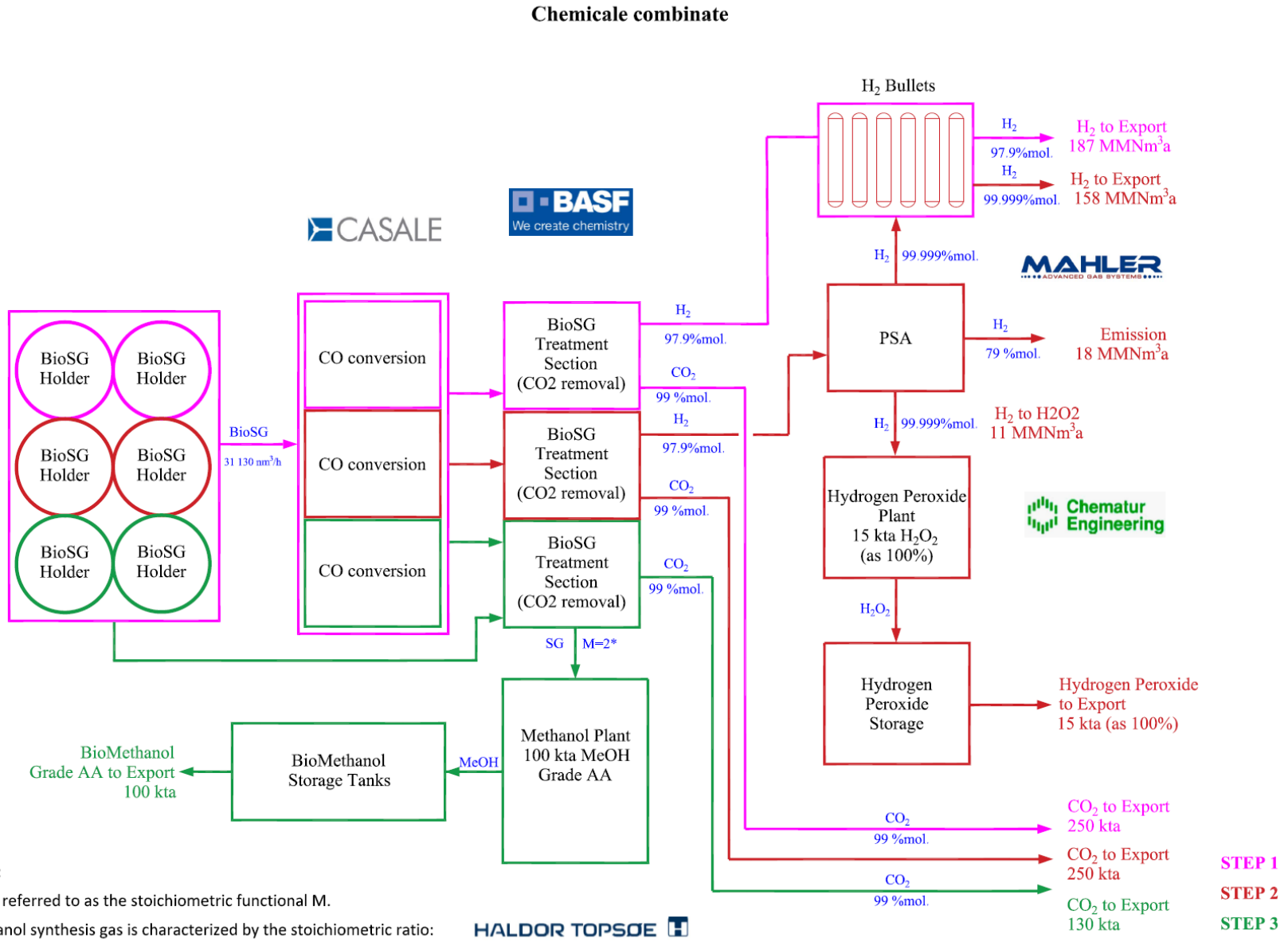
1 Rationale for product selection

Ukraine imports 100% of methanol for industrial needs. In addition, methanol is a raw material for further synthesis of a number of products. Therefore, the production of **green** methanol (using biomass-generated **green** synthesis gas, **green** electricity and **green** heat) solves the following tasks:

- Import substitution
- Availability of raw materials for synthesis
- The green component in the final products



SCHEMATIC LAYOUT OF THE CHEMICAL PLANT



NOTE:

Often referred to as the stoichiometric functional M.

Methanol synthesis gas is characterized by the stoichiometric ratio:

$M = (H2 - CO2) / (CO + CO2)$

CIZ“CHORNOBYL” PRODUCTION COMPLEX INVESTMENT COST

No.	Name	CAPEX $ million (US)
1	Project of preparation of degraded ecosystems for recovery	120
2	Plant for utilization of contaminated wood and production of clean synthesis gas (full development)	500
3	Energy station	146
4	Green hydrogen production	16,0
5	Green hydrogen peroxide production PSA hydrogen purification up to 99.999%	25,0* 5,0
6	Biomethanol production	100,0*
TOTAL CAPEX		912
Total (investment) project implementation cost		**1 368**
Note: * ISBL - within the license components (methanol, hydrogen peroxide)		