AZ art

Participant of development programs on platforms:

AGENCY FOR STRATEGIC INITIATIVES

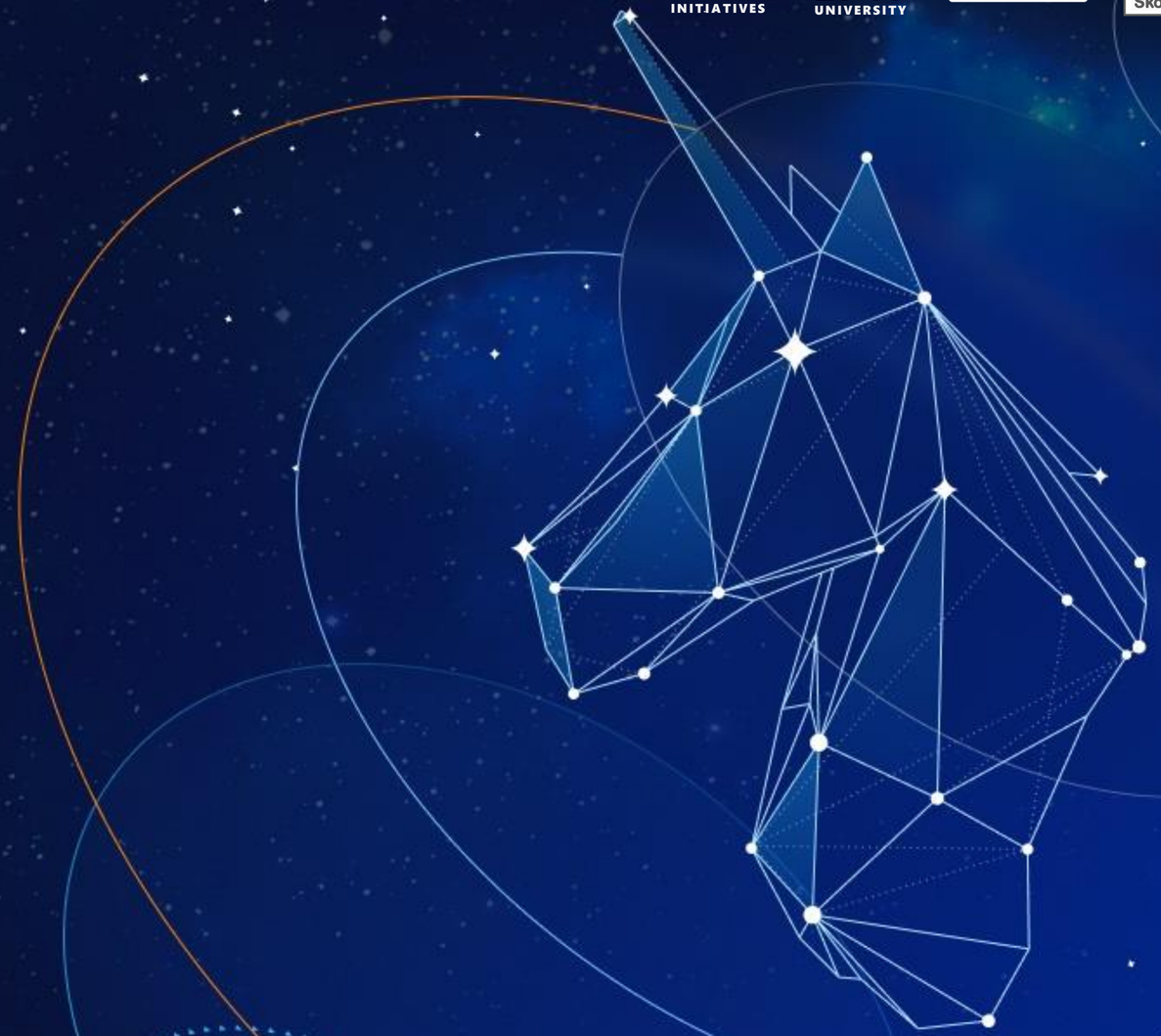
20.35 UNIVERSITY

NTI PLATFORM

Sk Skolkovo

Moscow Confederation of Industrialists and Entrepreneurs (Employers)

INNOVATIVE MULTI-FUEL (HYDROGEN) INTERNAL COMBUSTION ENGINE



RUS 2023

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Trend:

LOW CARBON ECONOMY

Environmental friendliness and efficiency of internal combustion engines are the main factors predetermining the prospect of their further use as the main propulsion and generating power plants.

Conceptually, a rotary-vane engine (RVE) has an overwhelming advantage in compactness over traditional piston engines (PE) of equal working volume.

The innovative design of the AZART RVE makes it possible to achieve significantly higher efficiency than that of promising PE.

The parameters of the dynamics of changes in the volumes of the working chambers of the promising AZART RVE create conditions for the efficient use of hydrogen as a fuel.

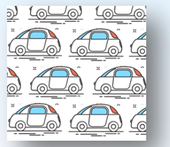
The possibility of dynamic and significant change in the compression ratio makes it possible to design AZART RVE multi-fuel, with a dynamic transition to hydrogen (or gas, gasoline), which makes such an engine an indispensable missing link in the transition to "green" mobility and support for the transition of the country's economy to hydrogen energy.

Problem

Expected changes by 2050:

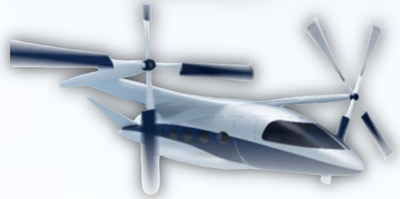
Population of the planet:

+ 2 billion



Car fleet of the planet:

+ 1 billion



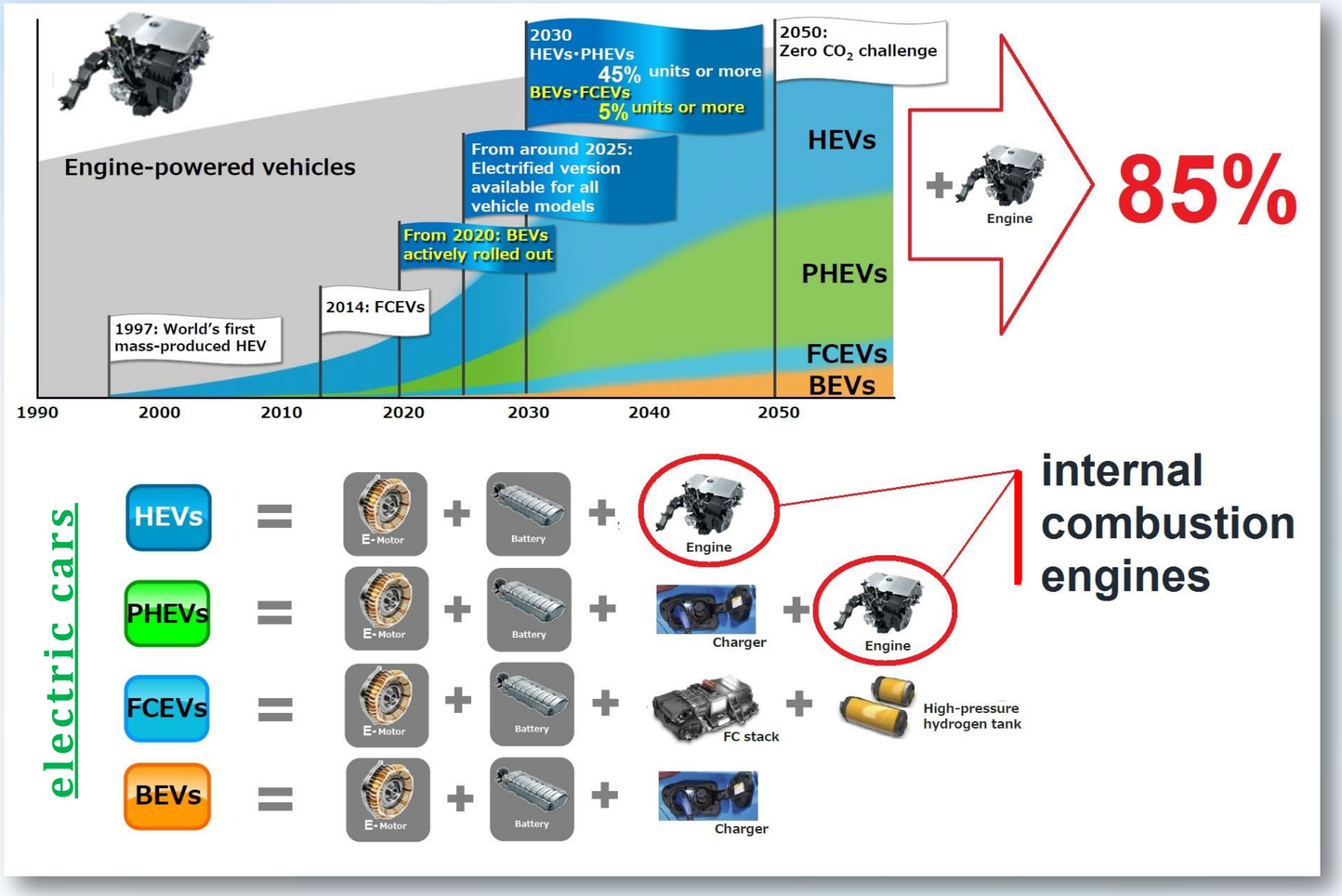
Volume of short-haul air transportation:

+ 500 %

Consequently:

Deterioration of the ecological situation

The need to take measures to increase the share of electric transport



Environmentalists insist on «Zero CO_2», but consumer needs

effective mobility!

How to reduce the level of CO_2 emission?!

Solution

The innovative **rotary vane engine (RVE)** has all the necessary qualities to become the most efficient alternative to traditional internal combustion engines.

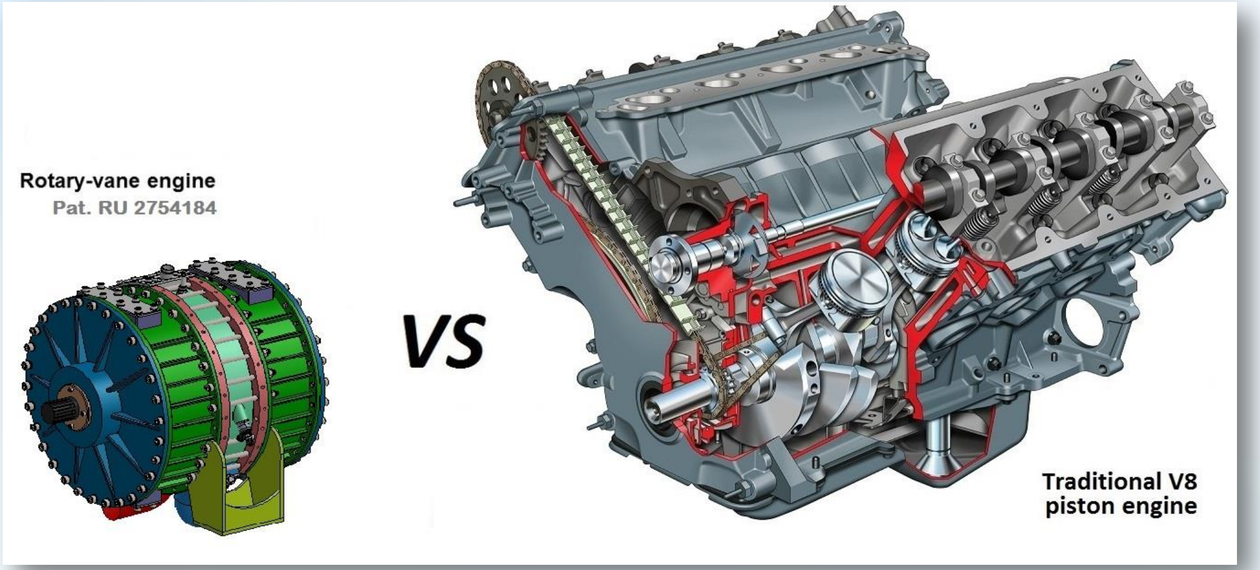
RVE

Specific power

Fuel consumption

Efficiency

V8

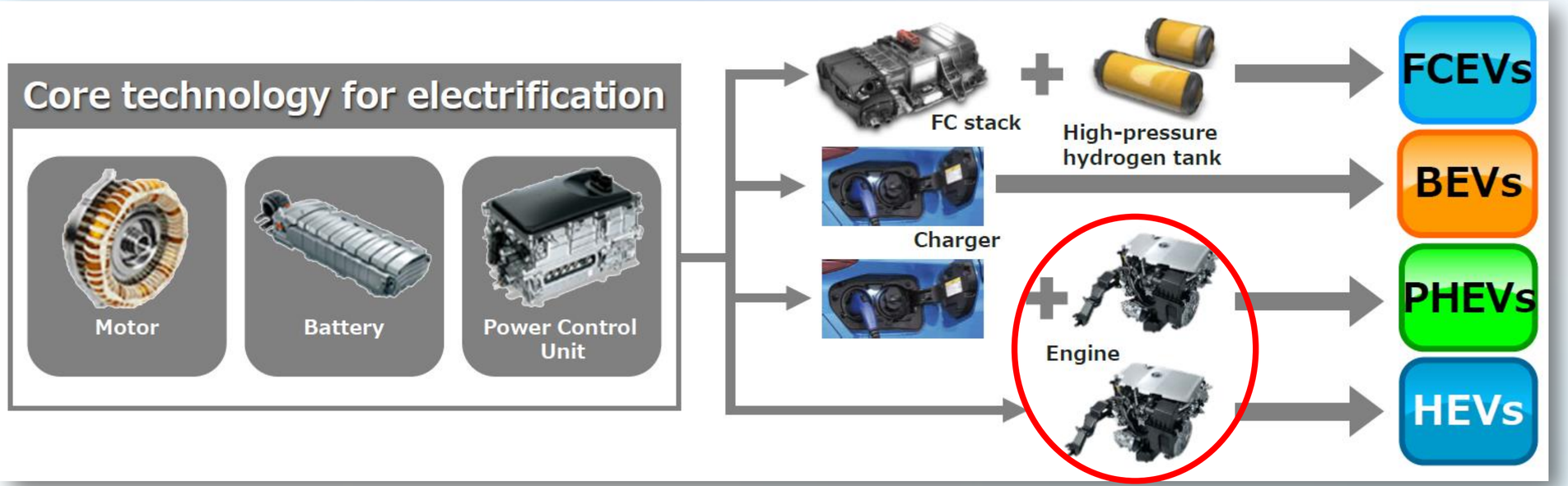


For the user: savings + pleasure

For the manufacturer: profit

For environmentalists and politicians: solution to the problem

Main trends in the field of the project

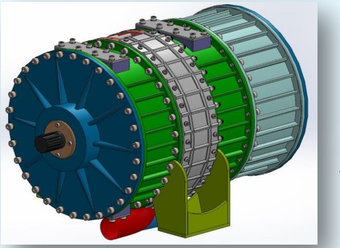


Internal combustion engines will gradually be replaced by power plants with electric drives.

One of the most popular segments will have an internal combustion engine as part of a hybrid power plant.

The innovative **rotary vane engine (RVE)** has all the necessary qualities to become the most efficient alternative to traditional internal combustion engines in hybrid and classic propulsion systems.

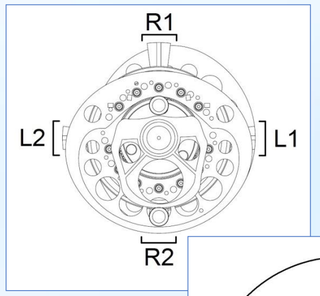
RVE + EM

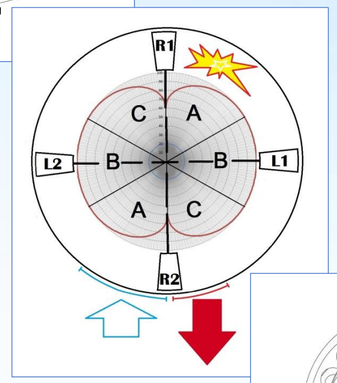


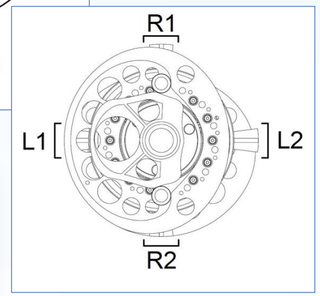
= the best solution for hybrid technologies

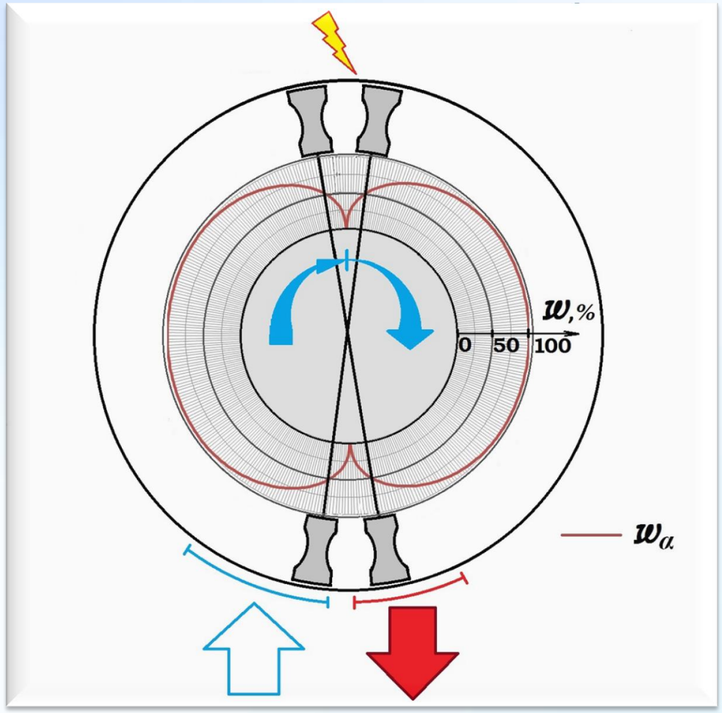
Technology

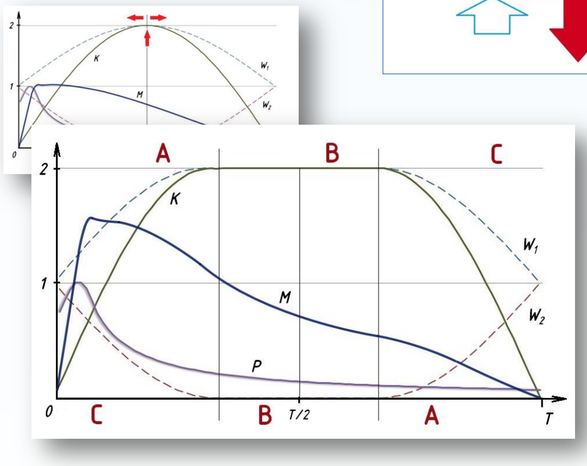
The innovative principle of converting energy into RVE











The fundamental advantage of the rotor-vane scheme is the compact size of this type of engine, since in four working chambers of one section of the RVE, in one shaft revolution, the flow of 4 full four-stroke cycles is ensured, which corresponds to such a characteristic of a 8-cylinder traditional piston engine.

Accordingly, when comparing material consumption, the number of assemblies and parts, mechanical losses, product cost, etc., one should compare a 1-section RVE with an 8-cylinder engine of traditional design.

The developed algorithm for synchronizing the motion of the blades makes it possible to achieve the efficiency of converting the energy of expanding gases into torque, which is impossible for engines with a crank mechanism.

At the same time, the peculiarities of the dynamics of changes in the volumes of the working chambers in the RVE AZART create better conditions for the use of **hydrogen** as fuel than in classic internal combustion engines.

In addition, the ability to dynamically change the compression ratio makes it possible to make the RVE AZART multi-fuel, with a dynamic transition to a **hydrogen** supply.

Effects of implementation

1. The calculated efficiency of the RVE AZART is about 1.4 times higher than that of the classic piston engine. At the same time, its calculated specific power is approximately 2.5 times higher. The overall effect will make it possible to save at least 50% of hydrocarbon fuels in all areas of ICE application with a corresponding reduction of harmful emissions.

2. The introduction of a **hydrogen** RVE will give the **«Zero CO_2»** effect ⇨ no "carbon footprint" of vehicles.

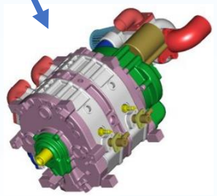
3. The ability to dynamically change the compression ratio makes it possible to make RVE AZART multi-fuel, with a dynamic transition to **hydrogen** power, which makes RVE AZART the missing link in the transition to "**green**" mobility with the effect of a flexible and painless transition from traditional fuels to "environmentally friendly".

Competitors

RVE competitors

GTE

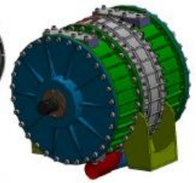
piston engines



Wankel engines

Comparative characteristics of upcoming* and manufactured engines

Engine	Honeywell TPE-331-12	**RVE * (estimated)**	Wankel KKM 504d *	Lycoming IO-540 - AF1A5	RED A03
type	turboprop engine	rotary-vane engine	4-rotor rotary engine, turbo & intercooler	air-cooled horizontally opposed 6-cylinder piston engine	compression-ignition four-stroke V12 piston engine, turbo&Intercooler
fuel type	kerosene	multi-fuel	heavy fuel	gasoline	multi-fuel
power output, kW	810	**370**	300	194	373
RPM	41730	5000	8000	2700	4000
displacement, L	…	1,65	2,0	8,9	6,1
dry weight, kg	175	137	121	188	357
L x W x H, mm	1088 x 533 x 676	600 x 490 x 500	793 x 480 x 435	1025 x 850 x 560	1114 x 870 x 712
overall volume, dm^3	392	147	166	488	690
power-to-weight ratio, kW / kg	4,6	**2,7**	2.5	1,0	1,0
specific power, kW / dm^3	2.1	**2,5**	1.8	0.4	0.5
specific fuel consumption, g/h.p.*hr (g/kW*hr)	243 (330)	**150 (204)**	200 (270)	210 (285)	154 (210)



RVE = E^3

- more efficiently
- more economical
- more environmentally friendly

Market parameters

RVE, as a more efficient type of engine, is able to replace traditional piston engines in almost all areas of their application. The most relevant for the development of RVE technology are the following areas:

Aviation sector. The aircraft engine industry is in dire need of new technologies to create more compact, reliable and economical engines with high specific power. The market volume is relatively small, but stable and even developing in the sector of production of engines for short-haul aviation and UAVs.

Automotive sector. The huge volume of the automotive engine market is quite inert, but it also anticipates increased demand for efficient, compact, high power density engines for use in hybrid powertrains, which, along with electric drives, are expected to displace traditional powertrains from the market soon.

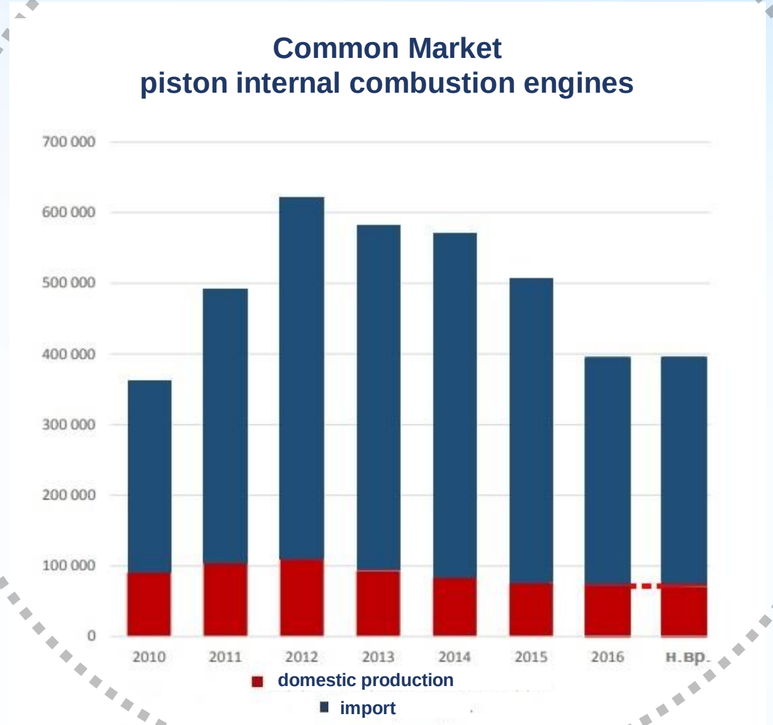
Mobile generation sector. The market volume is not large, but stable. More compact and economical RVEs will easily displace traditional ICEs from this sector.

Special attention is paid to the most capacious **automotive engine market**. Today, the ICE market is not stable due to the economic downturn, tightening environmental standards, and also due to the development of electric mobility.

These trends play into the hands of our project because the decrease in the production of ICE vehicles is compensated by the emergence of a large number of hybrid vehicles. And hybrid technologies desperately need a compact and efficient internal combustion engine, which is a rotary vane engine.

RUSSIAN MARKET

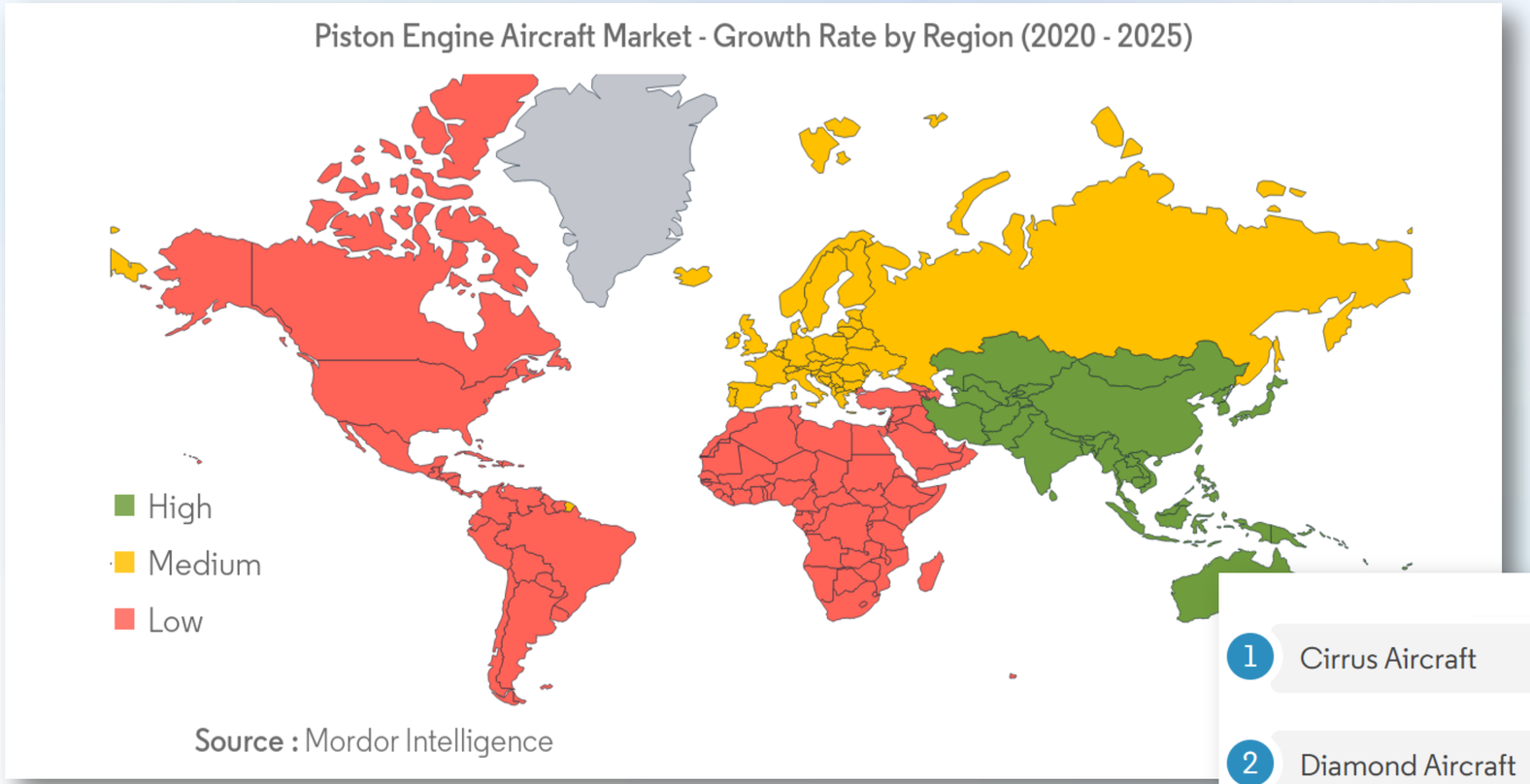
₽400 billion (1.2 million units)



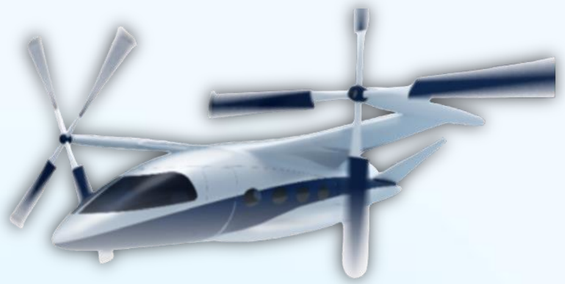
The world market of piston engines is much wider than the Russian market

$600 billion ⟵ ⟶ **150 million units**

Market parameters



PISTON ENGINE AIRCRAFT MARKET



Major Players

1. Cirrus Aircraft
2. Diamond Aircraft
3. Piper Aircraft Inc.
4. TECNAM Aircraft
5. Textron Inc.

*Disclaimer: Major Players sorted in no particular order

Market Concentration

Consolidated– Market dominated by 1-5 major players

Piston Engine Aircraft Market

Fragmented – Highly competitive market without dominant players

Source: Mordor Intelligence

The Asia-Pacific region is expected to register the highest growth rates. This growth is associated with an increase in aircraft purchases to serve the growing passenger traffic in the region from countries such as China, India, Indonesia, Vietnam and Australia.

Resources

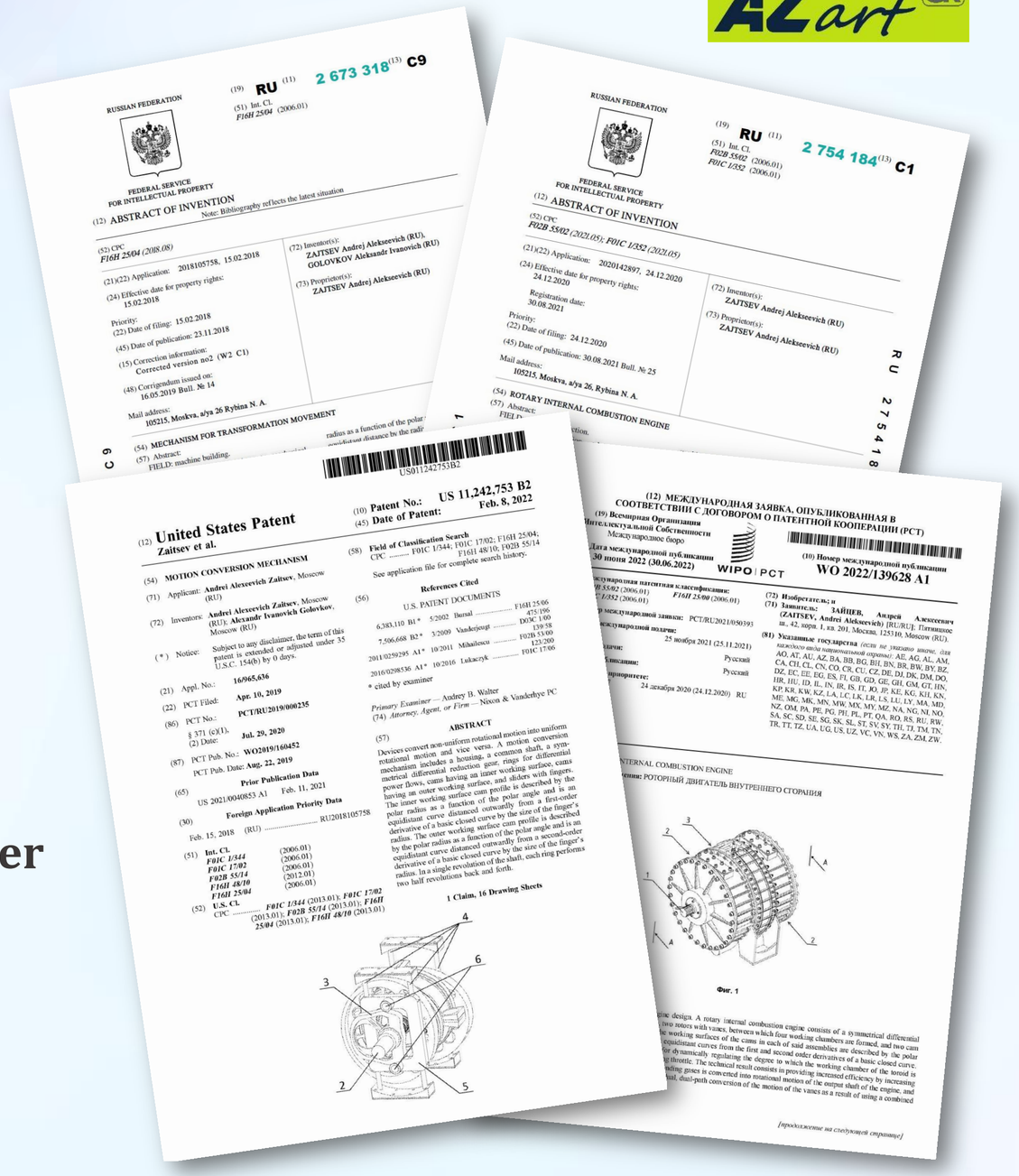
At the moment, the project is developing exclusively on the basis of the internal resources of the team.

The stage of preliminary design has been completed, prototyping has been carried out, kinematic tests and computer modeling of work processes has been carried out, research work continues.

According to the RVE design, patents of the Russian Federation and the USA have been received. An application for international patenting under the PCT system has been published.

The status of a resident of the Skolkovo innovation center was received.

Further development of the project requires the attraction of additional resources.

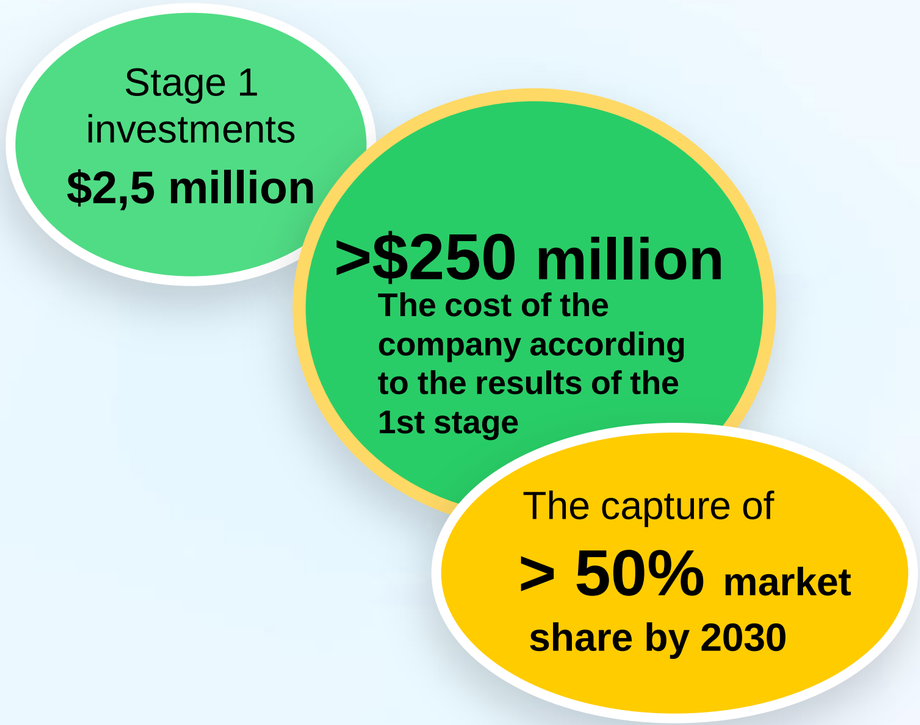


Objectives of the project

The project will continue to develop further with any kind of additional support from the following:

- **cooperation with a specialized corporate partner;**
- **financial support from a venture investor;**
- **receiving a grant.**

#	Purpose and timing
1	During 2023-2024, to develop design documentation for a prototype engine, collect prototypes, conduct tests and bring the design to the state of an industrial design.
2	In 2024-2025, to introduce RVE into mass industrial production.
3	In 2025-2027, to ensure the quantitative and nomenclature expansion of production to occupy the maximum possible number of niches for the use of internal combustion engines.



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