ROSATOM

STATE ATOMIC ENERGY CORPORATION “ROSATOM”

«Energy related devices and systems based on high temperature superconductors»

Pantsyrny V.,
Director on development JSC «Russian superconductor»

Project "Superconducting industry"

The modern Energy Systems nowadays are under principal transformation that assume the massive infiltration of advanced technologies in all main areas of generation, transmission, distribution and management of energy recourses. One of the such advanced technologies is superconducting technology.

In December 2015 the works on the project "Superconducting industry" that was the part of the Integrated Project "Innovations in Energy" initiated by the President's Commission on modernization and technological development of the Economy of Russian Federation has been successfully finished.

- **Main objective of the Project**

  Creation of the innovative technological infrastructural basement for enhancement of the Energy efficiency of the Russian Federation Economy.

- **Ways of attainment**

  The development of the basement for the industrial scaled production of the range of perspective fundamentally innovative prototypes of energy oriented equipment on the base of superconducting technologies

- **Results**

  Prototypes of the energy oriented devices and schemes of their industrial production.

- **Management** ***State Corporation "Rosatom"***
- **Duration**: *2010 – 2015*

Main tasks of the Project “Superconducting Industry”

Development of	long length YBCO-2G Coated Conductors Production
Development of	Fault Current Limiters (FCL) for Energy transmission grids with voltage of 3,5/10/35 kV
	Kinetic Energy Storage System (Flywheel) with superconducting suspension 5-20 MJ
	Superconducting electro motors (200 kJ)
	Superconducting transformers 1 MVA
	Superconducting Generators 1-10 MW
	Superconducting Magnetic Energy Systems (SMES) with energy in the range 1-30 MJ
	High current Current Leads (tens kA) for large scale Magnet Systems
Support of the infrastructure of the cryogenic test facilities	

Project ”Superconducting industry” – is the national scale complex Project

More than 20 organizations (scientific, commercial, education, project) took part in carrying out the concerted works.

The unique complex infrastructure for stable development of the innovative high tech area – technologies of superconductivity has been restored:
Universities – Fundamental science – Applied science – Industry.

2G HTS long length (up to 1000 m) wires

Equipment



NIITFA.

INDUSTRY

Development and production

SCIENCE

Equipment



NIIEFA.

Research line

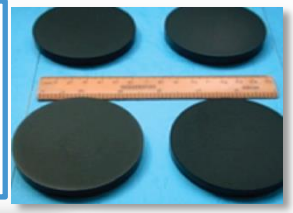


NRC KI

Technical - economical modelling and calculation have shown that on the base of the results obtained during the Project implementation, the establishment of large HTSC production would be economically efficient at the scale of 7000 km per year.

Ceramic targets and substrate tapes

VNIINM



Superconducting Fault Current Limiters
(3.5, 4.0, 10, 28 kV)

Specifications:

- **Nominal voltage:** 3,5 kV
- **Design current:** 2 кА
- **Clamping current:** 10 кА
- **Current limiting period:** *less than* 8 msec

Key benefits:

- Response rate 2-3 times higher
- Design conditions losses up to 20 times less
- Decrease of mechanical stress for the network
- equipment - longer durability of work.

Areas for most efficient integration:

- Traction energy systems (railroad and waterborne transport)
- Existing and contemplated electric power supply systems

HTS Transformer
(1 MVA, 10 kV, three phase)

Specifications:

- **Power:** 1000 kVA
- **Frequency:** 50 Hz
- **High voltage:** 10 kV
- **Low voltage:** 0,4 kV
- **Flux guide core:** amorphous steel

Key benifits:

- Decreased electric power dissipation:
- In frames *(load losses)* – up to 30 fold
- In flux guide *(standby losses)* – up to 5 fold
- Increased overload capacity;
- Fire safety

Areas for most efficient integration:

- Transport electric propulsion systems;
- Superconducting electrical power complex.

Flywheel Energy Storage *(5-20MJ)* with HTS magnetic bearings

Specifications

- **Energy storage capacity:** *not less then* 5 MJ
- **Dynamotor power output:** *up to* 100 kW
- **Time of discharge:** 50 sec
- **Output voltage spread:** 350–150 V
- **Output voltage frequency:** 50 Hz
- **Dimensions**: 2060 mm x 1110 mm x 1110 mm

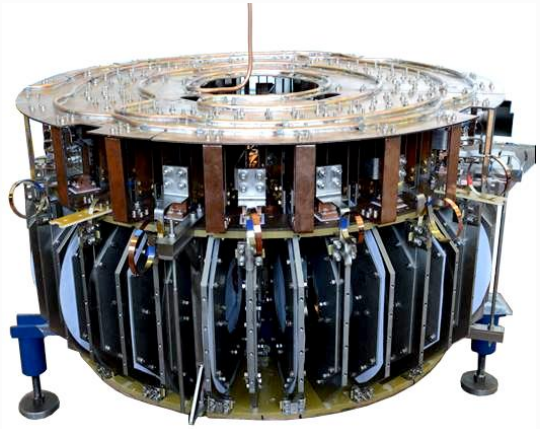
Key benefits:

- High specific power capacity and intensity;
- Fast operation speed;
- Long life;

Areas for most efficient integration:

- Uninterruptible power systems;
- Power storage and recuperation systems (as a part of electric propulsion systems)

Superconducting magnetic energy storage *(1-30 MJ)*



Specifications

- Power capacity: 1 MJ
- Maximum power: 1000 kVA
- Maximum power build-up time: *below* 10 msec

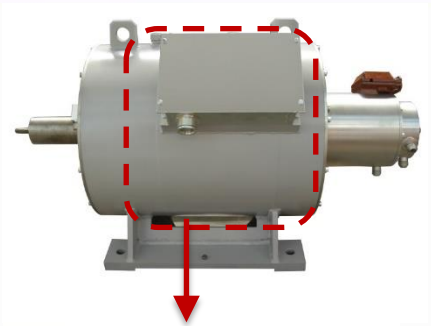
Key benefits:

- High efficiency of energy
- conversion and storage ;
- Fast operation speed;
- High life span;

Areas for most efficient integration:

- Very fast release of stored Energy required in pulsed Systems

HTS Electric Motor
(for vehicles – 200 W)



Specifications:

- Power rate: 200 kW
- Stator frame phase power supply: 450 V
- Nominal current frequency: 75 Hz
- Nominal rotary velocity: 1500 turns/min
- Nominal performance: 96,3%

Key benefits:

- Reduced weight and dimensions – 2 fold;
- Increased specific capacity – 2 fold;
- Increased overload capacity;
- Increased life span;
- Fire safety.

Areas for most efficient integration:

- Electric propulsion systems (automotive, railroad and waterborne transport);
- Electric drivers for commercial plants

HTS Generator for wind turbines
(1 MW)

Specifications:

- Nominal power: 1000 kVA
- Design voltage: 1195/690 V
- Nominal frequency: 50 Гц
- Phase current: 500 A
- Output torque: 16 kN*m
- Rated power factor *(cos φ)*: 0,99
- Performance 99,2 %

Key Benefits:

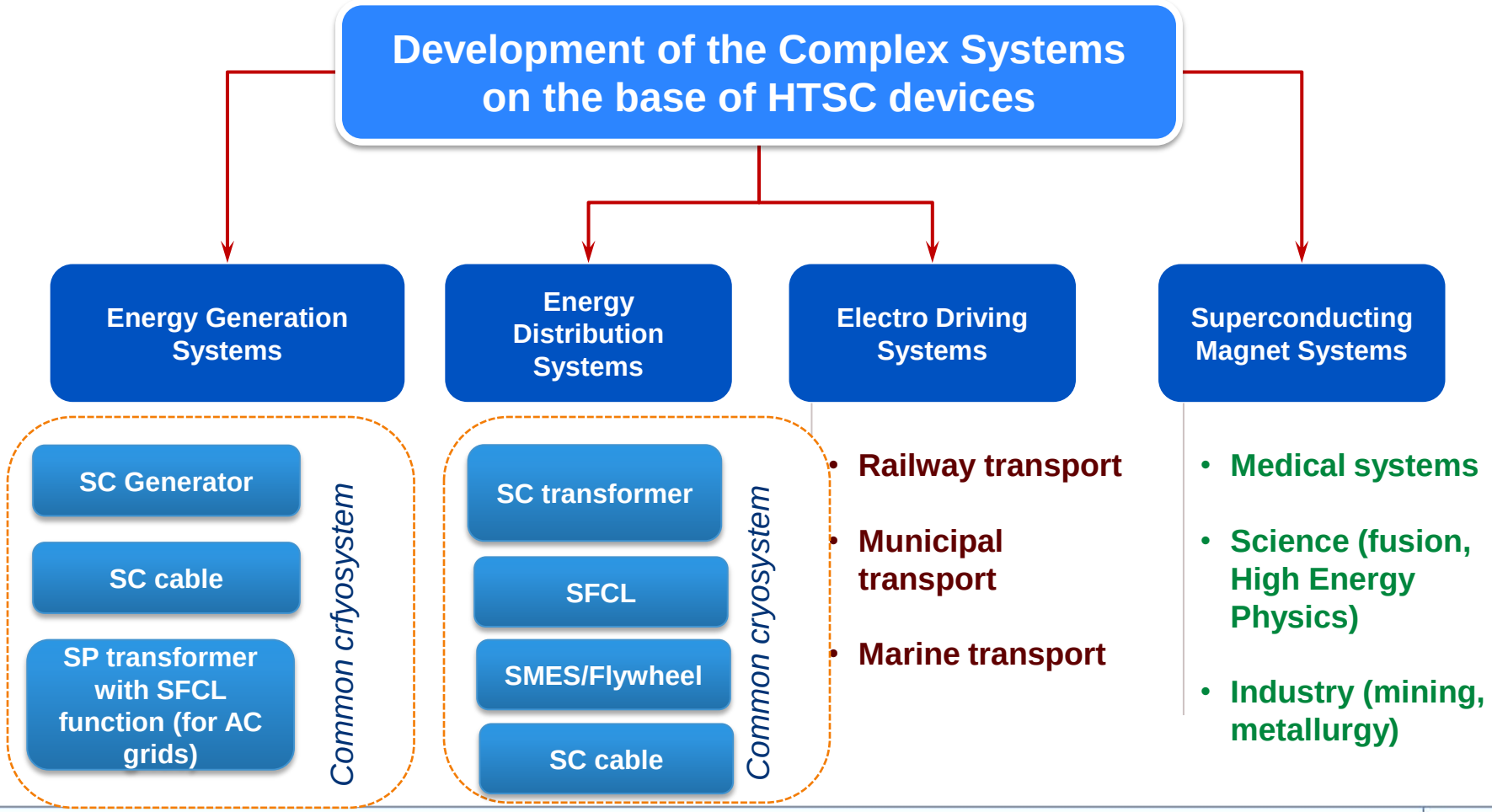
- Reduced weight and dimensions – 2-3 fold;
- Increased specific capacity – 2-3 fold;
- Improved performance;
- Increased overload capacity;
- Increased life span;
- Fire safety.

Areas for most efficient integration:

- Superconducting wind energy stations;
- Waterborne transport electric propulsion systems.

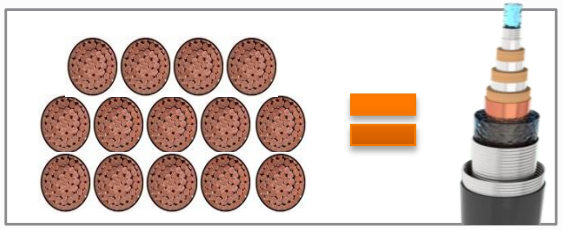
Further steps of the Program

- Decrease of weight and dimensions parameters in 2-3 times
- Increase of Efficiency coefficient on 1-3 %
- Decrease of Energy losses in Energy Transfer Lines in 2 times



Project HTSC cables and SFCL

Comparison of the traditional and HTSC cables



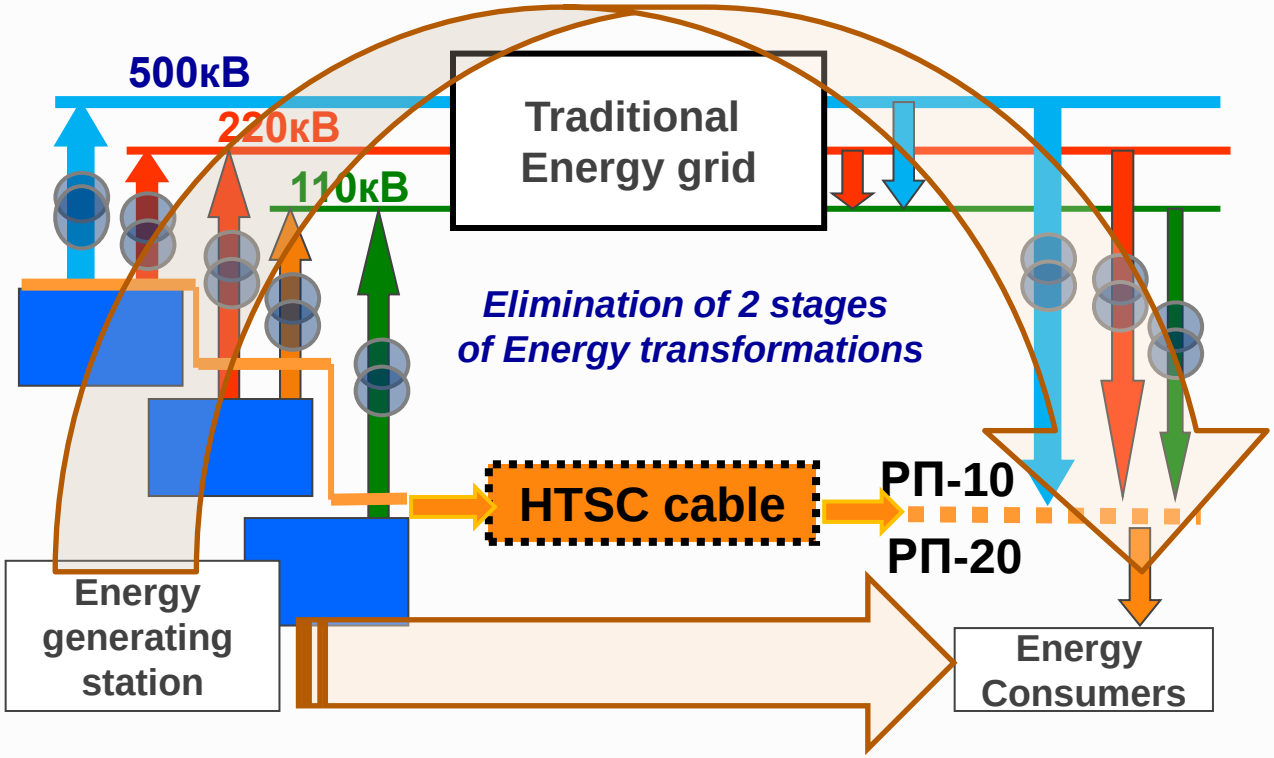
Safety zone

ETL

100 м

HTSC-2

до 4 м



- Connections on the “low voltage” side between the different sectors of Energy grid without the risks of increasing of the level of Faults Currents;
- Possibility to avoid the transformation to the High voltages and transfer of large amount of energy at the Generator voltage.
- At least 2 times smaller Energy losses in HTSC cables

The economy of space under the Energy Transfer Lines in Large Cities and Industrial Centers

Concluding remarks

- The Project “Superconducting industry” resulted in development and fabrication of the significant set of devices on the base of HTS conductors that are perspective for energy oriented applications: SFCL for energy grids 4-28 kV (DC and AC), Transformer 1 MBA, kinetic and induction (Flywheel and SMES) energy storage systems up to 30 MJ, Motor - 200 кW, Generator - 1 MW.
- Scientific infrastructure has been established for further development of HTSC-2.
- Industrial scaled equipment for commercial production of HTSC has been developed
- The level of development of the HTS technologies enables to initiate the next stage – creation of complex energy systems that strongly enhance the economic efficiency of the application of the superconducting technologies.