

Main achievements in replacement and disposal of RTGs in Russia

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List of abbreviations

APSS – alternative power supply source
RTG – radioisotope thermoelectrical generator
RHS – radioisotope heat source
SEI – solar energy installation
WEI – wind electrical installation
RRC – Russian Research Center
PA – production association
CNIIMF – Central Research and Development Institute of the Navy
VNIITFA – State Technical Physics and Automation Research Institute

Bottleneck problems 2 years after the CEG RTG workshop in Oslo, February 2005

The IAEA Contact Expert Group (CEG) workshop Security and Safety of Radioactive Sources: Decommissioning and Replacement of Radioisotope Thermoelectric Generators was arranged based on the decision taken at the 18th meeting of the CEG (Moscow, October 2004) and was held in Oslo, Norway, February 16-18, 2005.

The workshop was arranged by the Norwegian Agency for Radiation Protection and the CEG Secretariat in close cooperation with Rosatom.

Representatives of the following eleven countries took part in the CEG workshop: Canada, Finland, France, Germany, Norway, Russia, Sweden, Great Britain, United States of America, Denmark, Japan as well as representatives of the three international organizations: European Commission, IAEA and NEFCO.

At the workshop the Russian side represented the following information on RTGs:

Table 1: RTGs to be decommissioned and disposed of in Russia

Region / Responsibility	Navy	Agency of Sea & River Transport (Mintrans)	Rosatom¹	Other² organizations	Total
North-West Russia ³	93 Baltic	46			139
Russian North	98	196			294
Far East ⁴	145	85			230
Total	336	327	52	~ 50	~ 765

Notes: 1 – in the process of decommissioning (disposal)
2 – other organizations and agencies

- 3 – including the Baltic Region
- 4 - including Pevek and Providence Bay

As it was stated at the CEG workshop in Oslo, the RTG operation experience demonstrated their high reliability and efficiency as a power supply source for aids to navigation supporting safe navigation.

However, in the recent years potential ecological and radiological threat posed by these generators has largely increased. Numerous acts of unauthorized dismantlement of RTGs as well as barbaric acts affecting RTGs have been recorded. The possibility of a terrorist attack with the use of RTGs should not be also neglected.

Based on the above, the workshop of experts in Oslo recommended to structure the RTG problems, some of which are still topical, in the following way:

- Immediate decommissioning of RTGs that expired their design life;
- Construction of regional accumulating sites and temporary storage facilities equipped with necessary safety and security systems for interim storage of RTGs withdrawn from operation and with installations for RTG disassembling where necessary;
- Increase of the RTG dismantlement rate in accordance with the transport and technology flow chart that are being implemented through upgrading and enlargement of transportation containers and transportation means fleet;
- Improvement of the current regulatory and state supervision system on the RTG management activities;
- Development and implementation of security and alarm systems at RTG installations which operation should continue, and arranging emergency response measures and teams;
- Development of alternative power supply systems for navigation equipment and their implementation instead of dismantled RTGs;
- Development of the methodology for dealing with accident RTGs, elaboration of technical and organizational solutions for accident RTGs handling and their implementation.

At the Oslo workshop it was mentioned that there were no visible obstacles to immediate expansion of international activities on decommissioning and disposal of RTGs and all necessary steps should be taken to assist Russia in handling the stated problems important not only for Russia but also for most countries of the Northern hemisphere of the Earth.

To follow and concretize the Oslo workshop resolutions, a working meeting Decommissioning and Replacement of Radioisotope Thermoelectric Generators in the Russian Federation was held in Moscow, April 25-26 2005, on the initiative of the Federal Agency of Atomic Energy (Rosatom). Sergei Antipov, Deputy Head of the Federal Agency of Atomic Energy, presided at the working meeting hosted by the RRC Kurchatov Institute.

Representatives of such seven countries as Germany, Denmark, Canada, Norway, Russian Federation, United States of America, France and one representative of NEFCO numbered among the participants of the meeting.

The purpose of the meeting was to determine and specify problems for 2005 to be faced by the Russian side and donor countries in the sphere of the RTG decommissioning in the Russian Federation, that is:

- Determine specific regional tasks for each of the cooperation program participants for 2005, estimate fund sources and their adequacy;
- Find out whether there were contracts concluded with Russian partners, reveal content, time lines and milestones of the contracts;
- Inform about current status of the work, give forecasts for the end of 2005 and further on.

By the end of April 2005, there were 717 RTGs of various types and manufacture dates operated or stored at the facilities of the Navy, Ministry of Defense, and Rosmorrechflot:

- Barents and White Sea coast. Owner – Northern Fleet of the Russian Navy (100 RTGs);
- Along the Northern Sea Route (from the city of Archangelsk up to Providence Bay). Owner – Rosmorrechflot Hydrographic Service, Mintrans (328 RTGs);
- Far East coast from Bering Strait up to Vladivostok, including Sakhalin and Kuril Islands. Owner – Pacific Fleet of the Russian Navy (160 RTGs);
- Baltic Sea coast and islands. Owner – Baltic Fleet of the Russian Navy (93 RTGs).
- separate groups of RTGs (36 RTGs in total) in the mainland of Russia. Owner – Departments of the Ministry of Defense of Russia.

Since the working meeting in Moscow (see Proceedings of the working meeting, in particular Table 3, Appendix 1) the donor countries have been working in the following directions:

- Norway has been concentrating its financial and technical support in the Barents Sea, White Sea, Nenetsky and Yamalo-Nenetsky Autonomous Areas;
- The USA has been actively providing financial support to activities in the Far East (RTGs of the Pacific Fleet), assisting in completion of the earlier commenced work in the Baltic region;
- Germany has been working on preparation of a contract for dismantlement of RTGs in the Baltic region;
- Denmark has been preparing the project specifications for replacement of decommissioned RTGs with photovoltaic systems in the Baltic region;
- Since autumn 2005 Canada has been providing financial support to develop the RTG Master Plan;
- Since autumn 2005 France, England, Sweden headed by Norway have been providing financial support to work on improvement of the Russian Regulatory basis under the contract with Rostekhnadzor (VO Bezopasnost);

More detailed information is given in Appendix 2.

In 2005-2006 Russian beneficiaries of the international technical assistance included:

- North-West Region - Murmansk Region Administration;
Norway – donor country. Murmansk Region Administration - managing company and beneficiary;
- Far East region - Navy and Rosatom (DalRAO-1, 2). The USA – donor country. RRC Kurchatov Institute - managing company and beneficiary;
- Rosmorrechflot of Mintrans – the Northern Sea Route. The USA – donor country. VNIITFA - managing company and beneficiary;
- Rostekhnadzor. VO Bezopasnost - managing company and beneficiary.

RTG work main subcontractors in 2005-2006:

- Atomflot of Rosmorrechflot, Mintrans – transfer and interim storage of RTGs in the North-West region;
- DalRAO of Rosatom – interim storage of RTGs in the Far East;
- Mayak PA of Rosatom – final disposal of RTGs (RHS vitrification and isolation);
- Regional Hydrographic Departments of the Navy – RTG dismounting;
- Sosnovy Bor Radon LSP (Rosstroy of Minregionrazvitie) – dismounting, transfer and interim storage of RTGs in the Baltic region;
- Irkutsk and Novosibirsk Radons – interim storage of the earlier dismantled RTGs;
- Rostekhnadzor – regulatory support of the RTG related activities, improvement of the regulatory basis

As of today, the State Supervising Agency for Nuclear and Radiation Safety of the Ministry of Defense of the Russian Federation does not participate in the RTG related activities. Rostekhnadzor took charge of all supervising problems.

The following information can describe Russia's input into the RTG disposal problem solution. For the period from 2001 to 2005 the Russian Federation at its own expense dismantled 77 RTGs, disposed of 74 RTGs, sent 74 RHS-90 to Mayak PA for a long term storage.

A good deal of money was spent to search the lost RTGs, to mitigate consequences and dispose of the wrecked RTGs in various regions of Russia.

According to plans and contracts in force the following is to be done in 2006:

• **Under financial support of Norway**

In February 2006 governors of the Finnmark Province and Murmansk region signed one more protocol based on which some contracts were signed in May 2006 for disposal of 30 RTGs, including 17 RTGs from the Barents Sea (one of which, IEU-2 located in Motovski Bay, was wrecked) and 13 RTGs from the White Sea, and installation of 30 alternative power sources at the beacon sites.

In addition, in 2006 VNIITFA under its operating contracts with the Norwegian side is planning to perform the following work:

- Dismantlement of 24 RTGs delivered to VNIITFA in 2005;
- Development of a technological scheme (method) to dismantle RTGs of Senostav type and transfer RHSs extracted from these RTGs to Mayak PA.

As a whole it is planned to complete dismounting RTGs in the Murmansk region in 2006 (at present there are 17 operating RTGs left in this region), in the Arkhangelsk region – in 2007 (RTGs of the Hydrographic Department of the Northern Fleet). There is an intention to dismount RTGs in the Yamal-Nenetsk Autonomous District in 2008 (RTGs of Rosmorrechflot of Mintrans of Russia).

• **Under financial support of the USA**

Contracts for the following work were concluded with RRC Kurchatov Institute:

- Decommissioning and replacement with solar power systems of 31 RTGs used to power aids to navigation in the Far East;

- Putting into operation the RTG storage facility in the territory of DalRAO designed for interim storage of the Far East and Chukotka RTGs in October 2006 (under a contract with the American side).

VNIITFA under its contracts in force is planning to perform the following work:

- Dismantlement of one RTG being stored on the premises of the enterprise for a long time;
- Installation of nine alternative power sources based on solar batteries and wind generators to replace the RTGs removed from the range lights in Yugorski Shar Strait.

Additional proposals from VNIITFA for expansion of cooperation with the USA:

- Dismantlement of 2 problem RTGs of Gorn type and development of a technological scheme for dismantlement of 4 problem RTGs of Beta-M type;
- Dismounting and transportation of 30RTGs from the Northern Sea Route to VNIITFA.

- **Under financial support of Canada**

In January 2006 on the initiative of Rosatom an Implementing Arrangement was signed between the Department of Foreign Affairs and International Trade of Canada and RRC Kurchatov Institute (project number 4035-03/05 of January 12, 2006) for development of a Master Plan to decommission, replace with alternative power sources and dispose of radioisotopes thermoelectric generators in the Russian Federation.

The Master Plan is being developed in the best interests of Rosatom, Navy, Ministry of Defense of Russia, Rosmorrechflot, Roshydromet, Rosstroy, Rostekhnadzor, administration of the Murmansk region and other agencies and departments as well as enterprises and organizations responsible for decommissioning, replacement with alternative power sources and disposal of RTGs.

The Master Plan is designed not only in the interests of the Russian side but also for use by the donor countries as a tool to justify funds allocation for RTG decommissioning. The Master Plan will make it possible to consolidate funds allocated by the foreign partners, to lay foundation for subsequent implementation of a number of projects under international grants and contracts.

In 2006, along with the Implementing Arrangement on the Master Plan, another Implementing Arrangement was signed between the Department of Foreign Affairs and International Trade of Canada and VNIITFA to manufacture 17 transportation containers, 16 protection cages, and 20 link-and-hook-sling units to transport RTGs of B type.

- **Cooperation with Germany**

In April 2006 the Ministry of Foreign Affairs of Russia by a verbal note made a proposal to the Federal Republic of Germany to enter into cooperation on decommissioning RTGs located in the Baltic region. Main goals of the project are as follows:

- Dismount radioisotope thermoelectric generators, accumulate and transfer them to the Radon Leningrad Special Plant (Sosnovy Bor) of the Federal Agency of Construction, Housing Maintenance and Utilities of the Ministry for Regional Development of the Russian Federation;
- Upgrade the RTG interim storage facility at the Radon Leningrad Special Plant (Sosnovy Bor);

- Provide interim storage of radioisotope thermoelectric generators at the Radon Leningrad Special Plant (Sosnovy Bor);
- Load radioisotope thermoelectric generators into the wagons and transport them to the Mayak PA (Ozersk) of the Federal Agency of Atomic Energy;
- Create a dismantlement site for radioisotope thermoelectric generators, including a hot cell, at the Mayak PA (Ozersk);
- Dismantle radioisotope thermoelectric generators at the Mayak PA (Ozersk);
- Vitrify radioactive waste and provide its long-term storage at the Mayak PA (Ozersk);
- Solve other problems encountered within the process of the radioisotope thermoelectric generators decommissioning.

In 2006 numerous working meetings of representatives of the GRS mbH (Germany), Rosatom and RRC Kurchatov Institute were held in order to discuss work to be performed under the above mentioned project and described in the verbal note submitted to the German side for consideration.

According to the German side, the Federal Republic of Germany could possibly sign a reply note in autumn 2006. After that it is planned to sign a contract with the RRC Kurchatov Institute for development of a Feasibility study under the above project.

- **Cooperation with Denmark**

Now Rosatom, Russian Navy and RRC Kurchatov Institute carry on talks with the Danish side for supply of 73 sets of navigation equipment required to replace RTGs located in the Baltic region. In May 2006 the Danish side informed that it could supply the required equipment and allocate funds to purchase LED programmable lamps and controllers of Russian manufacture for 7 beacons located in the Kaliningrad region.

Rosatom in its letter of May 25, 2006 confirmed readiness of the Russian side to cooperate under this project and made a proposal in respect of beginning of pre-contractual talks under this project.

A working meeting of responsible representatives of the Navy, RRC Kurchatov Institute and Denmark was held in July 2006. In October 2006 RRC Kurchatov Institute sent the Danish side a technical proposal on the photovoltaic systems for the light beacon of the Baltic Sea. This proposal is being considered by the Danish side.

- **Russia**

In the Russian Federation it is planned to continue using funds allocated by the federal budget to solve the problems related to the RTG decommissioning.

In 2006 the federal budget began to allocate funds under the project to mitigate consequences of the unauthorized access to the RTG, which powered the Navarin Cape RTG. According to estimates, it will take 1.5 year and require more than 60 million rubles to perform this work. A List of Activities to Improve Nuclear, Radiation and Ecological Safety in 2007 provides for 13.8 million rubles to develop technologies for disposal of the wrecked RTGs as well as methods and criteria to estimate threat posed by the sources of ionizing radiation

Rosatom has prepared a draft federal program “Ensuring Nuclear and Radiation Safety in 2008 and for the Period to 2015” which is now under consideration

If the plans for 2006 listed above are successfully implemented there will be 533 RTGs operating at the sites at the beginning of 2007 (see Fig. 1, 2).

Geographically these RTGs are located in four regions of Russia:

- Coast of the Barents and White Seas. Operating organization – Russian Navy (27 RTGs, if plans for dismantling 30 RTGs in 2006 year are completely implemented);
- Along the Northern Sea Route (from Novaya Zemlya archipelago to Chukotka), Operating organization – Hydrographic Service of Rosmorrechflot of Mintrans (218 RTGs);
- Far East region of Russia – starting from Vladivostok in the south to the Bering Strait in the Far North including Sakhalin and Kurile Islands, operating organization – Russian Navy (77 RTGs).
85 Chukotka RTGs of Rosmorrechflot should be also considered as RTGs of this region. Operating organization – Hydrographic Service of Rosmorrechflot
- Islands and cost of the Baltic Sea, operating organization – Russian Navy (90 RTGs);
- Groups numbering 36 RTGs in total operated by other departments of the Ministry of Defense of Russia (not by the Navy). Their status will be reported additionally.

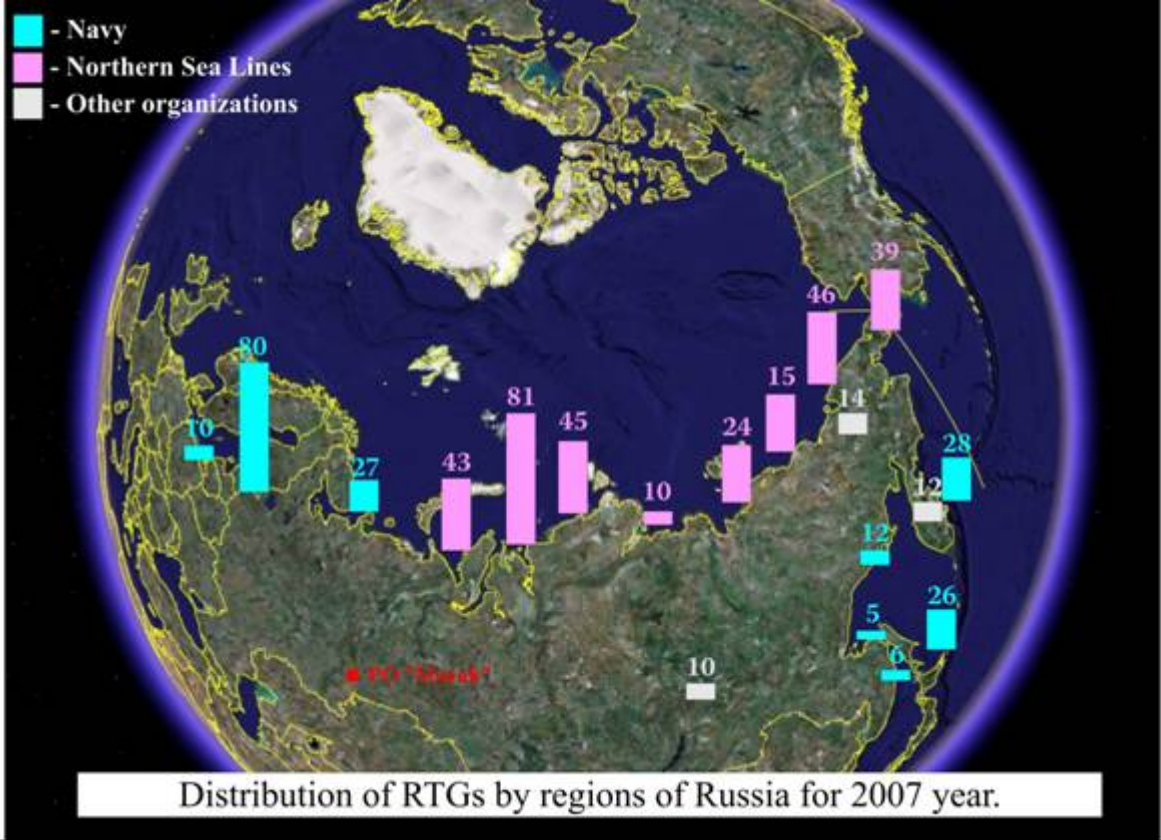


Fig. 1

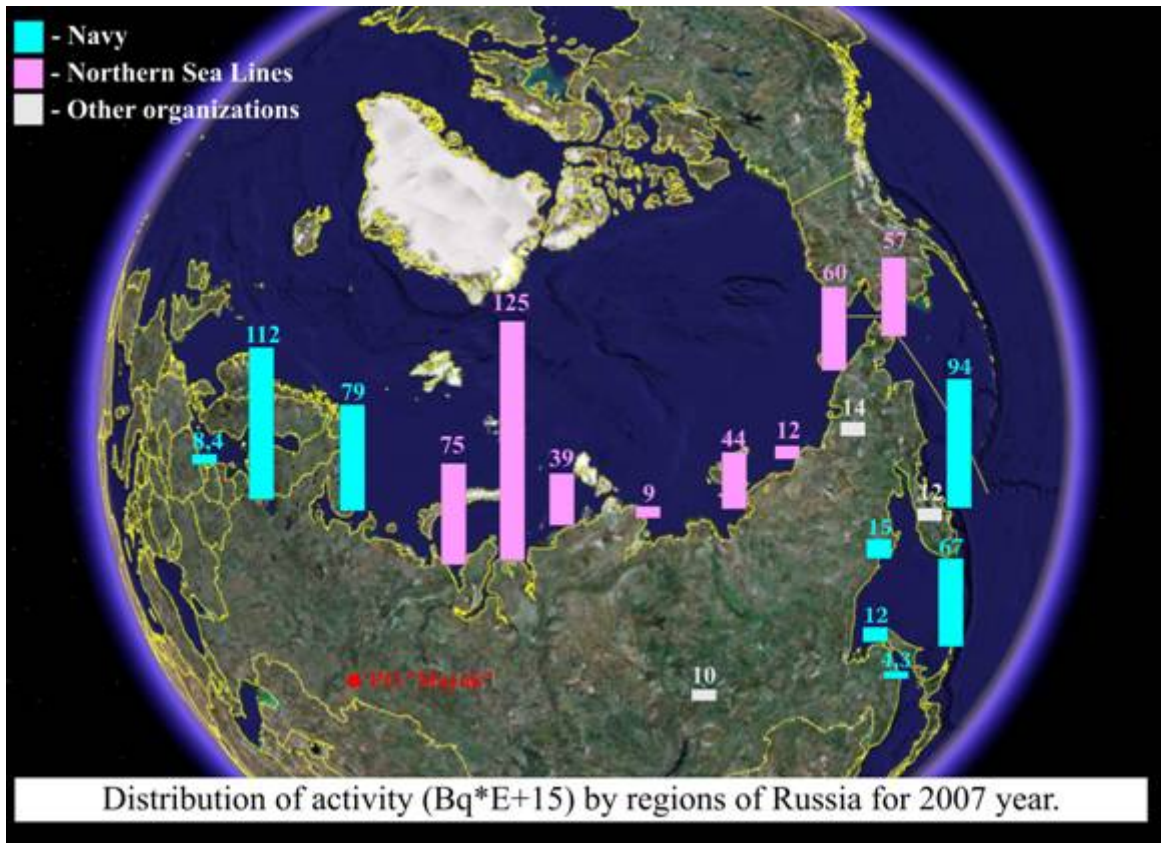


Fig. 2

Today it is very important to define more precisely **content of problems of current situation** with RTGs and conduct improvement of goals and top-priority tasks for nearest perspective.

At our opinion for today following requirements are of a current importance as source prerequisite for composition **conception of activities with RTGs**, namely:

- Decrease risks connected with possibility of unauthorized dismounting of RTGs during their autonomous operation with their further use in terrorist goals;
- Decrease of risks connected with destroying of RTGs during their autonomous operation with further pollution of environment.
- Provision of acceptable level of radiation safety during conducting of activities intended for dismounting and disposal of RTGs.

Also it is necessary to define priorities of different works (types of works) with RTGs and sites with RTGs in condition of financial limitations.

It is also necessary to take into account **principle of non-proliferation** of radioactive materials similar to how it is done in respect to non-proliferation of nuclear materials having in mind possibility of construction of different dirty bombs and other devices from RTGs and methods for intentional radiation injury of population.

Problem of non-proliferation and increase of threats from terrorist activities during maintenance and handling with RTGs is obviously more critical while organizing of priorities and ranking of tasks and measures in comparison to same problems with decommissioning of nuclear submarines.

It is necessary to stress the fact that for the past years positive technical-organizational experience is gained and also several pilot projects are implemented. They enable us to speak about technical practicability of one or another variant, cost of implementation and also timeframes during which one or another project (type of activity, measure or so on) could be fulfilled.

Also to one of the achievements of international cooperation we can ascribe fact that because of financial help of Norway the practically whole cost of the Kola peninsula is cleared from RTGs.

Similar positive tendency could be observed at Far East region where it is planned to clear cost of Primorye area from RTGs to the end of 2006 year at the expenses of the USA. Corresponding storage facility is built at DalRAO enterprise for storage of those RTGs.

Analyzing current situation and also preceding period following already solved problems and problems which need to be solved could be singled out from the points of view of RTGs Master plan:

1. Procedures of RTGs dismounting at islands and sea cost are developed and tested (with use of automotive pontoons, barges, vehicle, hydrograph ships, helicopters).
2. Optimal constructions of SEI for mounting of APSS (except lighthouses with long operating distances ≥ 15 miles and Far North districts of the Northern Sea Route) are defined.
3. Problems of transportation of RTGs to gathering sites of hydrograph services and interim storage of RTGs are solved. Though during storage protection of sites, installation of RFID signaling system and also mobile means of physical protection are required.
4. Problem of transportation of RTGs from gathering and interim storage sites to specialized sites (Radon in Sosnoviy bor, Atomfleet, DalRAO and in future possible to Zvezdochka) by ships and automobile transport is solved. From those specialized sites RTGs by special railway wagons (Atomspetztrans) are transported to VNIITFA or/and are transported to Mayak PA for disassembling and long-term isolation and storage of RHS.

However today it is necessary to make a decision to create modern high-production center for disassembling of RTGs and storage of RHS at Mayak PA.

Being discussed alternative way is decentralization principle and fulfillment of the task with help of local centers equipped with mobile hot cells. Such centers could be located in DalRAO, Zvezdochka, Radon in Sosnoviy Bor regions where experience of work with radioactive wastes exists.

In above mentioned case RTGs could be disassembled in regions, only RHS would be transported to Mayak PA. They would be sent in amounts and by the time when Mayak PA within the frameworks of its manufacturing feasibility would be able to receive RHS for so called "vitrification".

In both variants we are proceeding from the assumption that center of final storage of RTGs and their reliable isolation from unauthorized access and from environment is Mayak PA.

Situation with RTGs in Far North region of Russia and along Northern Sea Lines is difficult. Problems for Far North and Northern Sea Lines lie not only in expensiveness of works intended for dismantling of RTGs and their transportation to Murmansk or Arkhangelsk but also in absence of reliable (equivalent in electrical power to RTG) APSS (SEI or combined SEI + WEI). Wind electrical generators delivered by Denmark are not operating now because of several reasons. SEI under USA order are not installed yet (according to information of RRC KI and CNIIMF) and it is yet not known how they would behave in conditions of polar night and strong cold (up to -50°C).

That situation makes some representatives of owners of RTGs located at the Northern Sea Route (Hydrograph service Rosmorrechflot of Ministry of transport and CNIIMF) say that for today there is no equivalent alternative for RTGs at the Northern Sea Route. And according to their forecasts 163 RTGs would be in operation until 2011 year [3].

Problems noted at Seminar in Oslo and during 19 session of CEG are still very important but as we think following themes are becoming most relevant (Those themes require study and discussion):

1. Creation of high -production center for disassembling of RTGs and storage of RHS at Mayak PA.
2. Possibilities of disassembling of RTGs with help of mobile hot cells at regional sites with further transportation of RHS to Mayak PA for vitrification.
3. In spite of the fact that there is successful experience of implementation of pilot projects with USA absence of financing holds activities in the Baltic region.
4. Economically acceptable APSS for extreme operation conditions for operation at Far North and at the Northern Sea Route are still not developed.

Because problem of creation of high-production center at Mayak PA would not be solved during nearest two years may be we will have to follow principle of “deferred” [1,2] disposal though it will cause additional charges (though not a big one) for storage of RTGs while waiting for their disassembling at Mayak PA. That refers mainly to Chukotka and Far East region.

Storage building design is implemented at DalRAO site. Storage is considered for 250 RTGs. There is storage at “Zvezdochka” which could be adjusted for storage of 100 RTGs.

There is storage for 10 RTGs in Radon in Sosnoviy Bor. It is possible in case of safety substantiation to use other capacities for up to 90 RTGs.

“Radon” enterprises in Irkutsk and Novosibirsk could also be used.

Thus “Radon” in Sosnoviy bor and “Zvezdochka” could simultaneously storage almost all RTGs in Baltic an North-West.

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Mr. Antipov during Oslo seminar and after in Moscow set a problem for dismantling of all RTGs before 2012 year.

Undoubtedly, International Atomic Energy Agency CEG should recommend to donor-countries to conduct ranging of RTGs problems of cause in part in which that problem touches interests of one or another donor-country.

From our side in the existed conditions of limited financing we can propose to examine following factors characterized RTG problems and some comments to those problems.

List of factors of current importance during definition of priorities is the following:

1. Global safety.
2. Safety of population and environment.
3. Financial capabilities and investments of donor-countries.
4. Regional international interests of donor-countries.
5. International technical projects, implementation of which until is connected or could be subjected to implementation stoppage threat:
 - Baltic. Export-import of gas, oil;
 - The Barents Sea. Oil, gas production, fishery;
 - Sakhalin. Biological resources of Pacific coast of Russia, oil, gas production;
 - International and regional navigation (export-import);
 - International and regional fishery;
6. Production potentialities and infrastructure for implementation of replacement of RTGs in regions.
7. Interest of Russian departments (services).
8. Regional interests in Russia.
9. Value of possible input of Russian side
10. Social factors inside Russia (employment, level of criminality, standard of living at regions ...).
11. Social factors in region of other countries adjacent to Russia
12. International and regional public opinion.

It is clear that list is open for discussion, correction and extension.

Scale of possible accidents and incidents with RTGs is presented in Table 2; also attempt of estimation of potential economical damage is outlined– on a basis of expert estimations.

Table 2: Scale of possible accidents and incidents with RTGs

Possible event	Risk according to RES Center	Possible place and circumstances	Assumed damage
Local use of “dirty” bomb at stadium arena (around 50 thousands spectators) or at any other mass performance	Estimated maximum permissible radiation doze is 2,3 Sievert	Everywhere	Cost for deactivation Not yet defined
Damage of RTG because of explosion with help of TNT, accompanied by outlet of ⁹⁰ Sr out of RTG	Irradiation of personnel of Navy HS RHSP, ingress of ⁹⁰ Sr into the water, because lighthouses are located at hills of	Navarin lighthouse - assumption	> 60 millions rubles. Costs for dismounting and transportation to Vladivostok at DalRAO

	islands and at peninsula		
Unauthorized disassembling of RTG with extraction of RHS	Irradiation of personnel of Navy HS RHSP and HS. Cases of death between infringers.	Baltic Kola bay the White sea Far East	Costs for RHS search, its delivery and further procedures for making radiation environment safe.
Unauthorized damage of RTG construction without extraction of RHS, with breaking of biological protection	Irradiation of personnel of Navy HS RHSP and HS	Everywhere	Special containers and special measures during transportation is required
RTGs are falling down at Northern Sea Line and “disappear”		Described in Master plan	
RTGs are being lost during transportation by helicopter	Possible drop into the sea with following outlet of ⁹⁰ Sr into the water	Described in Master plan	Costs for RTG search at Sakhalin coats are already
Accidents happened during transportation by sea, by rail road, by plane, by vehicle			

At the end of the report several diagrams are presented. They characterized situation with RTGs in different regions of Russia.

Diagram 1 enables comparison of radiation potential of RTGs in different regions.

It is clear that value of potential radiation influences to a great extent the following:

- Risk for local population and population of adjacent countries during damage, accident and incidents;
- Economical damage or costs for elimination of consequences of those incidents.

At diagrams 2, 3, 4 total number of RTGs divided by regions is presented and also translation per 1 km of coastal line and also “loading” of Bq per 1 person are presented. That gives basis for prioritizing from the point of view of RTGs vulnerability because of their big number and also from the point of view of possible potential infringers inside of Russia and also potential infringers from other countries.

At diagram 5 evaluation data characterizing intensity of navigation in different regions is presented. That from one side enables us to judge about navigation concernment of lighthouses with RTGs and from another side about level of theft threat having in mind that unauthorized access to RTG could be carried out by crew of those passing ships.

Far East region of Russia has first rank in navigation intensity index recalculated per one RTG – as it could be seen from diagram 6.

At the sea coast of Far East from Pos'yet at south at the boarder with Korea to Tiksi at Far North 22 sea ports are located. 11 of them are ports with round year navigation, they have outlets to railway main lines of the country. In Primorye region such ports are Vladivostok, Nakhodka, Nakhodka – oil-port, Vostochniy, Po'yet, Zarubino. In Khabarovsk – port Vanino. At Sakhalin island – ports Holmsk and Korsakov. At north part of the Sea of Okhotsk – port Magadan. At Kamchatka – Petropvalovsk-Kamchatskiy.

It is well known fact that Far East region of Russia represents very rich source of energy resources and minerals, serves as transportation lines and gives outlet from Russia and Europe to Asian-Pacific region. Also increase in delivery of cargos into far north part of that region and also arrival of cargos from that region has started additionally to export and import via sea ports of Far East.

Factors of necessity of reduction of risks of unauthorized access to RTGs at unattended lighthouses and provision of secure navigation during subsequent development of natural resources of Far East region enables assigning of high priority to the task of dismounting of Pacific Fleet RTGs. People security, safety of vessels and ladings, hydrograph constructions, ecological situation in north part of the Pacific Ocean which could be worsen as a result of accidents with vessel transporting mineral oil, liquefied gas and other potentially dangerous in ecological terms ladings depend on successful solution of that problem.

Diagrams 7-8 are dedicated to evaluative costs of separate types of activities and total averaged recalculated cost for 1 RTG connected with removal of RTG and its replacement on APSS.

Authors were not able to receive precise structured data for cost of works at Northern Fleet financed by Norway and that is why we do not present them in our present report.

Diagrams 9-10 presented below show tendencies and dynamic of RTGs decommissioning depending on region. On there basis it is possible to make an optimistic conclusion that in case current financing support will be saved for the Northern Fleet and Pacific Fleet regions then fulfillment of all task is possible until 2012. In case works at Baltic region would be started in 2007 year it would be possible to finish all work in time.

Difficult situation is with Northern Sea Lines. Chukotka where 85 RTGs are located also has its own specific place in that situation.

In conclusion about our proposals for **conception of works with RTGs at the nearest future.**

Those proposals are presented in accordance with main tasks which were already defined in due time at CEG in Oslo but over past period they didn't loose their topicality.

Main provisions of our conception for nearest period could be formulated in the following way:

A. Disposal of maximum possible number of RTGs, which designed lifetime expired and/or there is no necessity in their further operation:

1. Conducting of works intended for survey of state of RTGs [5,7]
2. Large-scale radiation safe dismounting of decommissioned RTGs [4,7]

3. Determination of optimal amount of aids to navigation on the sea lines, first of all for Northern Sea Lines. [5]

B. Construction (provision of the necessary facilities) of regional sites for accumulating and temporary storage, equipped with necessary physical protection and radiation safety systems for temporary storage of decommissioned RTGs and installations for dismantling of RTGs at places where necessary.

1. Construction of sites (facilities) for interim storages of decommissioned RTGs and equipping of those sites with systems of monitoring and systems of prevention of unauthorized access. [5,6,7]

C. Optimization of processes of delivery of RTGs in accordance with upgraded and new transportation – technological schemes.

1. Upgrading of means of transportation for delivery of RTGs from their maintenance (installation) places to temporary storage sites in order to provide compliance with modern requirements for radiation safety; provision of specialized means of transportation and modern means of personnel technical protection.[4, 5, 6, 7]
2. Upgrading of requirements for transportation means intended for transportation of RTGs (regulatory document). [6]
3. Provision of physical protection of RTGs during their transportation to temporary storage sites. [5]
4. Elaboration of new transportation - technological schemes (see Fig.3).

D. Creation of modern high – production center for dismantling of RTGs and storage of RHS at Mayak PA.

1. Technology of disassembling and disposal should provide handling with all types of RTGs being in operation in Russian Federation;
2. It is necessary to design and create hot cell for disassembling of RTGs.
3. Being created infrastructure should provide productivity of disassembling and disposal of up to 120 RTGs per year.

E. Development and implementations of safety and signaling systems at sites operation of which will continue and organizations of measures for reaction on force-majeure (extraordinary circumstances) and groups of reaction on force-majeure (extraordinary circumstances).

1. Organization of signaling system and protection from unauthorized access to RTGs which will stay in operation for some time. [4, 5, 6, 7]
2. Selection of optimal variants of signaling and protection of RTGs during their maintenance and transportation. [5]

F. Development alternative power supply system for navigation equipment and their implementation in place of removed RTGs.

1. Selection of alternative power supply sources economically reasonable and acceptable depending on regional conditions. [6]
2. Definition of required numbers of APSS for replacement of RTGs on alternative power supply sources. [5]

3. Replacement of RTGs by alternative power supply sources. Organization of their pilot maintenance with carrying out analysis of maintenance experience, carrying out checks, testing in working conditions. [5, 6]
4. Development and introduction of measures necessary for provision with physical protection of navigation means with alternative power supply sources. [4, 5]

G. Development of methodology for handling with wrecked RTGs, upgrading of technical and organizational solutions for handling with wrecked RTGs and its implementation.

1. Isolation of wrecked RTGs, delivery of modern instrumental means of search and personnel protection means for those who take part in activities intended for elimination of consequences. [4, 5, 7]
2. Participation in financing and execution of works intended for solving a problem of dismounting of wrecked RTGs and RHSs extracted from RTGs which could not be decommissioned in accordance with current procedures. [7]

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Fig.3. Possible ways of the RTG transportation

RTG summary activity regional distribution as of October 2006

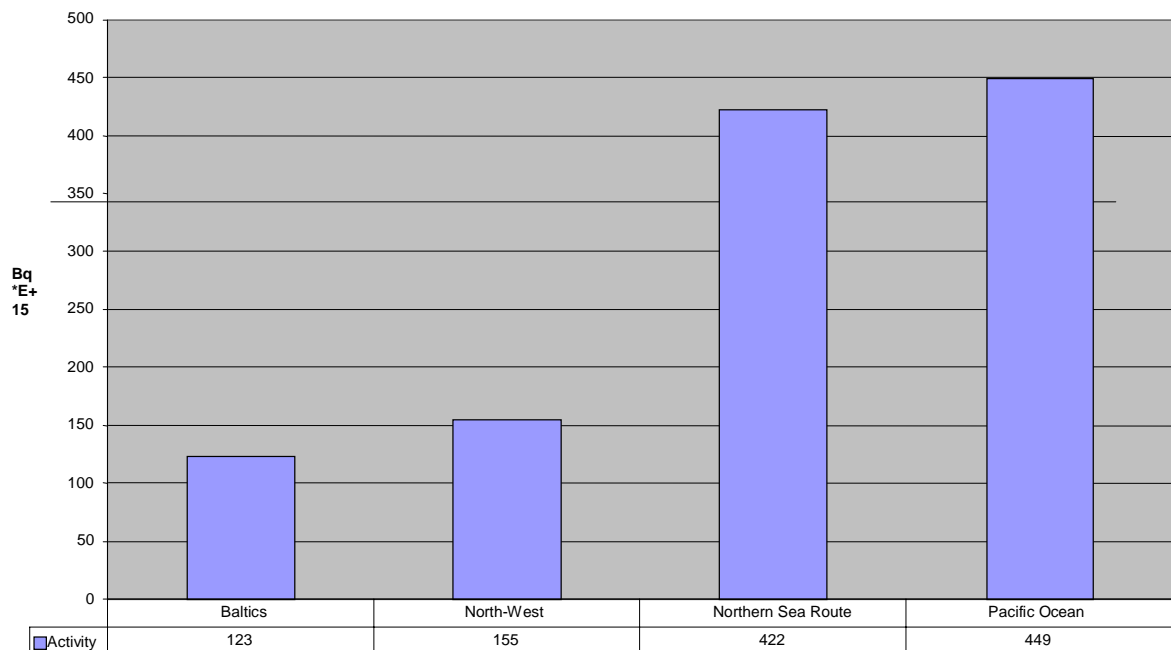


Diagram 1

RTG regional distribution as of October 2006

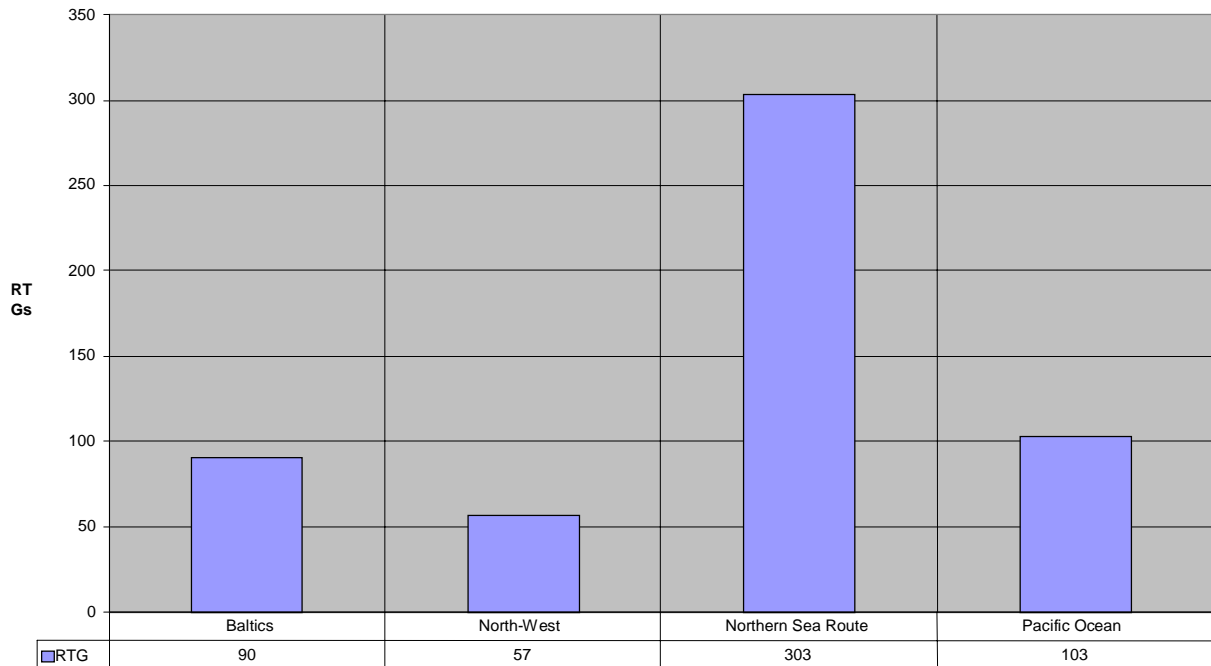


Diagram 2

Estimated RTG radiation load per 1 km. of the coastal line in the Russian regions

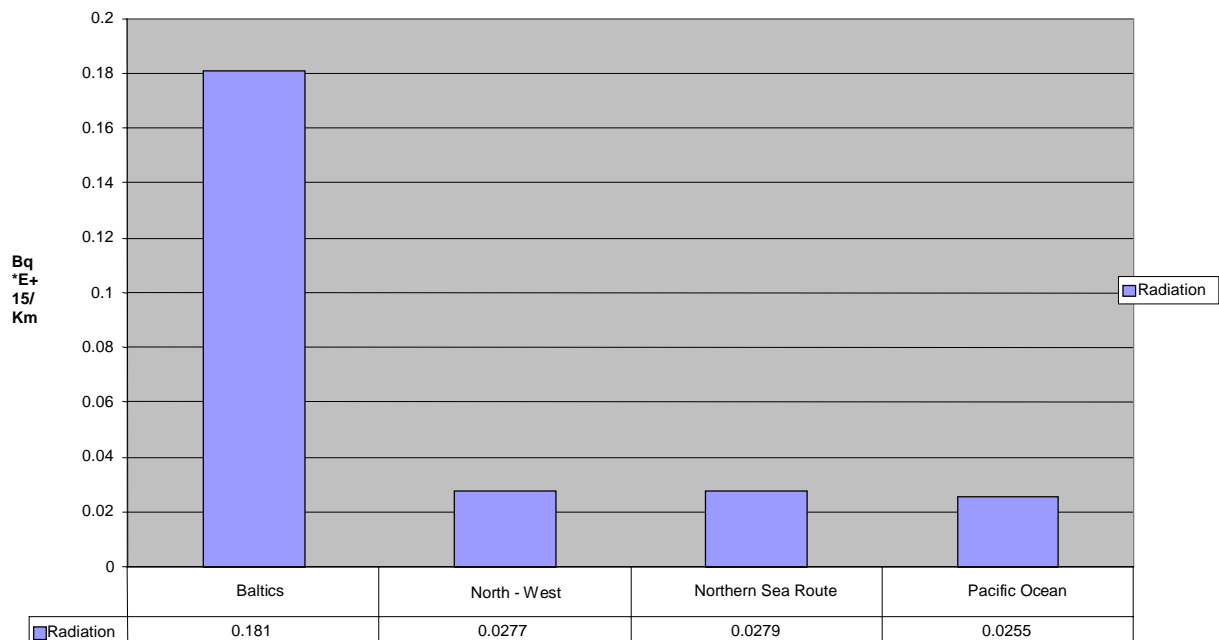


Diagram 3

Estimated ratio: population / 1 Bq of the RTG activity per region

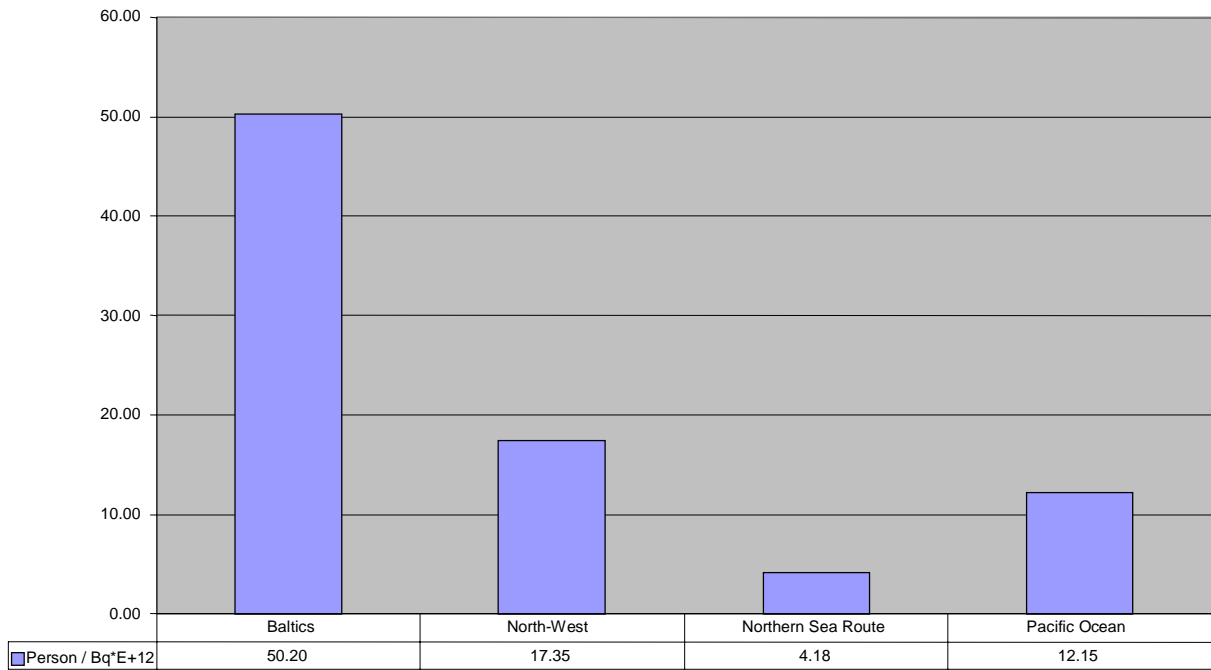


Diagram 4

Regional navigation intensity per month

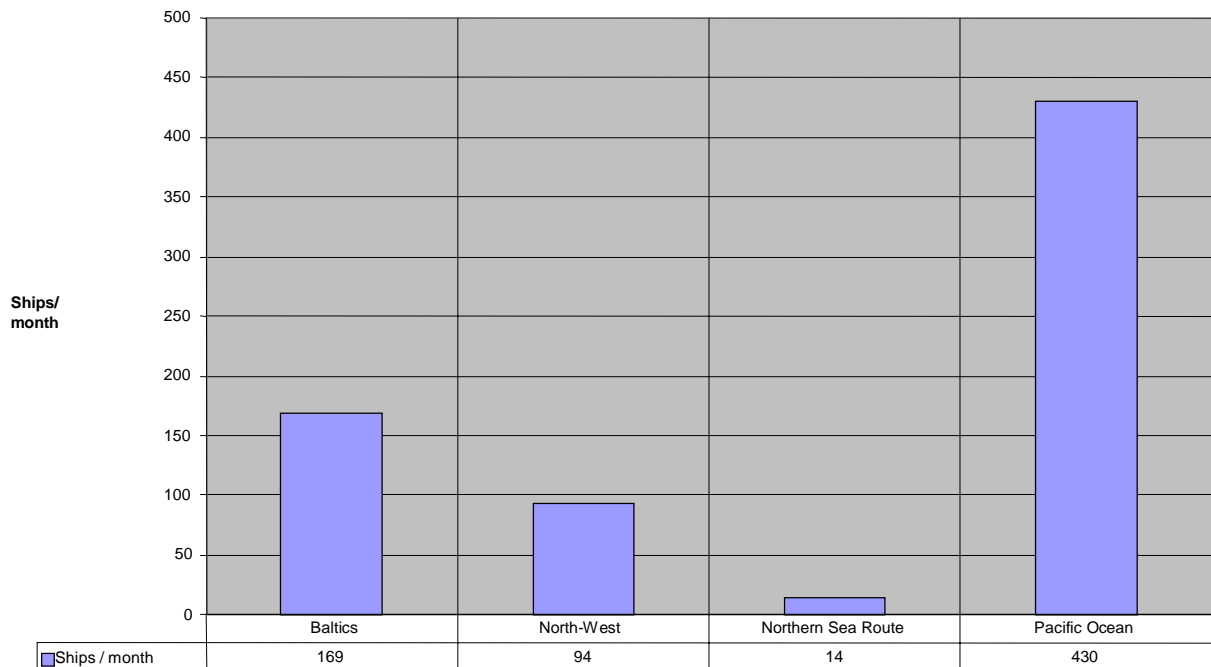


Diagram 5

Estimated number of ships swimming by one RTG per month

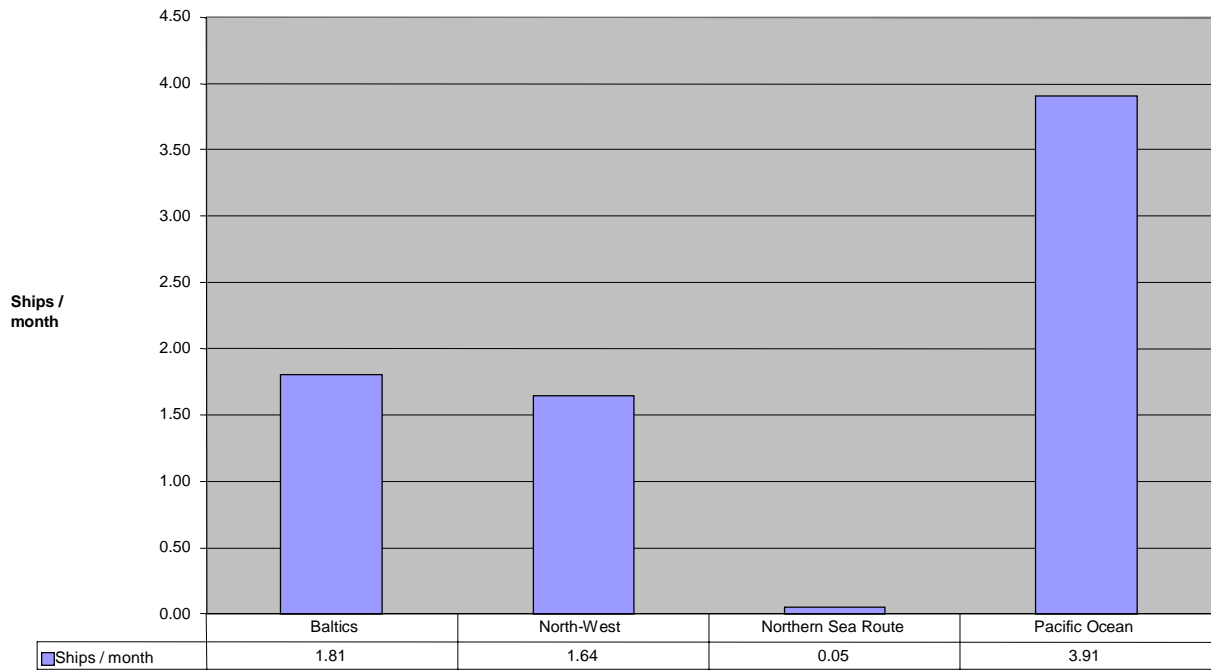


Diagram 6

RTG decommissioning and disposal cost per region

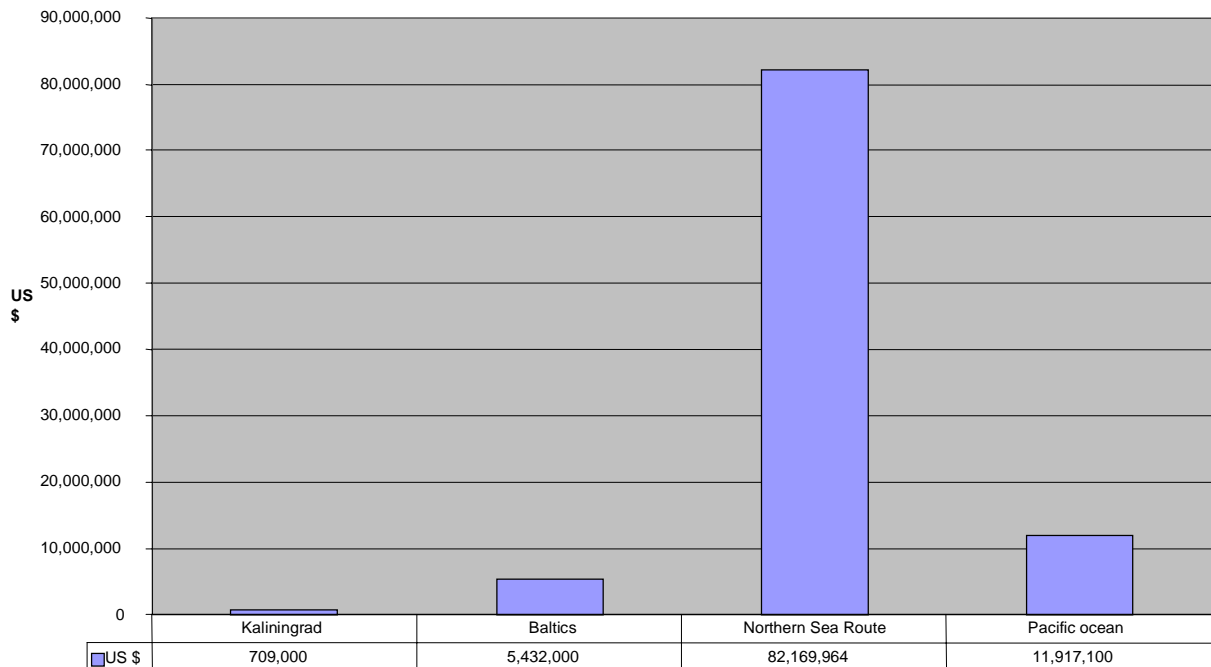


Diagram 7

Estimated cost of the RTG decommissioning and disposal at different stages at 2006 values

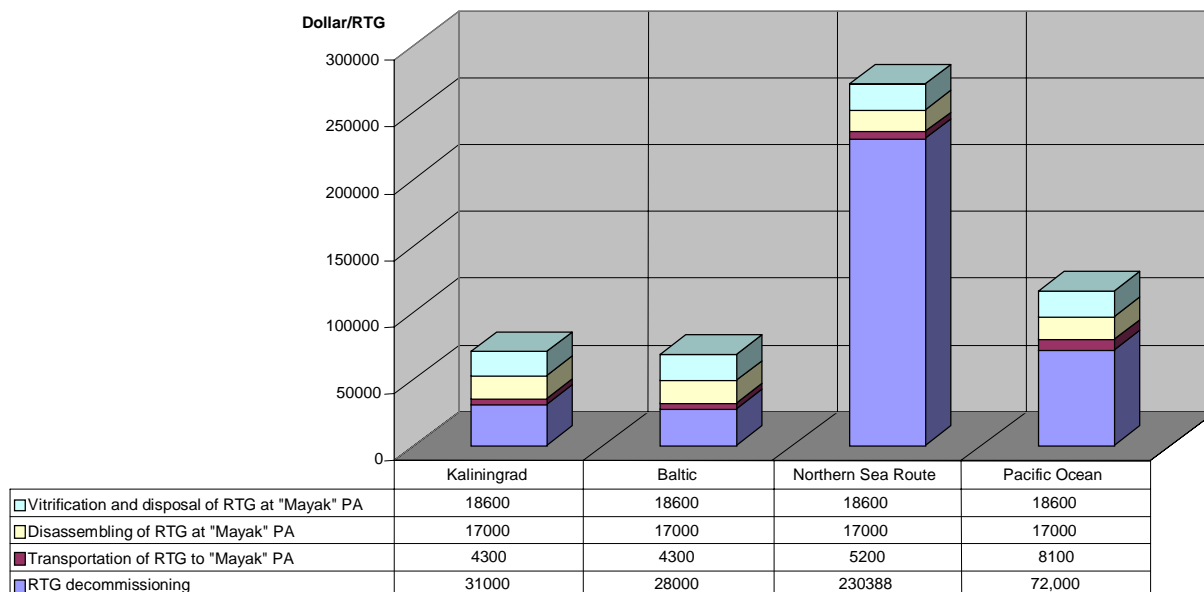


Diagram 8

RTG decommissioning and accumulation progress



Diagram 9

RTG decommissioning and accumulation progress

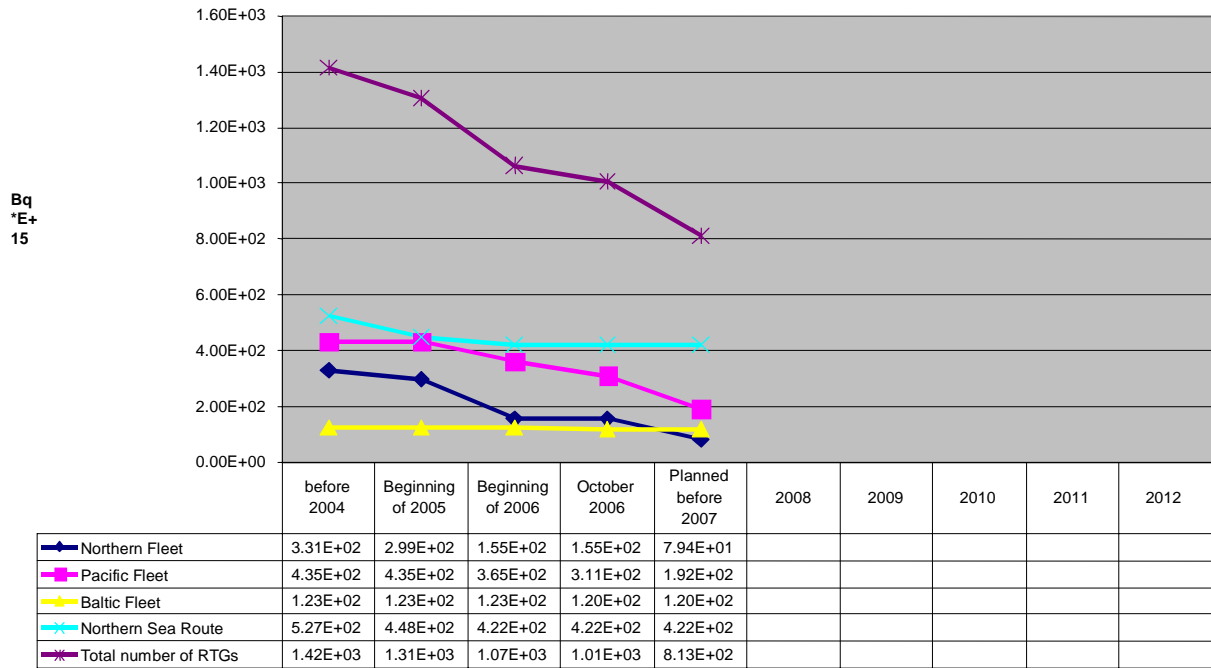


Diagram 10

Decommissioning and replacement of radioisotope thermoelectric generators in the Russian Federation

Working meeting proceedings

April 25-26, 2005

Moscow, Russia

Working meeting on decommissioning and replacement of radioisotope thermoelectric generators of the Russian Federation was initiated and arranged by the Federal Agency of Atomic Energy (Rosatom). Rosatom held the meeting in cooperation with the RRC Kurchatov Institute.

Representatives of such seven countries as Germany, Denmark, Canada, Norway, the Russian Federation, the United States of America, and a representative of NEFCO took part in the meeting.

The goal of the meeting was to determine and specify problems to be addressed in 2005 by the Russian Federation and donor-countries in respect of decommissioning RTGs of the Russian Federation, namely:

- to determine regional tasks selected by each member of the cooperation program for 2005; estimate availability and adequacy of funding sources; inform about contracts concluded with Russian partners (statements of work and due dates for main stages within the frameworks of these contracts);
- to estimate current state of affairs and make forecasts for the end of 2005.

At the working meeting the following presentations were made: on removal and disposal of RTGs operated and stored by enterprises of Mintrans and Minoborony, on replacement of RTGs with alternative power sources, on activities supported by donor-countries in different regions of the Russian Federation. Proposed options of RTGs transportation and technological schemes as well as creation of required infrastructure facilities to provide decommissioning of RTGs were considered. Proposals of the donor-countries relating to their preferable spheres of activities (geographical areas and scope of activity) were also examined.

Now 717 RTGs of various types and years of manufacture are being operated or stored at the sites of Minoborony and Rosmorrechflot.

The RTGs are situated in the four regions:

- Coastal area of the Barents Sea and White Sea. Owner - Minoborony (100 RTGs);
- Along the Northern Sea Route (From the city of Arkhangelsk to the Providence Bay). Owner – Hydrographic Service of Rosmorrechflot of Mintrans (328 RTGs);
- Far East coastal area from Bering Strait to the city of Vladivostok, including Sakhalin and Kuril Islands. Owner – Minoborony of Russia (160 RTGs);
- Islands and coastal area of the Baltic Sea. Owner – Minoborony of Russia (93 RTGs).
- A small group of 36 RTGs is located in the continental regions of Russia – the Krasnoyarsk Territory and Yakutia. Owner – Minoborony of Russia

Based on the results of the presentations discussions, the following conclusions and recommendations were worked out in the course of the meeting:

1. Pace of work on decommissioning of RTGs should agree with the rate of replacement of all decommissioned RTGs with alternative power sources.

2. To collect and provide interim storage of removed RTGs in their transportation cages, as well as to perform loading-unloading operations when transferring RTGs in their transportation cages from boats into special railcars, it is supposed to use premises of the following companies:

2.1. Atomflot Federal State Unitary Enterprise in the city of Murmansk:

- for RTGs evacuated from the Northern Sea Route, until the date when all the problems connected with accumulation and storage of the RTGs in their transportation cages on the premises of the Zvezdochka Federal State Unitary Enterprise are settled;

- for RTGs belonging to the Ministry of Defense and removed from the coastal area of the Barents Sea.

2.2. Depot of the base of the Radiological, Chemical, and Biological Protection Service of the Northern Fleet near the settlement of Roslyakovo:

- for RTGs in their transportation cages belonging to the Ministry of Defense and removed from the coastal area of the Barents Sea. These RTGs should be delivered to the depot by helicopters as external helicopter cargo.

2.3. Zvezdochka Federal State Unitary Enterprise in the city of Severodvinsk:

- for RTGs belonging to the Hydrographic Service of Rosmorrechflot of Mintrans and evacuated from the Northern Sea Route as well as for RTGs belonging to the Ministry of Defense of Russia and evacuated from the coast of the White Sea.

2.4. Radon Leningrad Special Plant in the town of Sosnovy Bor in the Leningrad Region:

- for RTGs belonging to the Ministry of Defense of Russia and removed from the Baltic Sea coastal area.

2.5. DalRAO Federal State Unitary Enterprise in the town of Fokino:

- for RTGs belonging to the Ministry of Defense of Russia and removed from the Far East coastal area, from Bering Strait to Kuril Islands, including Sakhalin Island and Kuril Islands as well as one RTG belonging to the Hydrographic Service of Rosmorrechflot of Mintrans and situated eastward of the settlement of Pevek.

Comment: taking into account extent of the territory, it seems feasible to establish an interim storage site for RTGs on the premises of DalRAO Federal State Unitary Enterprise in the city of Viluchinsk, Kamchatka.

3. It is considered expedient to send RTGs located in the continental regions of Russian directly to the sites for dismantlement and disposal bypassing temporary storage facilities.

4. Before their dispatch RTGs should be specially prepared to meet requirements stated in safety regulations for transportation of radioactive materials NP-053-04.

5. All RHS-90 units extracted from RTGs are to be disposed of only in the territory of the Mayak PA Federal State Unitary Enterprise. The Mayak PA capacity makes it possible to dispose of about 140 RHSs per year (this number could be increased up to 280 RHSs per year).

6. The following additional measures should be taken to provide disposal of the extracted RHSs units in accordance with the proposed scenarios:

6.1. First option. Based on current capacities of the VNIITFA, Atomspetstrans, VO Izotop, Mayak PA and in case of additional funding the following could be performed:

- manufacture of additional transportation containers, like those being at disposal of VNIITFA, to increase their total number from 19 up to 34-36;

- manufacture of new protecting cages for RTGs of various types – 40-50 sets.

Total cost of production - - 350 – 400 thousand dollars.

In this case about 100 RTG could be decommissioned, removed and disposed of in a year.

Dismantlement of all RTGs and disposal of all RHS units could be completed, according to this scenario, by 2011.

Based on the experience accumulated by VNIITFA during the period from 2001 to 2004, implementation of this scenario requires 65 million of US dollars.

Schedule of RTGs decommissioning and RHS-90 units disposal is given in Table 1.

6.2. Second option. In parallel with dismantlement of RTGs at VNIITFA, dismantlement of RTGs is started at Mayak PA (100 RTGs per year).

In this case additional investments are required to upgrade their hot camera and prepare a production sector for dismantlement of RTGs at Mayak PA.

In this case all RTGs could be dismantled and all RHS-90 units could be disposed of by 2009.

Implementation of this scenario requires 68 million of US dollars.

If this scheme is implemented, Mayak PA could dispose of 300 RHS-90 units per year as maximum.

Schedule of RTGs decommissioning and RHS-90 units disposal for this option is given in Table 2.

7. To avoid parallelism and redoubling in financing of RTG dismantlement activities, it is proposed to divide, based on geographical location and type of activity, fields of operation among the donor-countries as it is presented in Table 3.

8. Attention of the participants was attracted to the fact that no one of the donors declared his intention to support work on removal of RTGs located in Western and Eastern sections of the Northern Sea Route and in continental regions. These regions were left out of the cooperation activities zone.

9. To approve proposals and draft concept of the International Coordination Group proposed by Mr. A. Heyes, Chairman of the Contact Group of Experts of IAEA This group is to be created based on the following provisions:

- the group should not be big, it should include 1-2 representatives of each donor-country, total number of the group members should not exceed 15 persons;
- the group should be open for new donor-countries to join it;
- the group should be managed by Rosatom.

Sergei V. Antipov

Deputy Head of the Federal Agency of Atomic Energy

**Table 1: Schedule of RTG decommissioning and RHS-90 units disposal
Option 1**

	Year of dismantlement						
	2005	2006	2007	2008	2009	2010	2011
Number of RTGs to be dismantled at VNIITFA	100	100	100	100	100	100	100
Number of RHS-90 units to be disposed of at Mayak PA	140	140	140	140	140	140	140

**Table 2: Schedule of RTG decommissioning and RHS-90 units disposal
Option 2**

	Year of dismantlement				
	2005	2006	2007	2008	2009
Number of RTGs to be dismantled at VNIITFA	100	100	100	100	
Number of RTGs to be dismantled at Mayak PA			100	100	100
Number of RHS-90 units to be disposed of at Mayak PA	140	140	280	280	140

Table 3: Spheres of activities of the donor-countries supporting RTG decommissioning process

##	Виды деятельности/ Types of activity	Балтика	Баренцево и Белое моря включая Ненецкий АО	Севморпуть	Севморпуть	Дальний Восток	Материк
	Регионы/Regions	Baltic sea	Barents and White Seas including Nenets Autonomous Area	Northern Sea Route (western part)	Northern Sea Route (eastern part)	Far East	Mainland
1	Закупка и установка альтернативных источников/ Purchase and installation of the alternative power supply sources	Дания 3 объекта - США/ Denmark 3 sites - USA	Норвегия/ Norway			Переговоры по пилотным работам США / USA –pilot sites talks	
2	Снятие РИТЭГов с позиций и вывоз их на базы/ Removal of RTGs from their sites and transportation to the bases	НЕФКО Германия 3 объекта - США/ NEFCO Germany 3 sites - USA	Норвегия НЕФКО/ Norway NEFCO		Завершена работа - США/ Work is completed - USA	Переговоры по работам США / USA - talks	
3	Разборка РИТЭГов и захоронение РИТ/ Dismantlement of RTGs and disposal of RHTs	Германия 3 объекта - США/ Germany 3 sites - USA	Норвегия НЕФКО/ Norway NEFCO		Завершена работа - США/ Work is completed - USA		

4	Дооснащение транспортных средств и поставка контейнеров/ Upgrading transport facilities and supply of transportation containers		Канада/ Canada			Завершено 8 контейнеры - США/ 8 containers are manufactured - USA	
5	Дооборудование горячих камер (пунктов разборки)/ Upgrading hot cells (dismantlement sites)	Маяк/ МАУАК ДальРАО/ DalRAO					
6	Оборудование пунктов хранения РИТЭГ/ RTG storage facilities construction (upgrading)		Германия/ Germany	Канада/ Canada			Переговоры по объекту США / USA Site talks

Work in 2005 Summary

As known, more than 1000 radioisotope thermoelectric generators were manufactured in the USSR.

By the end of 2005 there were a number of RTG decommissioning projects actively implemented in the Russian Federation under the international assistance provided by the donor countries to the Russian Federation, namely:

Norway

Since 2001 within the framework of frontier cooperation between the Governor of the Finnmark Province of Norway and Administration of the Murmansk region some projects aimed at the disposal of RTGs and their replacement with alternative power sources at the beacons operated by the Hydrographic Department of the Northern Fleet of the Ministry of Defense of Russia and located in the territory of the Murmansk and Arkhangelsk regions have been successfully implemented. For this period 96 RTGs have been sent for disposal, including 68 RTGs from the Murmansk region and 28 RTGs from the Arkhangelsk region.

For the period from 2001 to 2005 96 RTGs in the Russian Federation had been dismantled under financial support of the Norwegian side, including 5 RTGs through a Norwegian project at the expense of Canada and 2 RTGs at the expense of France. For the same period 65 RTGs had been disposed of. 84 RHS-90 units had been sent for a long-term storage to Mayak PA.

Since autumn 2005 a project for improvement of the regulatory system to provide safety in the course of the RTG decommissioning and recovery has been implemented at the expense of the Norwegian side and under the supervision of Rostekhnadzor.

An agreement on the RTGs of the Barents and White Seas, including Nenetsky and Yamal-Nenetsky Autonomous Areas, was also signed with Norway in 2005.

USA

Since 2003 within the framework of the International Radiological Threat Reduction Program the US Department of Energy has been allocating funds used by Rosatoms's enterprises, RRC Kurchatov Institute and owners of the RTGs (Russian Navy and Rosmorrechflot) to evacuate and dispose of the RTGs that expired their design life.

For the period from 2003 to 2005 under the technical assistance of the USA 115 RTGs had been removed from their operating sites, 115 RTGs had been disposed of, 135 RHS-90 units had been sent to Mayak PA for a long-term storage.

The transportation containers fleet used to transfer the RHSs for disposal to Mayak PA has been renewed and enlarged to support the conducted activities.

A database on the RTGs operating in Russia was created. And now it is being maintained.

Nine alternative power sources based on the solar batteries and wind generators had been developed and tested.

Interagency tests of the monitoring and alarm systems of the RTGs operating in the Baltic region had been conducted.

3 RTGs in the Baltic region, 2 RTGs in the Vladivostok region, and 2 RTGs on Kamchatka peninsular had been replaced with solar power systems.

A pilot wind generator of domestic manufacture was installed at Cape of Karbuz in Cola Bay. This wind generator is operating successfully.

Work on design and construction of interim storage facilities for radioisotope thermoelectric generators in the territory of the coastal technical base in Sysoeva Bay (Vladivostok) and at the site in Viluchinsk (Kamchatka) (DalRAO of Rosatom) was commenced.

Canada

The Canadian side provides financial assistance within the framework of the Norwegian project for decommissioning the RTGs located in the Murmansk and Arkhangelsk regions. 5 RTG were dismantled at the expense of the Canadian side.

Denmark

In 1999 Denmark implemented the first pilot project for replacement of the RTGs located in the Baltic Sea region with alternative power sources. Four sets of solar navigation equipment manufactured in Denmark were placed at the disposal of the Head Department of Navigation and Oceanography (HDNO) of the Ministry of Defense of Russia for pilot testing.

In 2005 Rosmorrechflot of Mintrans commenced testing the four wind generators supplied by the Danish side in 2004.

France

2 RTGs were dismantled at the expense of the French side within the framework of the Norwegian project. France participates in the Norwegian-Russian project (Rostekhnadzor and VO Bezopasnost) on improvement of the regulatory basis to ensure safe evacuation and disposal of RTGs.