

# A study of functions of “The Bank (Thorium Energy Bank)”

**KAMEI Takashi**

*Research Institute for Applied Sciences, 49, Tanaka-Oi-cho, Sakyo-ku, Kyoto, 606-8202, Japan (hae00675@nifty.com)*

**Abstract:** Several approaches are required in parallel for constructing a sustainable society. One of them is to fight against global warming. Nuclear power has been used for peaceful purpose because nuclear power produces electricity without emitting CO<sub>2</sub>. Though nuclear power plant has a possibility of severe accident such as the Fukushima Dai-ichi accident, its advantage is still valuable for the world. Thorium plays an important role for solving global warming. Fertile thorium can be used as nuclear fuel by support of fissionable plutonium-239 from spent uranium fuel. Plutonium-239 obtained from uranium fuel enables implementing 392 GWe of thorium nuclear power. Thorium itself is now obtained as a by-product of rare-earth mining, which is used for high-tech products including photovoltaic cell, wind-mill, and electric vehicle. However, thorium is not taken care of environmental hazard adequately so far. Both to take care of environment and to support implementation of high-tech product, an international framework of storage of thorium will be presented.

**Keyword:** thorium; rare-earth; by-product; storage

## 1 Introduction

From a view of sustainable supply chain of industrial material, the author has been studied about rare-earth<sup>[1]</sup>. Though the usage amount of rare-earth materials is not so large to be around 130 thousand tons per year, they play an important role for the sustainable society. Rare-earth is a group of some element which can be used to enhance characteristics of material such as permanent magnet. This permanent magnet is an indispensable device of electric motor, which is used for electric vehicle as low carbon mobility, and dynamo of wind-mills, which is one of renewable energies. But the problem of supply chain of rare-earth is its by-product, thorium. Rare-earth production is growing these years and as a result amount of thorium as by-product also increases. The author has already proposed a framework to solve this problem as named as “The OREEC (Organization of rare-earth exportation countries)”<sup>[2]</sup>. Main purpose of the OREEC is to establish financial fundamental by collecting treatment fee from final consumers of rare-earth products. In this framework, thorium is separated at a rare-earth refining plant. This separated thorium is stored in “The Bank (Thorium Energy Bank)”. In this paper, functions of “The Bank” will be discussed.

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## 2 Functions of “The Bank”

### 2.1 Over view

As described in the previous paper<sup>[2]</sup>, “The Bank” is a substructure of the OREEC having a role of storing thorium separated at refining factories of rare-earth locating in the member states of the OREEC (Fig. 1).

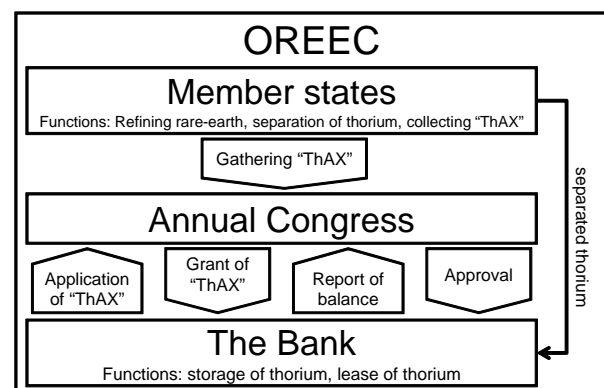


Fig. 1 Relation of “The Bank” in the OREEC.

Member states of the OREEC collect ThAX (Thorium Tax) which is added to sales price of rare-earth products for exportation. This ThAX is used as a financial background for preparing equipment of separating and storing thorium to protect environment as well as to achieve healthy rare-earth market. “The Bank” makes an application to annual congress of the OREEC to use ThAX. The result of usage of ThAX has to be reported to the annual congress.

“The Bank” itself has several functions. The main function is to store materials. The most important item for storage is thorium. Other items will be discussed in the next subsection. Purpose of this function is to protect environment.

The other major function is to lease stored materials. The most important items for lease are thorium and uranium-233 as nuclear fuel. Details will be discussed in the following subsection, too. Purpose of this function is to enhance the ability of protection of environment by giving incentive to keep thorium under control of human activity. Effectiveness of this internalization is described in the previous paper<sup>[3]</sup>.

In order to use thorium as nuclear fuel, it must be prepared as some kind of fuel form before its usage. Thus, “The Bank” has a function of thorium fuel fabrication. This function can be outsourced because thorium fuel fabrication is a profitable activity and relating material flow can follow ordinary balance of demand and supply.

The leased thorium fuel must be returned to “The Bank”. This returned spent thorium fuel contains many elements. In order to extract uranium-233, “The Bank” has a function of reprocessing of spent thorium nuclear fuel. This function can be outsourced, too.

Items stored in “The Bank” are nuclear materials thus inspection is indispensable from a view of non-proliferation. “The Bank” itself does not have this function thus IAEA will provide this ability as done in nuclear nations,

## 2.2 Function of storage

### 2.2.1 Storing items

As mentioned above, the primary item for storage is thorium. This thorium can be leased in some form of nuclear fuel. The spent thorium fuel contains not only remained thorium but also uranium-233 contaminated with uranium-232, fission products (FP) and minor actinide (MA). Even though combination of thorium and uranium-233 is used, small amount of plutonium is produced. Thus this plutonium originated from leased thorium fuel must

be returned and stored in “The Bank”. In the beginning of operation of “The Bank”, only thorium will be stored. Other items become to appear after the use of thorium as nuclear fuel.

### 2.2.2 Ownership of the stored items

In the framework of the OREEC, propriety right of thorium is owned by the OREEC<sup>[2]</sup>. At the same time, the right of use of thorium can be held if the states of the origin of this thorium want to have it. The thorium whose right of use is kept by member states of the OREEC will be tagged to indicate its ownership. This stock is called as “Deposit” as shown in Fig. 2.

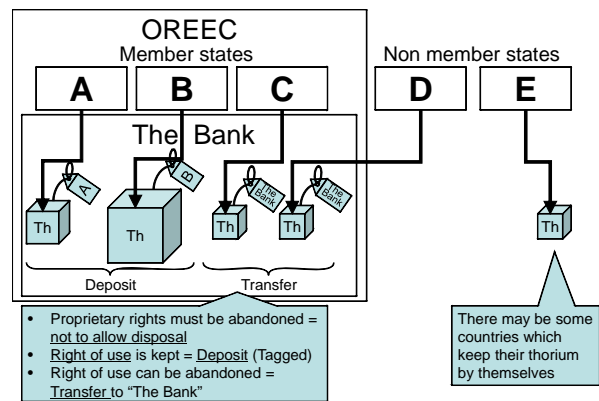


Fig. 2 Ownership of thorium.

If some member state of the OREEC only wants to use the function of storage of “The Bank”, to say, they do not want to keep the right of use of their thorium, the right of use of thorium is transferred to “The Bank”. This stock is called as “Transfer” as shown in Fig. 2.

In order to use thorium as nuclear fuel, some fissile material has to be used simultaneously. Since there is no stockpile of any kind of fissile material in “The Bank” in the beginning of its operation, those countries which want to use thorium of “The Bank” have to prepare some kind of fissile from outside of “The Bank”.

Plutonium obtained from the uranium fuel cycle is one candidate as shown in Fig. 3. This plutonium does not belong to the OREEC. Some part of originally fed plutonium will remain depending on

burn-up condition. This remained plutonium cannot come to "The Bank". Though small amount of plutonium is produced from thorium, it is impossible to separate this plutonium from originally prepared plutonium. Thus, the plutonium existing in the spent plutonium-thorium fuel is sent back to the country of initial plutonium. In other words, the OREEC leaves the ownership of this plutonium.

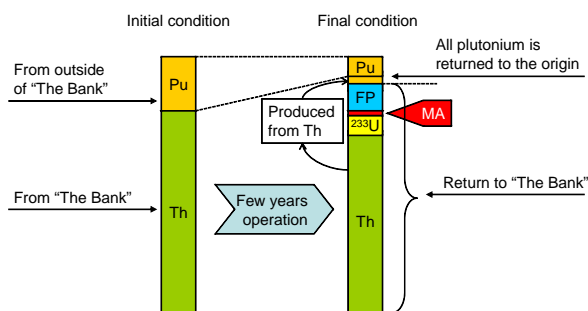


Fig. 3 Ownership of plutonium produced from thorium for the case of combined use with plutonium from outside of "The Bank".

Once thorium is used, uranium-233 is produced. If this uranium-233 is provided together with thorium, small amount of plutonium is produced. In this case, ownership of initially fed materials belongs to the OREEC, thus, the OREEC keeps ownership of this newly produced plutonium. This plutonium is returned to "The Bank" as shown in Fig. 4.

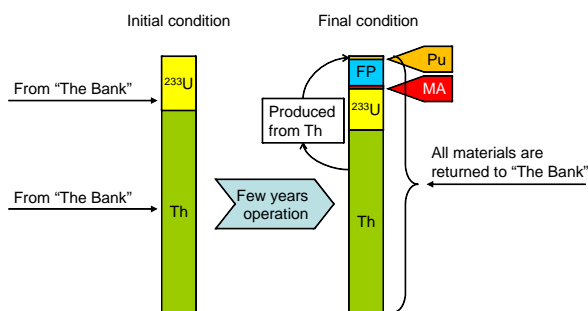


Fig. 4 Ownership of plutonium produced from thorium for the case of combined use with uranium-233 from "The Bank"

In any cases mentioned above, uranium-233 is produced from thorium. Propriety right of uranium-233 belongs to the OREEC. This uranium-233 is treated as interest by thorium use,

thus the right of use of this uranium-233 is not laid on the country which had "Deposit" of thorium.

Other materials such as FP and MA are owned by the OREEC and the right of use of these materials is not given to any country.

### 2.2.3 User of "The Bank"

Member states of the OREEC are allowed to use "The Bank". There are several countries which have stockpile of separated thorium because they refined rare-earth before but do not refine now such as Japan. They cannot be a member state of the OREEC unless they do both refining of rare-earth and its exportation. However, this kind of unused thorium may become a cause of environmental hazard [4]. Thus it is allowed for non-member states of the OREEC to utilize "The Bank". In this case, only "Transfer" is allowed (Fig.2). It means that this country cannot keep the right of use of this thorium. If this country wants to have "Deposit", the country can purchase it in "TRES" (ThoRium EXchange market) which is a trading market of thorium in the OREEC [2].

### 2.2.4 Warehouse of "The Bank"

Warehouse of "The Bank" will be categorized to different 4 types based on items to store as summarized in Table 1. Type 1 stores all materials. Candidate countries of its location will be the U.S., UK, France, Russia and China. This is because type 1 warehouse stores fissile materials including uranium-233 and plutonium.

Table 1 Types of warehouse of "The Bank"

	Th	<sup>233</sup> U	Pu	FP	MA	Candidates of location
Type 1	○	○	○	○	○	U.S., UK, France etc
Type 2	○	×	×	○	○	Countries using thorium
Type 3	○	×	×	×	×	Not using thorium
Type 4	×	×	×	○	○	Only non-fuel material

○: store, ×: not store

### 2.3 Function of lease of stored items

#### 2.3.1 Lease of thorium

There will be countries who wish to use thorium as their nuclear fuel. If they have their own “Deposit” in “The Bank”, they can use these thorium by lease. These countries have to return the thorium and its transmuted materials to “The Bank” because they have only the right of use. Once these countries apply “The Bank” to use thorium, “the Bank” will check how many “Deposit” they have in “The Bank”. If their requirement is smaller than their “Deposit”, “The Bank” will lease the required amount. If the requirement is larger than their “Deposit”, “The Bank” will allocate “Transfer” for their lease. If there is still lack of thorium, “The Bank” will negotiate with other countries which have their unused “Deposit”. If it is allowed, “The Bank” will allocate other country’s “Deposit” to the requesting country. If some lack remains, only available amount of thorium will be leased. Countries that do not have their “Deposit” in “The Bank” are also allowed to use the “Transfer” by lease. Other processes are the same to above. It is not necessary to pay for this lease of thorium (Fig. 5).

Amount of leased thorium will be determined by the corresponding amount of fissile which have to be declared by these countries. The declaration will be confirmed by “The Bank” whether the number is rational or not. This limitation is not to ship excess amount of thorium which may cause disposal to environment.

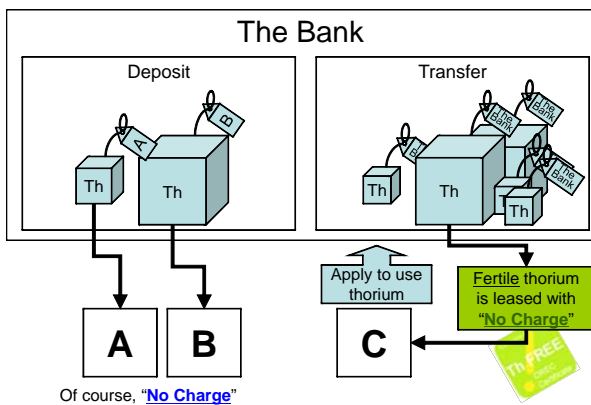


Fig. 5 Lease of thorium from “The Bank”.

#### 2.3.2 Lease of uranium-233

In the beginning of operation of “The Bank”, there is no stockpile of uranium-233. However, once thorium is used, uranium-233 becomes to make stockpile. If a country wishes to use thorium but cannot prepare fissile material outside of “The Bank”, and if there is stockpile of uranium-233 in “The Bank”, this uranium-233 can be leased. On the contrary to the case of thorium, commission fee has to be paid for the lease of uranium-233 (Fig. 6). Primary reason of this commission fee is to prevent from nuclear proliferation. It includes preparing safeguard of shipment of uranium-233. The second reason is to reprocess spent thorium fuel because the return of thorium is still in some form of fuel.

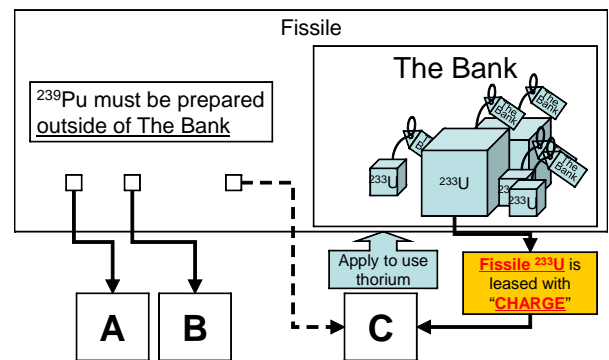


Fig. 6 Lease of uranium-233.

## 3 Conclusion

Functions of “The Bank” are discussed in detail. Thorium obtained as by-product of rare-earth refining can be stored by “The Bank” if countries of rare-earth production want to utilize this function. Proprietary right of thorium must be abandoned in order to hang responsibility of environment protection on “The Bank”. Even in this case, right of use of thorium can be kept to the equity which brings the thorium. This is called “Deposit”. If the equity does not have any plan to use thorium, the right of use can be moved to “The Bank” and this is called “Transfer”.

“The Bank” can lease thorium without payment. Fissile material has to be prepared by the countries which want to use thorium. “The Bank” can lease uranium-233. This is not free because of

non-proliferation purpose. Spent thorium fuel must be return to "The Bank" and stored.

Remaining subjects of "The Bank" such as quantitative evaluation of storing amount of thorium, cost of construction and operation of warehouses will be studied in the future.

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### **References**

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