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FROM: PLEASANT, John Paul: ENERGY FRONTIERS INTERNATIONAL

TO: DR. D.A. BROMLEY

DATE OF  
CORRESPONDENCE: 05/17/92

SUBJECT: HE IS WRITING TO REQUEST A MEETING WITH DR. BROMLEY  
FOR PROFESSOR KAZUO FURUKAWA FROM TOKAI UNIVERSITY,  
JAPAN, REGARDING COMMERCIAL NUCLEAR ENERGY.

\*\*\*\*\*  
DIRECTORATE STAFF  
ASSIGNED: INTERNATIONAL/POLICY ASSIGNED:

ACTION STAFF  
REQUIRED: AS NECESSARY ACTION:

\*\*\*\*\*  
SENDER'S DUE DATE:  
OSTP DUE DATE: 06/01/92 STAFF DUE DATE  
DATE COMPLETED: DATE COMPLETED/DEPT: 6/9/92  
\*\*\*\*\*

COPIES TO: D. Allan Bromley  
PHYSICAL SCIENCES

\*\*\*\*\*

WHITE HOUSE TRACKING #: CONTACT PERSON:  
PHONE: EXT:

REMARKS: DAB, Lee Schroeder met w/ Furukawa on 6/8/92.  
See attached memo.

OSTP RECEIVED: 05/18/92 DEPT RECEIVED:  
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CENTRAL FILES: Nuclear Energy



Energy Frontiers International

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22 MAY 19 13:07

J. PAUL PLEASANT, President

MAIL ROOM

Dr. Allan Bromley  
Assistant to the President  
Science and Technology  
The White House  
Washington, D.C.

May 17, 1992

Dear Dr. Bromley:

It has been suggested by W. Henson Moore, Deputy Chief of Staff to the President that I communicate with your office directly.

Professor Kazuo Furukawa, Institute of Research and Development, Tokai University is one of Japan's leading nuclear physicist. He has taken a public leadership role advocating that Japan, and the world, avoid the production of plutonium in the utilization of commercial nuclear energy.

Professor Furukawa is the leading exponent of THORIMS-NES, an Accelerator Molten-Salt Reactor concept utilizing thorium. This concept will require a close cooperative effort with the Oak Ridge National Laboratory.

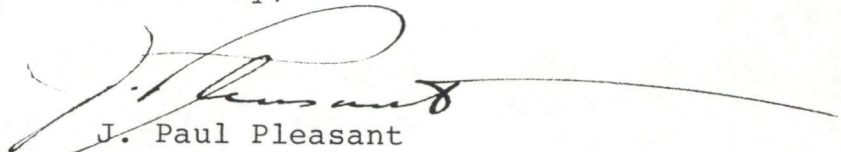
Professor Furukawa will visit the United States in June and has expressed a strong desire to meet with you, or staff, in Washington, D.C. on June 10 or 11.

Enclosed are copies of recent correspondence. The correspondence reflects a developing international interest in this nuclear energy project.

I believe it is most important to the long-term interests of the United States that Japan avoid an energy future based upon plutonium dependence. I strongly urge that Mr. Furukawa be granted a personal opportunity to discuss his vision of Japan's energy future.

Please advise if this meeting can be scheduled.

Sincerely,

A handwritten signature in dark ink, appearing to read "J. Paul Pleasant", with a long horizontal flourish extending to the right.

J. Paul Pleasant

President,

ENERGY FRONTIERS INTERNATIONAL



*International Specialists' Meeting on Potential of Small Nuclear Reactors  
for Future Clean and Safe Energy Sources  
October 23-25, 1991*

## **Flexible Thorium Molten-Salt Nuclear Energy Synergetics**

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### **Abstract**

The new global fission industry for the next century should solve perfectly and simultaneously the following all issues: (A)resources and environmental problems, (B)safety, (C)nuclear-proliferation and -terrorism, (D)breeding fuel-cycle, chemical processing and radio-wastes including their incineration, and (E)social acceptability and economy, including "North-South" problems. One of the most promising flexible systems to solve the above would be the Thorium Molten-Salt Nuclear Energy Synergetics[THORIMS-NES] depended on the isolation of fissile-producers and power-stations, allowing the smaller stations .

### **1. INTRODUCTION - GLOBAL ENERGY STRATEGY IN NEXT CENTURY**

The next 21st century will be a transient period from fossil fuel age to nuclear energy, as the global and especially local climate could not accommodate the excess heat emission more than 0.1% of solar input to globe. [The heat-emission type energy technologies will not be used as major ones in the 22nd century.]

If it might be accepted that the future global energy trend would be shown by the rational prediction of Marchetti [1] as shown in Figure 1, the total energy production by fission industry will amount to about 900TWe·year in the period of 200 years between 1965 and 2165, as shown in Figure 2 in absolute scale assuming the yearly growth rate of 2.3%.

This is 450 times larger than the past nuclear energy production of 2 TWe·year, and could not be replied not only by



latter reasons are as follows [2,3]:

- [I] low breeding power to climb up the steep curve of Figure 2: the real design requirement on the doubling-time of fissile breeding should be 5~8 years,
- [II] low flexibility in power-size: large sophisticated high-performance breeders will be refused, and
- [III] handling and transportation of a huge amount of Pu such as  $1 \sim 4 \times 10^4$  tons in LMFBR.

Now the strategy should be prepared rationally solving the following issues all: (A)resource and environmental problems, (B)safety, (C)nuclear-proliferation and -terrorism, (D)breeding fuel-cycle, chemical processing and radio-wastes, and (E)public and institutional acceptability and economy, including "North-South" problems. This would require a technological revolution or a new philosophy.

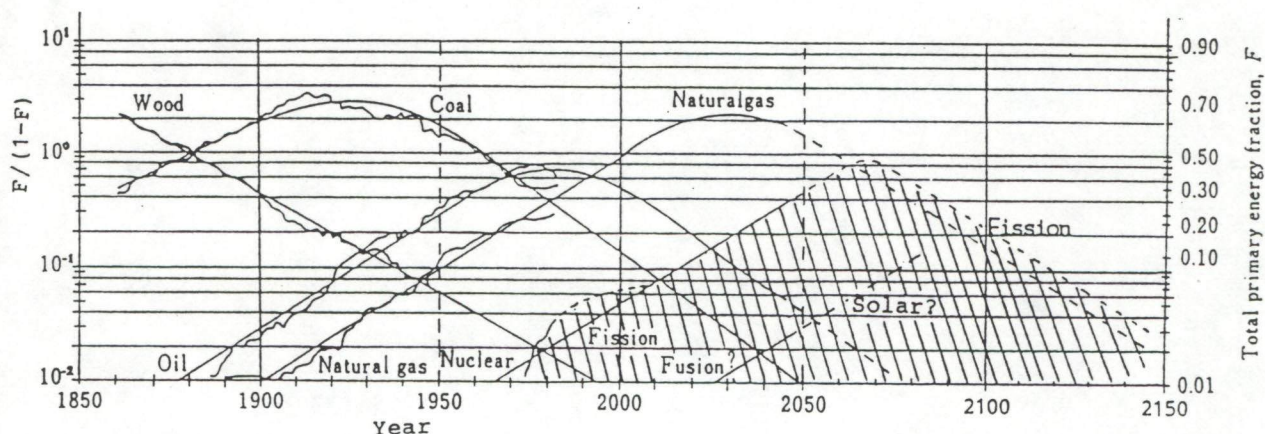
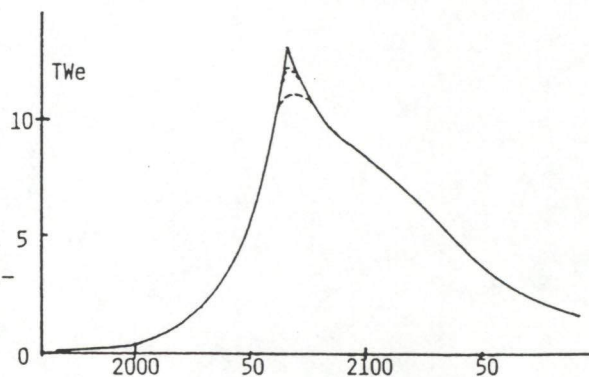


Figure 1. Historical trend in energy substitution of the world. [The amount of primary energy is plotted as fraction "F" of the total energy market [1]. The dotted curve of nuclear(fission) energy is added by authors.

Figure 2. Global energy production by fission industry, depending on Figure 1 and the yearly growth rate of 2.3%.





## 2. NEW NUCLEAR ENERGY STRATEGY -- THORIMS-NES --

Depending on the pioneer work of ORNL on the molten-fluoride fuel concept [4], a new philosophy: THORIMS-NES [Thorium Molten-Salt Nuclear Energy Synergetics] has been proposed by our group in recent [2,3].

### 2.1. New philosophy

Originally ORNL had aimed to establish the MSBR [Molten-Salt Breeder Reactor] in 1947~1976. However, MSBR has three difficulties: (i) inherently large power-size, (ii) troublesome core-graphite exchange, and (iii) very hard development of continuous chemical-process facility. These difficulties all could be overcome by our THORIMS-NES, which depends on the following three principles:

[I] Thorium utilization: refusing to use U resource and Pu,  
[II] Molten-salt fuel concepts: in practice, the "Flibe ( $\text{LiF-BeF}_2$ ) base molten-fluoride" concept should be applied, which has already established the sound technological basis by the brilliant long effort of ORNL people, USA, throughout 1947~76. It grounds on the successful operation of MSRE (Molten-Salt Reactor Experiment) and on their intense R&D works on MSBR (Molten-Salt Breeder Reactor) [4,5].

[III] Separation of fissile-producing facilities [MSB: Molten-Salt Breeders] and power stations [MSR: Molten-Salt Reactors]: now MSR is not a "breeder" such as MSBR.

This will be effective to establish the essential improvements in the above five (A) (E) issues, as explained in below.

### 2.2. What is the THORIMS-NES ?

For example, the Small Molten-Salt Power Station (MSR) of 350 MWth (155 MWe) named FUJI-II [cf. Figure 3 & Table 1] has the following performance [6,7,8,3]:

(a) fuel self-sustaining characteristics, which means practically the conversion ratio of 1.0 [in situ]. The amount of initial inventory and additional in transient stage is also excellently small, which means the best partner of MSB. It results a very few fuel transportation only.

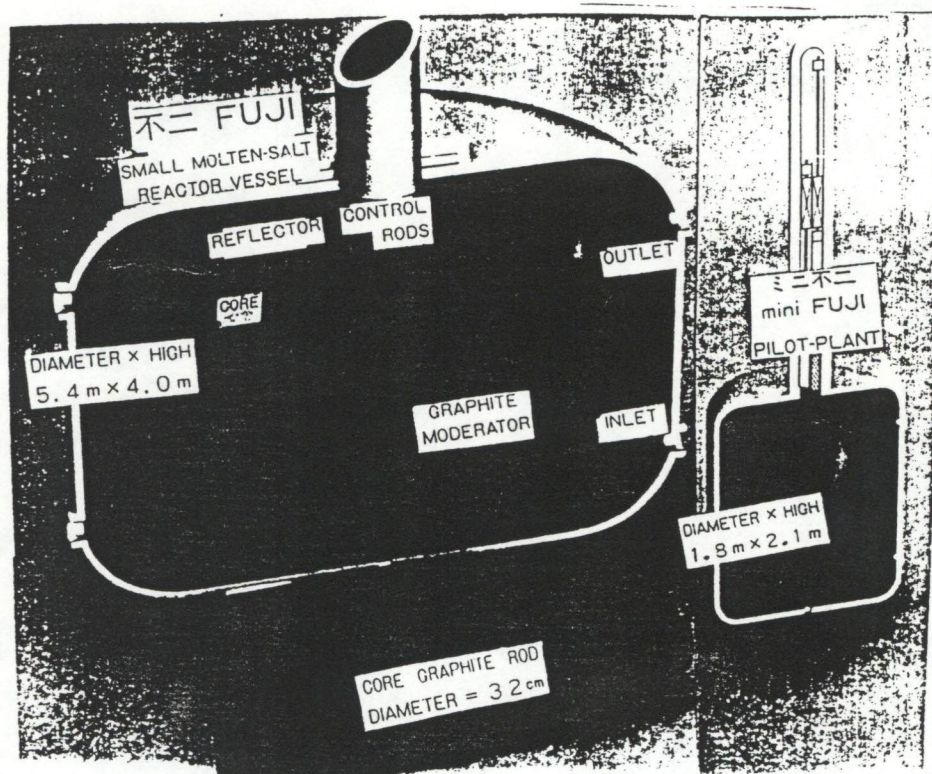
(b) simple structure, easy operation and maintenance works enhancing its safety and economy, because of (i) no opening of reactor-vessel, (ii) no fuel assembly fabrication, (iii) no fuel-processing in full life except the removal of Kr, Xe and T, achieving the burn-up of 500%, (iv) nearly no control-rod due to the very low excess reactivity, and (v) essentially no Trans-U elements (TRU). This system is practically effective for TRU-incineration and anti-terrorism.

Already, the following three types of MSBs were proposed:

- (1) Accelerator Molten-Salt Breeder (AMSB): by the neutrons generated from spallation reaction of Th nuclei in molten-salt target/blanket with 1 GeV protons [9,10].
- (2) Impact Fusion Molten-Salt Breeder (IFMSB): applying new ideas of axially symmetric mass-driver and shaped-projectile accommodating DT-pellet [11], and



(3) Inertial-confined Fusion Hybrid Molten-Salt Breeder (IHMSB): adopting the first wall of molten-salt waterfall for the elimination of radiation damage [10]. Its development is much easier than the pure fusion plant.



**Figure 3.** Vertical cross-sectional view of reactor-vessels "FUJI-II" and "miniFUJI-II" in same scale-sized models. (About 90 volume % in reactor vessels is occupied by graphite.)

These systems are designed promising the preparation of the target salt in high  $^{233}\text{UF}_4$  content (0.5~0.7mol%), which can be supplied directly to the fuel-salt tank of FUJI-series MSR fueled in low  $^{233}\text{UF}_4$  content (0.2~0.3mol%). A schematic flow of fuel-salt is shown in Figure 4.

They could be developed until 2010~2030 due to the recent rapid development of related technologies. AMSB will be the



Table 1. Main parameters of several small Molten-Salt Reactors

|                                                  | standard power station<br>(fuel self-sustaining)<br>F U J I-II | denatured-U fueled<br>(20% <sup>235</sup> U)<br>F U J I-V | pilot-plant<br>(super-compact)<br>miniFUJI-II | experimental reactor (ORNL)<br>(operated in 1965~69)<br>M S R E |
|--------------------------------------------------|----------------------------------------------------------------|-----------------------------------------------------------|-----------------------------------------------|-----------------------------------------------------------------|
| heat capacity (MWth)                             | 350.                                                           | 250.                                                      | 16.7                                          | 7.3                                                             |
| electric power (netMWe)                          | 161.                                                           | 100.                                                      | 7.                                            | --                                                              |
| thermal efficiency(%)                            | 46.                                                            | 40.                                                       | 42.                                           | --                                                              |
| reactor size (m)<br>(diameter x high)            | 5.5x 4.1                                                       | 5.0x 3.9                                                  | 1.8x 2.1                                      | 1.45x 2.2                                                       |
| high temp. containment                           | 12. x 8.                                                       | 11. x 8.                                                  | 3.7x 3.2                                      | 5.8 x 7.2)                                                      |
| fuel: conversion ratio                           | 1.002                                                          | 0.91?                                                     | 0.58                                          | ---                                                             |
| <sup>233</sup> U inventory(kg)                   | 370.                                                           | <sup>235</sup> U=340. ?                                   | 27.                                           | 32.                                                             |
| <sup>232</sup> Th (ton)                          | 20.1                                                           | 16.3                                                      | 0.65                                          | ---                                                             |
| fuel salt: <sup>233</sup> UF <sub>4</sub> (mol%) | 0.22*                                                          | <sup>235</sup> UF <sub>4</sub> =0.25?                     | 0.47*                                         | 0.14                                                            |
| total volume (m <sup>3</sup> )                   | 13.7                                                           | 11.1                                                      | 0.45                                          | 2.1                                                             |
| flow rate (m <sup>3</sup> /min)                  | 33.2                                                           | 33.0                                                      | 1.59                                          | 4.5                                                             |
| temperature (C)                                  | 585→725                                                        | 565→655                                                   | 560→700                                       | 632→654                                                         |
| main piping (inn. dia. cm)                       | 25.                                                            | 25.                                                       | 8.                                            | 15.                                                             |

(\*)  ${}^7\text{LiF} - \text{BeF}_2 - \text{ThF}_4 - {}^{233}\text{UF}_4 = (72-x) - 16 - 12 - x$  [mol%]

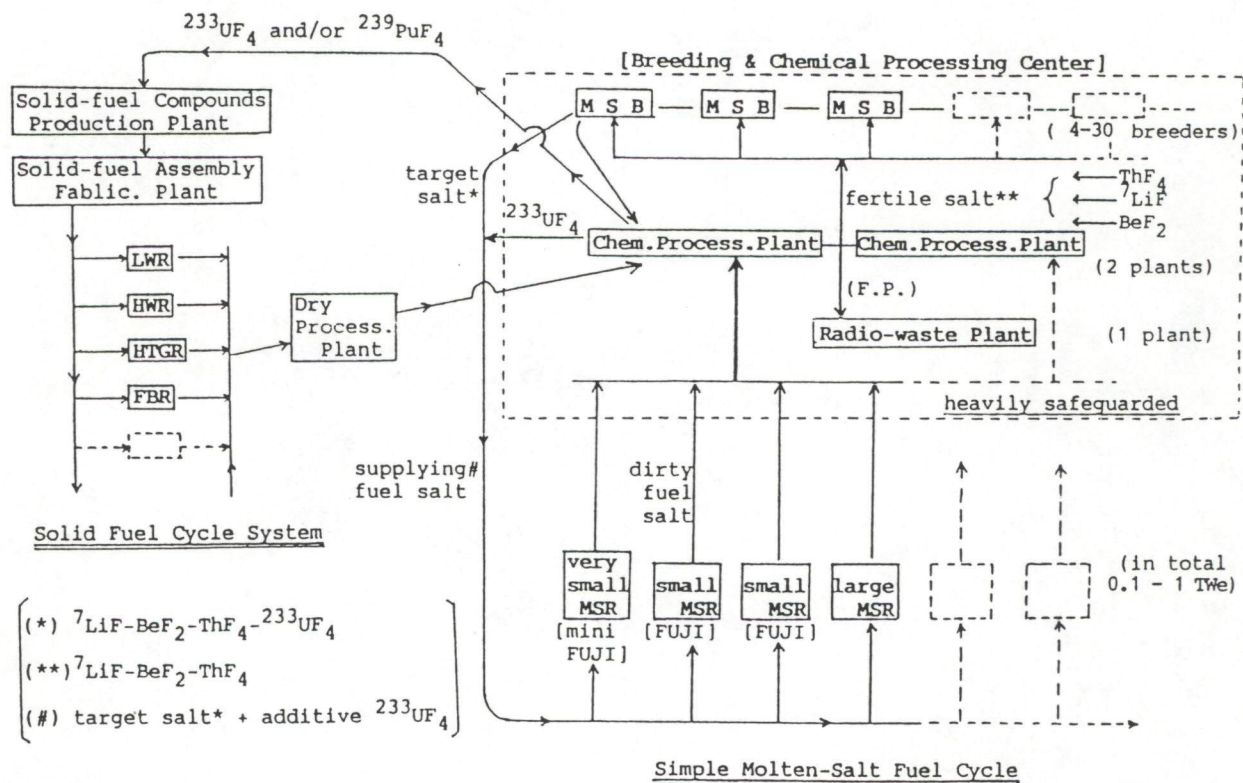


Figure 4. Molten-salt breeding fuel-cycle in THORIMS-NES composed of fissile-producers [MSB] and power stations [MSR].



most practical and promising concept including the reactor-chemical behaviors. However, IFMSB might become a "dark horse" in some case[9,3].

### 3. Significant characteristics of THORIMS-NES

The significant improvements in the above (A) ~ (E) issues will be briefly explained in belows:

#### 3.1. (A) Resource and environmental problems

At least, the nuclear industry has to contribute to the triangle-shaped energy share of about 900TWe·year as shown in Figure 1, suppressing the CO<sub>2</sub>, SO<sub>x</sub> and NO<sub>x</sub> emissions.

The Th resource is already confirmed more than 4 Mton, and never be monopolized. However, the full application of THORIMS-NES in the world, the total consumption of thorium will require only about 2~3 Mton Th (its about 30% will be fissioned), in contrast with 4~5 Mton Th in MSBR or with 140~180 Mton U in LWR system. This might introduce great advantages in the issues of resource, radiowaste and ecology.

#### 3.2. (B) Safety

In the normal condition, FUJI(MSR) is easy in operation with the following performances: (i)no need of fissile supply in life, (ii)self-controllable, (iii)load-followable, and (iv)very few maintenance work such as fission-gas and tritium removal, and slight addition of Th in about once per week.

In the accidental cases of FUJI, the supposition of "SEVERE ACCIDENTS" is very difficult. The full stop of fuel-salt flow means only a graphite temperature increase of about 500°C not requiring any control-rod function. A large leak of fuel-salt by the fracture will not result any "core-meltdown" or "recriticality", by the isolation of fuel and moderator [3].

Radioactivity is triple-confined by reactor-vessel, high-temperature containment, and reactor-containment. Even in the case of reactor destruction by military or terrorists' attack, it will be safer than any other reactor systems depending not only on the stationary removal of gaseous radio-activities from fuel, but also an easy suffocation-extinguishment of graphite fire without disturbance of fuel-salt [3,12]. [It will not be easy in the Modular Gas-cooled Reactors.]

#### 3.3. (C) Nuclear-proliferation and -terrorism

The social safety and especially anti-terrorism will become more important issue in the next century. If U breeding system would be deployed in the coupling of LWR & LMFBR following a conventional policy, the world has to handle the Pu in the amount of 11 and 28 Kton in the age of 2036 and 2050, respectively [3], which would be fatal for globe [13,14].

In Th breeding system, essentially no TRU(Pu, Am, Cm) will be generated, and THORIMS-NES is the most effective and practical system for their incineration [cf.(D)]. In THORIMS-NES, the



$^{232}\text{U}$  concentration in  $^{233}\text{U}$  fuel will become more than 500ppm [2] (30 times richer than that in MSBR), and fatal for terrorists (robbers) due to the strong 2.6MeV gamma-ray from  $^{208}\text{Tl}$ , the daughter of  $^{232}\text{U}$ .

In the transient stage before maturing the THORIMS-NES, FUJI-V fueled by denatured-U would be valuable(cf.sec.5).

### 3.4.(D)Breeding fuel-cycle, chemical processing and radiowastes

In the present nuclear technology, the once-through handling of fuel will be most economical. However, in the future, the complete fuel reprocessing is essential not only for establishment of breeding fuel-cycle but also for public acceptance. The Flibe-based molten fluoride fuel system will be the best system for the above purposes, and now will be able to establish the rational managements of "Radio-waste", which depend on the principles of "minimization of reprocess-steps and maintenance-works" and "full utilization of irradiated fuel materials" [15], as follows:

( cf.sec.3.1].

(ii)high-level waste: TRU will be 3 order of magnitude less than the amounts in U-Pu system, and essentially they are staying in fuel-salt as a fissile or fertile species.

(iii)low level waste: maintenance and chemical processing works in proper are very few, resulting a significant minimization of low-level waste in the order of 1/100 comparing with the case of present nuclear facilities.

(iv)graphite waste: fairly big amount of core and reflector graphite waste will be produced. However, the plate-out radio-activity on graphite will be removed for reuse by peeling 0.5mm in depth, diminishing the radio-waste [4]. The preliminary estimation on the total amount of final graphite waste is about 8 10 Mton. [MSBR will produce 30 Mton graphite waste.]

(v)structural materials [Hastelloy N]: induced radioactivity from the maximum irradiated reactor-vessel alloy will be reduced to 0.3 rem/hr/ton in 1 year after reactor shut-down [16]. It will mostly come from 0.871 & 0.703 MeV gamma of long life  $^{94}\text{Nb}$  [half-life:  $2.03 \times 10^4$  year]. However, it might be reused by the vacuum-remelting with the low contaminated alloy.

(vi)incineration of long-life Fission-Products: F.P. of half-lives longer than 30 years coming from own and other reactors might be easily incinerated in THORIMS-NES [3,15]:

(a) in the form of molten fluorides:  $^{129}\text{I}$ ,  $^{135}\text{Cs}$  and  $^{151}\text{Sm}$  by MSR or MSB, and  $^{90}\text{Sr}$ ,  $^{93}\text{Zr}$ ,  $^{126}\text{Sn}$  and  $^{137}\text{Cs}$  by MSB;

(b) in the metallic form casing in graphite, for example:  $^{59}\text{Ni}$ ,  $^{63}\text{Ni}$ ,  $^{94}\text{Nb}$  and  $^{99}\text{Tc}$  by MSR or MSB, and  $^{107}\text{Pd}$  by MSB.

(vii)incineration of TRU: TRU are valuable fissile or fertile isotopes, and should be effectively utilized as fissile fuels but not reproducing TRU. For this purpose MSR will be the best facility. In practice, a modification of FUJI-II named FUJI-IV[12] has been proposed, in which about 1/3 of  $^{233}\text{U}$  is replaced by TRU of 100~200 Kg, and fertile  $\text{ThF}_4$  is decreased to



8 mol% from 12 mol% resulting in the fissile shortage, which is supported by the further addition of TRU in burning rate of about 50 Kg/year. In this design it seems that any technological difficulties do not exist due to the following reasons:

- (a) TRU fluorides are stable trivalent and enough soluble in fuel-salt, not requiring any special pure separations;
- (b) Their incineration can continue more than 20 years among reactor-life, not same as 1~2 years in solid-fuel reactors, not producing any additive(induced) radioactivity, and not requiring any additive R&D.

### 3.5.(E)Public and institutional acceptability and economy, including "North-South" problems [3,12]

Excellent public acceptability will be expected from [a]high safety, [b]rational radio-waste management, [c]high resistance to nuclear-proliferation and -terrorism, [d]very few load-transportation of nuclear materials, [e]low thermal pollution, and [f]characters in proper suitable for utility facilities.

Institutional acceptability also will be enough due to the following reasons: [i]flexible capacity choice including smaller power stations, [ii]easy siting: accessibility to consumers, [iii]easy operation and few maintenance work, [iv] possibility of process-heat and district-heat supply.

These advantages will encourage its distribution to the developing countries area. This will be enhanced by the excellent economy due to the simple fuel-cycle system. The expected low cost of R&D is also significant as explained in below.

## 4.DEVELOPMENTAL PROGRAM

The basic technology of molten fluoride fueled reactors including material-compatibility problems has been prepared by the intense R&D study of ORNL in 1947 1976. After confirming them, the first step might be the development of Small MSR.

In the development of small MSR, the following "simple and rational nature" of MSR technology should be recognized [3,12]:

[A] no need of fuel irradiation test, due to no radiation-damage,

[B] simple chemistry ---high theoretical predictability of physico-chemical behaviors of fuel-salt, including structural-materials compatibility [5,3],

[C] simplicity in configuration, operation and maintenance: (i)no core-graphite exchange: no opening of the reactor-vessel; (ii)fuel self-sustainable, reactor self-controllable and load-following characters ---nearly no control-rod; and (iii)no need of sophisticated continuous chemical process facility,

[D] commercialization from the small reactors in the first step for maturing the new MSR technology, which means (i)the low capital cost in smaller ones, (ii)straight application of excellent experience of "MSRE", successfully operated throughout 4 years in ORNL, (iii)few additional R&D items, and (iv)not competition with the proven large Solid-fueled Power Reactors.



[E] wide applicability of Liquid-Na Reactor-Components development results, with the three advantages of MSR technology on the chemical inertness, low thermal shock and no oxidized vapor condensation comparing with Liquid-Na technology.

These MSRs might keep an excellent performance as effective partners of Fissile-producing MSBs in order to establish the practical THORIMS-NES all over the world including the developing countries and isolated areas.

In parallel, MSBs, especially AMSB could be developed by the rational step-wise increase of the proton-current among 20 years not expecting any big difficulties except a beam injection-plant technology.

As a practical first step, a pilot-plant named miniFUJI-II (16.7MWth, 7MWe) was proposed [7,3], which would be promising as a similar-size one as MSRE except electric generation. However, an alternative simpler 10 years' plan FUJI-V has been proposed for replacing the 12~15 years' plan of miniFUJI-II & FUJI-II [3].

*and enriched -*

## 5. FUJI-V PROJECT FUELED BY DENATURED-URANIUM

THORIMS-NES is strongly protective for nuclear-proliferation and -terrorism as explained, and the supply of initial  $^{233}\text{U}$  fuel will be also feasible [2,3]. However, as an alternative approach before maturing THORIMS-NES, the denatured-U fueled MSR might be considered, refusing any weapon materials [13,17].

In FUJI-V (cf.sec.3.3) the initial and additive fissile supply are 20% enriched-U ( $=20\%^{235}\text{U} + 80\%^{238}\text{U}$ ), and has been modified to simplified design and lower performance than FUJI-II as shown in Table 1.

The significant characteristics of FUJI-V are as follows: (a)much improved resistance for nuclear-proliferation and -terrorism, (b)still essentially  $^{233}\text{U}$  reactor, because Pu is only about 10% of fissile in final stage of life, (c)easier in thermal design in reactor-core, and (d)higher economy in plant-cost and power-cost.

## 6.CONCLUSIONS

In the next century, the further increase of fossil fuel utilization would not be acceptable, and the new-proposal : THORIMS-NES depending on the "molten fluoride" technology seems to be most promising for global application in huge-scale, considering all technological, social and ecological issues. The effective investment to this new "Energy Industry" will contribute to create a cultural healthy society solving "North-South" problems, because in near future the biggest problem in the world is the shortage of capital.

This would be one of the most practical replies to the Lilienthal's appeal of "A NEW START" in Nuclear Energy by encouraging "a revival of positive and affirmative fighting



spirit" of scientists and engineers [18].

#### [Acknowledgments]

The authors wish to express sincere thanks to many friends of USA, France, USSR, India, Switzerland, Canada, Germany, Belgium, Japan and the other countries for their kind cooperation and encouragements. A part of this work has been done by the Grant-in-Aid for Scientific research of the Ministry of Education, Science and Culture, Japan.

#### [REFERENCES]

- 1 C.Marchetti & N.Nakicenovic, RR-79-13, IIASA, 1987; Nucl.Sci. Eng., 90(1985) 521.
- 2 K.Furukawa, K.Mitachi, K.Minami & Y.Kato, Alternative Energy Sources VIII (T.N.Veziroglu, Ed.) vol.2, pp.3-22, Hemisphere Pub., 1989.
- 3 K.Furukawa, A.Lecocq, Y.Kato & K.Mitachi, J.Nucl.Sci.Tech., 27(1990) 1157.
- 4 M.W.Rosenthal, P.N.Haubenreich & R.B.Briggs, Devel. Status of Molten-Salt Breeder Reactors, ORNL-4812 (1972).
- 5 J.R.Engel, W.R.Grimes, H.F.Bauman, H.E.McCoy, J.F.Dearing & W.E.Rhoades, ORNL/TM-7207 (1980).
- 6 K.Furukawa, K.Minami, T.Oosawa, M.Ohta, N.Nakamura, K.Mitachi & Y.Kato, Emerging Nuclear Energy Systems (G.Velarde et al., ed.) p.235, World Science, 1987.
- 7 K.Furukawa, K.Minami, K.Mitachi & Y.Kato, Proc.Joint Int. Sympo.Molten Salts, Proc.Vol.87-7(1987) 896, Electrochem. Soc..
- 8 K.Mitachi, K.Furukawa, K. Minami, Y. Kato, J.Atom. Ene. Soc.Japan, 32(1990) 377(in Japanese).
- 9 K.Furukawa, K.Tsukada, & Y.Nakahara, J.Nucl.Sci.Tech., 18(1981) 79; K.Furukawa, Altern.Ene.SourcesVII (T.N.Veziroglu, ed.), vol.3, 353, Hemisph., 1987; K.Furukawa, et al.: Proc.1st Int. Sym. M.S.Chem.Tech., p.399, 406, 409, 497, Kyoto, 1983.
- 10 K.Furukawa, Atomkern.Kerntech., 44(1984) 42.
- 11 K.Ikuta, & K.Furukawa, Proc. Joint Int..Sympo.Molten Salts, Proc.Vol. 87-7(1987) 906, Electrochem.Soc..
- 12 K.Furukawa, K.Kato, K.Mitachi & A.Lecocq: Proc.Indo-Japan Seminar on Th Util.(Bombay, Dec., 1990).
- 13 A.Lecocq & K.Furukawa, Proc.2nd Workshop Verif.Arms Reduc.(Wien, Sept., 1990).
- 14 A.DeVolpi, Prog.Nucl.Energy, 10(1982) 161.
- 15 K.Furukawa, A.Lecocq, Y.Kato & K.Mitachi, Sp.Meeting Accel.-driven Transmut.Tech Radiowaste & Other Appl., (June, Saltsjobaden, Sweden, 1991).
- 16 T.Noda & K.Furukawa: unpublished.
- 17 K.Furukawa, A.Lecocq, K.Mitachi & Y.Kato, Materi.Sci.Forum, 73-75(1991) 685.
- 18 D.E.Lilienthal, Atomic Energy: A New Start. Harper & Row, 1980 [translated to Japanese by K. Furukawa: Kironitatu-Gennsiryoku. Nihonn-Seisannsei-Honnbu(Japan Productivity Center), 1982].





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Mr. J. Paul Pleasant  
President,  
Energy Frontiers International,  
11472 Ehren St.,  
Lake View Terrace, California 91342  
U.S.A.

9th March, 1992

Dear Mr. Pleasant,

Thank you very much for your letter of 2nd March, 1992 and copies of letters indeed.

I am quite waiting the successes of these actions. Please report me soon by Fax [ 463-58-1203]. I also want to know your Fax number, please.

Could you imagine now Japanese are also quickly understanding our opinion (good for all peoples) among top peoples or opinion leaders.

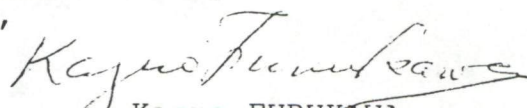
My next essay <sup>was</sup> ~~will~~ be published <sup>day</sup> ~~tomorrow~~ on the leading NewsPaper: ASAHI (5 M copies ?) much discussing on Pu: "Let extinguish the fire of Pu", they chosen this title. On 1st March, timely, Mr. Torii, a Editorial Writer of Japan Economy NP[Nihonn KEIZAI] presented quite clear essay: "New Nuclear Energy Way", quite following our way, he said, and really Ministry Foreign Aff. & Tokyo ELEC. Power Corp. are appreciating these proposal now.

Asahi also wrote a similar editorial on 22th Feb. titled "Re-examine the Pu policy". Therefore I sent them the above second essay.

Tokyo E.P.Co invited me on the end of this January.

I am meeting with Mr. K. Tanigawa, Minister of Sci. Tech. Agency on 10th March. Socialist Party has invited me for a lecture to rebuild their energy policy on 18th March.

Looking forward to seeing you near future,  
Sincerely yours,

  
Kazuo FURUKAWA

P.S. Please tell me your Fax number and the air-port for seeing you.  
(How to go there ?)



## 論点

私たちは、来世紀に向かっている環境およびエネルギー対策を、太陽エネルギーに頼るならば最良と思っている。だが何ぶん密度が低く不規則なので、補助が特殊目的から抜け出すのは困難であろう。

しかも環境対策にもなるように核エネルギーを生かそうとするならば、着実に規模を拡大し来世紀の面において、全世界で喜んで使ってもらえるものでなければならぬであろう。



東海大学教授

お かしわ 和男  
古 川 夫

今の化石燃料時代からこの太陽エネルギー時代への橋渡しをどうするか？ 一部の人は核融合に期待しているらしい。しかし、ITER(国際熱核融合実験炉)の推進者たちも、実用化は四、五十年先という。もし実現して世界エネルギーの二%を供給し始めたとしても、二、三〇%を占めるのは再来世紀初めになってしまう。

許された時間はせいぜい二、三十年にすぎないのであるから、核分裂利用をもつ一度、抜本的に見直してみる必要がある。ただし、資源、安全、核拡散・核テロ、廃棄物、社会適合、経済性のすべて

中に少なくとも七千万から一兆kW・年の電力を生産することが必要である。これでも、化石燃料の使用で増え続ける世界の炭酸ガス放出率は、二〇六五年によつて増勢が止まる程度である。過去の原発発電総量はわずか二億kW・年に過ぎず、その数百倍の生産は、とても既存の軽水炉の改良程度で追いつけることではなからう。ではどうしたらよいのか？

## 今こそ有望な「トリウム」燃料

固まつてきた。しかも前記の課題すべてを解決する見込みがある。安全性に関しては、炉が破壊されても過酷事故(炉心溶融・再臨界など)が想定できないくらい安全である。ガス状の放射能は常に除去されており、事故時に放出されるものはほとんどない。炉内は裸の黒鉛(空間の九〇%占有)とすきまを流れる溶融塩燃料だけから成り、フタなしの単純なタンクが本体である。

核燃料は自給自足されるので、余剰燃料が不要で制御棒なしに出るかも知れない。核燃料の路上輸送は、運転始めと終わりの二度だけでよい。燃料は空気・水と反応しない常圧の最も安定な液体である。冷えれば燃料塩はガラス状に固化し、放射能閉じ込めに最良で、水に溶けない。廃棄物についても、まず一番やっかいな超ウラン素類がほとんど生まれず、燃料をいじり回さないで、低レベル廃棄物を激減できる。

核拡散・核テロ対策では、トリウムの利用によりプルトニウム廃棄物の利用によりプルトニウム廃絶が可能である。トリウムは核分裂性の人工ウラン<sup>233</sup>に変えられて燃やされるのであるが、これは必ず強烈なガンマ線を伴い、テロリストは致死量を浴びてしまう。遮蔽(しゃへい)するには厚さ三十センチの鉛の容器が必要で、簡単に運搬できない。検知・監視はきわめて容易である(従って、燃料は液体にして遠隔操作され、作業員は被ばくをまぬかれる)。

このほか、この炉は小型化できる利点をもつ。既存の大型原発と不必要に競争せず、小型炉から次第に世界に展開していけばよい。技術成熟し、立地に有利である。米・仏・伊などには、かねがね

一刻も早く開発したいという仲間がいる。最近、ロシアの研究所が挙げて共同したいと動き出した。開発途上国でも、現にチェルノブイル災害に懲りて原発を拒否していたトルコ政府機関までが、一緒に検討させてほしいと言つて来ている。インド・インドネシアその他にも熱心な仲間がいる。

このような新しい炉は開発費が大変なうとよく言われるが、逆である。その証拠に、オクリッ

ジでは実にわずかの資金と最高二百人の陣容で、すでに実験炉が立派に運転され、技術基盤はできていのである。最小限の新技術実証には、約十年の年月と国連が今世紀内に必要という環境対策費一兆の千分の一ぐらいがあれば十分と思われる。経済性の高さも十分推察していただけるであらう。

これにはまた、世界が膨大な投資をしながら実用化されていない高速増殖炉用の液体ナトリウム技術が、有効に、しかもより易しく活用できるからである。日本におけるこの技術の基礎は、二、三十年前に筆者らが中心になり、この日のために育てておいた。

第二次大戦後の世界は核戦略の下で動いてきた。それが崩れた今、世界は日夜、核拡散・核テロに震えている。今こそ、今世紀初頭にアインシュタインが開いた核エネルギー技術の真の平和利用を求めて、人類が再出発すべき好機であらう。

(核エネルギー論)



# 論壇



古川 和男

朝日新聞の二月二十二日社説は、「プルトニウム政策を練り直せ」と題し、原子力平和利用の中核を成して来たウラン・プルトニウム核燃料計画の全面的見直しを提案している。これはまことに時宜をえたものである。戦後の国際政治を大きく支配して来た核兵器の大幅削減がまさに現実となっており、また、ちよと日本は原子力委員会が「原子力開発利用長期計画」を五年ぶりに改訂しようとしている時点だからである。ぜひ広く国民が参加して議論すべきであろう。

その際、当面のご都合に引きずられて中・長期への配慮が名か、冷静に考えてみたい。

わが国だけでも、二〇一〇年までに必要な原発七千万ワットの半分くらいしか、立地点の手配が付いていない、と新聞は報じている。環境対策上から

## プルトニウムの火を消そう

事者たちがこれから逃れられないのはよく分かる。現実に関連施設が、核物質が存在しているからである。しかし、だからといって、数十年先までこのままの基本路線をたどれるかどうか、冷静に考えてみたい。

なのはこれではなからうか。テロリストはプルトニウムを持っていなくて活動できる。「持っている」と確言できない時代」だからである。したがって、少なくとも検知の容易な技術に移行させるべきである。それが、ここで訴えたいと思うトリウム・ウラン核燃料サイクルである。トリウムは炉内でウラン233に変えて燃やされるが、その強烈なガンマ線により監視・検知

ばかりになってほしくない。また、十分に国際的視点から論議してほしいものである。

過去四十年の開発努力の九九％は、ウラン・プルトニウムサイクルに焦点を合わせて来たのは事実である。したがって、当

も、重大な事態に直面していると考えざるべきではないか。

われわれの課題はすべて世界の動向と直結している。わが国でも満足に展開できそうにないものが、世界に通用するはずがない。また、世界が受け入れないものを、わが国だけ利用できるはずもない。

社説では、「核テロ」の話題は敬遠しているが、本心に深刻は極めて容易である。すでに一九八六年の核テロ国際会議でも推奨されている(核燃料は液体にし遠隔操作する)。

なお最初に原発が社会との摩擦を引き起こしたのは、安全問題である。既知の炉構想では、ついに社会説得に成功していない。炉心溶融や再臨界事故の可能性を完全には排除できず、その対応策が複雑化・非経済化を

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た。プルトニウム核弾頭の有効利用消滅も容易である。ウラン・プルトニウム炉では、プルトニウムと線は切れない。

今後二、三十年は既存原発に頼らざるをえない。これは、化石燃料がいくら汚染を助長しても来世紀前半の主エネルギーであることを止められないのと同様である。しかし、その先のために、今こそ新しい道を探り始めるべきである。研究開発の基礎はほとんど整えられてあり、資金も手間はいくらもからない。小型化に適するので、既存大型炉と不必要な競合なしに、健全な移行が可能である。

呼んでいるからである。

また使用済み燃料再処理を世界的に展開できる見通しはない。増殖サイクル完成は夢であり、廃棄物対策も悪化をたどるだけだろう。ウラン採鉱による環境破壊も無視できない。

これらすべてに対して、われわれがかねがね検討を深めてきたトリウム・ウランサイクルの溶融塩燃料炉方式は、最良の対応ができる見通しが得られてき

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諸外国は賛成を始めている。皆で徹底的な論議をしてみようではないか。一層深刻化するのが明白な、南北問題打開への大きな一歩としようではないか。南北間の共同体制が整わねば、環境問題も社会争乱も手のほどこしようがないはずである。

(東海大学教授、核エネルギー論・高温融体工学)





TOKAI UNIVERSITY  
INSTITUTE OF RESEARCH & DEVELOPMENT

1117-Kitakaname, Hiratsuka, Kanagawa, 259-12 JAPAN

Phone 0463-58-1211 Ext. 2298, 2299, 5300

Fax " - " - 1203

Mr. J. Paul Pleasant  
President,  
Energy Frontiers International,  
11472 Ehren St.,  
Lake View Terrace, California 91342  
U.S.A.

18th February, 1992

Dear Mr. Pleasant,

Thank you very much indeed for your letter[and beautiful stamps] of 14th January(February ?), 1992.

Your statements all are quite agreeable and encouraging me. I am sorry for my silence, but I did a lot for Th. Partially I shall report you, as Th is on time:

0) Please tell me your Fax No.. Mine is 463-58-1203.

1) Th fuel cycle promotion by HTGR is natural for USA. However, the age is shifting, and really a new era. Your country has the base of MSR tech.. Comparing them, HTGR is an incomplete set, especially concerning "fuel processing", really. I discussed severely on it with Professor Schulten[Julich] 3 years ago, and off course, with other severals including EdF chief engineer (cf. II-5 section of our blue book prepared by the help of EdF.).

2) So long I am hoping for DOE to move on MSR development using ORNL, with which I have a deep connection as you know. I prepared a very easy approach than ORNL-MSBR, and can distribute all over the world. I enclosed our newest report here. ORNL peoples are supporting me.

I am very happy if you would couple with me to prepare the international coopo.system for th-MSR development. Would you please explain our idea to Mr. Henson Moore[ what is his previous career ?], because the several groups in the world are more and more supporting our proposal:

3) For example:

Now Russian Inst. for Theo. & Exptl Physics, Moscow [2500 persons, responsible for N. Weapon head incineration] is officially cworking in our direction.

Turkish Atomic E. Authority President presented his hope to study more on our system cooperatively (already progressing in partial). Please understand it means that this tech. is very attractive for developing countries, too. In recent, India, Indonesia, Czecho., Israel, --- are hoping to know more.

Will you know a week ago Indonesia nearly gave up PWR after



long examination choosing coal.

Japan is now more understanding the difficulty of LWR siting. Two days later (20th Feb.) the Japanese biggest conservative Newspaper "YOMIURI" is publishing an invited energy essay of mine in 9 million copies.

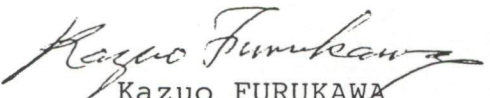
4) I have to explain more in detail. Could we meet together near future ? Where is your town ? Last year I missed to visit USA, but this year have to go, at least visiting LLNL, EPRI, Los Angeles, LANL ?, ORNL, Tennessee Univ.. Which period is suitable for meeting you ?

Would you have a connection with the former President Carter, who was a reactor fuel engineer and really promoted to use Th than Pu strongly ! ( I am also not impossible to find it.) Senate of Tennessee (who) should move to use ORNL more for not only USA but also the world, don't you ?

I shall move more now. Please help me.

Looking forward to seeing you near future,

Sincerely yours,

  
Kazuo FURUKAWA

P.S. I heard that Dr. Clark Gibb, the head of ETEC, Canoga Park, has an interest on MSR. More than 20 years ago, I had a deep connection with LMEC and Atomic International. I am writing him, too.



THE WHITE HOUSE  
WASHINGTON  
May 11, 1992

mtg on  
6/9, Tues.  
@ 10:00  
w/ DAB.  
Lee to  
attend

Dear Mr. Pleasant:

I have received your recent letter requesting a meeting with Professor Kazuo Furukawa of the Institute of Research and Development at Tokai University in Japan to discuss Japan's and the world's future role in the production of plutonium for the utilization of commercial energy.

While I continue to be most interested in these matters since I have come to the White House from the Department of Energy, due to the different kinds of assignments in which I am now involved, I would like to suggest Professor Furukawa would be better served by requesting a meeting with Dr. Allan Bromley.

As you are probably aware, Dr. Bromley is the Assistant to the President for Science and Technology. I have discussed your request with Dr. Bromley's office and they would welcome hearing from you.

With kindest personal regards, I remain

Sincerely yours,



W. Henson Moore  
Deputy Chief of Staff  
to the President

Mr. J. Paul Pleasant  
President  
Energy Frontiers International  
11472 Ehren Street  
Lake View, California 91342



# Energy Frontiers International

*Bentley*  
J. PAUL PLEASANT, President

Henson Moore  
Presidential Advisor  
The White House  
Washington D.C.

April 14, 1992

Professor Kazuo Furukawa, Institute of Research and Development, Tokai University is one of Japan's leading nuclear physicist. He has taken a public leadership role advocating that Japan, and the world, avoid the production of plutonium in the utilization of commercial nuclear energy.

Professor Furukawa is the leading exponent of THOREM-NES, a Accelerator Molten-Salt Reactor concept utilizing thorium. This concept will require a close cooperative effort with the Oak Ridge National Laboratory.

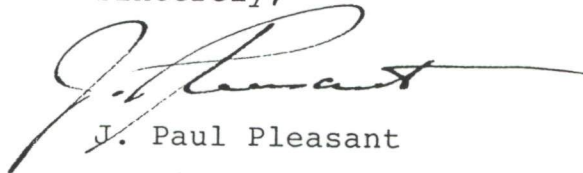
Professor Furukawa will visit the United States in June and has expressed a strong desire to meet with you, or staff, in Washington D.C. on June 10 or 11.

Enclosed are copies of recent correspondence. The correspondence reflects a developing international interest in this nuclear energy project.

I believe it is most important to the long-term interests of the United States that Japan avoid an energy future based upon plutonium. I strongly urge that Mr. Furukawa be granted a personal opportunity to discuss his vision of Japan's energy future.

Please advise if this meeting can be scheduled.

Sincerely,

A handwritten signature in dark ink, appearing to read "J. Paul Pleasant", with a long horizontal flourish extending to the right.

J. Paul Pleasant  
President

ENERGY FRONTIERS INTERNATIONAL



Mr. J. Paul Pleasant  
President,  
Energy Frontiers International,  
11472 Ehren St.,  
Lake View Terrace, California 91342  
U.S.A.

FAX : 818 890-4336

11th April, 1992

Dear Mr. Pleasant,

Thank you very much for your letter of 1st April, 1992, by which I have been encouraged so much.

Our movement is quite successfully growing. We have prepared a new Tokyo-office, and everything is progressing everyday. I cannot explain simply. I have to see you as soon as possible.

Now I have decided to participate in "Citizen Ambassador Program": Nucl. Fuels Management Delegation to the Commonw. of Indep. States (Moscow, Chelyabinsk, Kiev, Chernobyl), which will start on 13th June, 1992 from New York.

cf.: Ms. Kathy White,  
Project Coordinator  
People to people Cit. Amb. Program  
Dwight D. Eisenhower Building  
Spokane, Washington 99202

FAX: 509-534-5245  
TEL: 509-534-0430

Honorary Chairman:

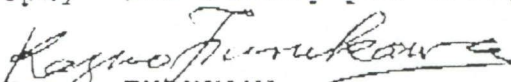
President George Bush

[ Half month ago, I was timely elected as a Foreign Member of Ukrainian Academy of science.]

Therefore, starting here on 31th May, and touching LLNL etc., I want to see you on 3rd June, 1992 at Los Angeles. Is it all right for you ?

After visiting ORNL [Director, Dr. Trivelpiece] including many friends (hoping to see Dr. A. Weinberg, too), I want to see Mr. Henson Moore on 11th or 10th June at Washington. (If impossible, to his staffs ! ) I should be very much obliged if you would kindly help me on it.

Looking forward to getting your reply and seeing you soon,  
Sincerely yours,

  
Kazuo FURUKAWA

Prof. Kazuo FURUKAWA  
Inst. of Research & Development,  
Tokai University,  
Hiratsuka, Kanagawa 259-12,  
JAPAN

FAX: 463-58-1203



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9th March, 1992

Dear Mr. Pleasant,

Thank you very much for your letter of 2nd March, 1992 and copies of letters indeed.

I am quite waiting the successes of these actions. Please report me soon by Fax [ 463-58-1203]. I also want to know your Fax number, please.

Could you imagine now Japanese are also quickly understanding our opinion (good for all peoples) among top peoples or opinion leaders.

My next essay <sup>was</sup> ~~will be~~ published <sup>day</sup> ~~tomorrow~~ on the leading NewsPaper: ASAHI (5 M copies ?) much discussing on Pu: "Let extinguish the fire of Pu", they chosen this title. On 1st March, timely, Mr. Torii, a Editorial Writer of Japan Economy NP[Nihonn KEIZAI] presented quite clear essay: "New Nuclear Energy Way", quite following our way, he said, and really Ministry Foreign Aff. & Tokyo ELEC. Power Corp. are appreciating these proposal now.

Asahi also wrote a similar editorial on 22th Feb. titled "Re-examine the Pu policy". Therefore I sent them the above second essay. Tokyo E.P.Co invited me on the end of this January.

I am meeting with Mr. K. Tanigawa, Minister of Sci. Tech. Agency on 10th March. Socialist Party has invited me for a lecture to rebuild their energy policy on 18th March.

Looking forward to seeing you near future,  
Sincerely yours,

  
Kazuo FURUKAWA

P.S. Please tell me your Fax number and the air-port for seeing you.  
(How to go there ?)





12月  
1992  
3/1

中外時評

世界中で使われる原子力を

「長期計画」改定、技術戦略示せ

論説委員  
鳥井 弘之

原子力委員会、わが国の原子力政策の基本となる「原子力開発利用長期計画」の改定作業に入らうとしている。原子力を巡る情勢は大きく変化しており、新しい時代の中で原子力をどう位置づけて行くかが世界の関心事になっている。今回の改定作業は、それに対するわが国の回答であり、従来の改定と比較にならないほど重大な意味を持っている。

地球環境問題は原子力を考える上でも重要な要因になる。化石燃料

料の消費によって発生する炭酸ガスが地球温暖化の原因になると考えられ、六月にリオデジャネイロで開かれる地球サミットに向かって、二酸化炭素の排出抑制に関する

議論が続けられている。省エネルギーなど地道な努力も必要だが、それだけで、抑制の目標を達成できるわけではない。

世界のエネルギー需要は、省エネとが出来るのだろうか。言い換えると、世界の多くの国が原子力に頼ることを無条件で賛成できるか、という点になる。

また考える必要があるのは核の拡散の問題である。原子力発電所の増設の伸びると予想され、二酸化炭素を排出しないエネルギー源がどうしても必要になる。それに答える最も有力な候補が原子力である。昨年のロンドン・サミットでも原子力の重要性が経済宣言に盛り込まれたように、原子力に対する期待は大きくなっている。

※ ※ ※

原子力はこの期待をたえる。

主権人民共和国（北朝鮮）パキスタン

判明している。

本努力をしても、年率二割以上の増減の問題である。原子力発電所の増設の伸びると予想され、二酸化炭素を排出しないエネルギー源がどうしても必要になる。それに答える最も有力な候補が原子力である。昨年のロンドン・サミットでも原子力の重要性が経済宣言に盛り込まれたように、原子力に対する期待は大きくなっている。

※ ※ ※

現に、湾岸戦争後のイラクに対するIAEA（国際原子力機関）の特別査察によってイラクの核兵器開発が明るみに出た。朝鮮民主主義人民共和国（北朝鮮）パキスタン

もう一つの問題は、安全の確保である。チェルノブイリの原子力事故によって、事故の被害が一国の中に止まらず、周辺にも大きな影響を与えることが認識されるようになった。一方、東欧などの

原子力発電所の増設は、安全の確保が前提となる。チェルノブイリの原子力事故によって、事故の被害が一国の中に止まらず、周辺にも大きな影響を与えることが認識されるようになった。一方、東欧などの

原子力発電所の増設は、安全の確保が前提となる。

わが国の原子力発電所の安全性は世界でも最高水準にある。安全性が保たれている背景には、広島の長崎の経験、国民の教育レベル、文化、経済状況など、様々な要素がある。世界のどこでもわが国と同じような安全性が確保できるとは限らない。世界の現状を見れば、原子力施設が戦火を浴びることも考慮しなければならない。

こう考えると、原子力に対する期待は大きくなるのに、現在の原子力は、長期的な世界という視点からは、その期待にたえず格が足りないように思われる。期待にこたえるためには、プルトニウムなど核燃料に代わる物質を作らない原子力が必要だ。厳重な管理をしながら安全な原子力が確保される。これらの条件を考慮した新しい原子力に関する技術的進歩案もいくつかある。

日本の原子力利用は、ウラン濃縮、軽水炉、使用済み燃料の再処理など、欧米の路線をまっしぐらに進めてきた。新型炉の開発でも、新型軽水炉、高速増殖炉など欧米が打ち出した旗幟を取り入れた。わが国の原子力利用は、これを考えるなら、それで十分と考える。

しかし、将来の世界に対して日本が責任を持つなら、世界中で使える原子力技術の開発に日本が取り組むべきであろう。技術的には完成しない。その意味で現在の軽水炉を否定するわけではなく、技術の完成を待つ。わが国の原子力利用も、徐々に新しい技術体系に切り替えて行けばよい。

今や、日本は世界の将来がどうあるべきかを考え、それを世界に示していく立場にある。技術開発も日本のためという視点だけでは不十分である。原子力について言うなら、それが平和利用に際する日本の立場の証明にもなる。長期計画では、当面の核不拡散やプルトニウム利用をどう考えるかも重要だが、長期的な技術戦略も検討するべきであろう。



# 論点

私たちは、来世紀に向かつての環境およびエネルギー対策を、太陽エネルギーに頼れるならば最良と思っている。だが何ぶん密度が低く不規則なので、補助が特殊目的から抜け出すのは困難であろう。

今の化石燃料時代からこの太陽エネルギー時代への橋渡しをどうするか？ 一部の人は核融合に期待しているらしい。しかし、ITER(国際熱核融合実験炉)の推進者たちも、実用化は四、五十年先という。もし実現して世界エネルギーの二、三〇%を占めるのは再来世紀初めになってしまふ。



東海大学教授 小川 和男

許された時間はせいぜい二、三十年にすぎないのであるから、核分裂利用をもつて一度、抜本的に見直してみる必要がある。ただし、資源、安全、核拡散・核テロ、廃棄物、社会適合、経済性のすべて

中に少なくとも七千万から一兆KW・年の電力を生産することが必要である。これでも、化石燃料の使用で増え続ける世界の炭酸ガス放出率は、二〇六五年によつて増勢が止まる程度である。過去の原発発電総量はわずか二十億KW・年に過ぎず、その数百倍の生産は、とても既存の軽水炉の改良程度で追いつけることではなからう。ではどうしたらよいのか？

東海大学教授

それにはウランの代わりに「トリウム」を利用する道がある。さらに固体をやめて液体の溶融塩核燃料利用に移るのである。米国防工務省の国立研究所の人々が、この基礎研究をまとめ推進を始め、一九五八年ころから、筆者も生涯の仕事と決めた三十年以上努力してきたが、ようやく来世紀世界に展開するにふさわしい具体構想が

核燃料は自給自足されるので、余剰燃料が不要で制御棒なしに出るかも知れない。核燃料の路上輸送は、運転始めと終わりの二度だけでよい。燃料は空気・水と反応しない常圧の最も安定な液体である。冷えれば燃料塩はガラス状に固化し、放射能閉じ込めに最良で、水に溶けない。廃棄物についても、まず一番やっかいな超ウラン

ジでは実にわずかの資金と最高二百人の陣容で、すでに実験炉が立派に運転され、技術基盤はできているのである。最小限の新技術実証には、約十年の年月と国連が今世紀内に必要という環境対策費一兆五千分の一ぐらいがあれば十分と思われる。経済性の高さも十分推察していただけるであろう。

## 今こそ有望な「トリウム」燃料

固まつてきた。しかも前記の課題すべてを解決する見込みがある。安全性に関しては、炉が破壊されても過酷事故(炉心溶融・再臨界など)が想定できないくらい安全である。ガス状の放射能は常に除去されており、事故時に放出されるものはほとんどない。炉内は裸の黒鉛(空間の九〇%占有)とすきまを流れる溶融塩燃料だけが成り、フタなしの単純なタンクが本体である。

一刻も早く開発したいという仲間がいる。最近、ロシアの研究所が挙げて共同したいと動き出した。開発途上国でも、現にチェルノブイル災害に陥りて原発を拒否していたトルコ政府機関までが、一緒に検討させてほしいと言つて来ている。インド・インドネシアその他にも熱心な仲間がいる。

このような新しい炉は開発費が大変なうとよく言われるが、迎撃である。その証拠に、オーククリッ

ン元素類がほとんど生まれない。燃料をいじり回さないで、低レベル廃棄物を減減できる。核拡散・核テロ対策では、トリウムの利用によりプルトニウム廃絶が可能である。トリウムは核分裂性の人工ウラン<sup>233</sup>に変えられて燃やされるのであるが、これは必ず強烈なガンマ線を伴い、テロリストは致死量を経験してしまふ。遊離(しゃへい)するには厚さ二十センチの鉛の容器が必要で、簡

単に運べない。検知・監視はきわめて容易である(従つて、燃料は液体にして遠隔操作され、作業員は極くくをまぬかれる)。

このほか、この炉は小型化できる利点をもつ。既存の大型原発と不必要に競争せず、小型炉から次第に世界に展開していけばよい。技術成熟し、立地に有利である。米・仏・伊などには、かねがね

これはまた、世界が膨大な投資をしながら実用化されていまい高速度増殖炉用の液体ナトリウム技術が、有効に、しかもより易しく活用できるからである。日本におけるこの技術の基盤は、二、三十年前に筆者らが中心になり、この日のために育てておいた。

(核エネルギー論)





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Mr. J. Paul Pleasant  
President,  
Energy Frontiers International,  
11472 Ehren St.,  
Lake View Terrace, California 91342  
U.S.A.

18th February, 1992

Dear Mr. Pleasant,

Thank you very much indeed for your letter[and beautiful stamps] of 14th January(February ?), 1992.

Your statements all are quite agreeable and encouraging me. I am sorry for my silence, but I did a lot for Th. Partially I shall report you, as Th is on time:

0) Please tell me your Fax No.. Mine is 463-58-1203.

1) Th fuel cycle promotion by HTGR is natural for USA. However, the age is shifting, and really a new era. Your country has the base of MSR tech.. Comparing them, HTGR is an incomplete set, especially concerning "fuel processing", really. I discussed severely on it with Professor Schulten[Julich] 3 years ago, and off course, with other severals including EdF chief engineer (cf. II-5 section of our blue book prepared by the help of EdF.).

2) So long I am hoping for DOE to move on MSR development using ORNL, with which I have a deep connection as you know. I prepared a very easy approach than ORNL-MSBR, and can distribute all over the world. I enclosed our newest report here. ORNL peoples are supporting me.

I am very happy if you would couple with me to prepare the international coopo.system for th-MSR development. Would you please explain our idea to Mr. Henson Moore[ what is his previous career ?], because the several groups in the world are more and more supporting our proposal:

3) For example:

Now Russian Inst. for Theo. & Exptml Physics, Moscow [2500 persons, responsible for N. Weapon head incineration] is officially cworking in our direction.

Turkish Atomic E. Authority President presented his hope to study more on our system cooperatively (already progressing in partial). Please understand it means that this tech. is very attractive for developing countries, too. In recent, India, Indonesia, Czecho., Israel, --- are hoping to know more.

Will you know a week ago Indonesia nearly gave up PWR after

long examination choosing coal.

Japan is now more understanding the difficulty of LWR siting. Two days later (20th Feb.) the Japanese biggest conservative Newspaper "YOMIURI" is publishing an invited energy essay of mine in 9 million copies.

4) I have to explain more in detail. Could we meet together near future ? Where is your town ? Last year I missed to visit USA, but this year have to go, at least visiting LLNL, EPRI, Los Angeles, LANL ?, ORNL, Tennessee Univ.. Which period is suitable for meeting you ?

Would you have a connection with the former President Carter, who was a reactor fuel engineer and really promoted to use Th than Pu strongly ! ( I am also not impossible to find it.) Senate of Tennessee (who) should move to use ORNL more for not only USA but also the world, don't you ?

I shall move more now. Please help me.

Looking forward to seeing you near future,  
Sincerely yours,



Kazuo FURUKAWA

P.S. I heard that Dr. Clark Gibb, the head of ETEC, Canoga Park, has an interest on MSR. More than 20 years ago, I had a deep connection with LMEC and Atomic International. I am writing him, too.



Institute of Research & Development

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VIA AIR MAIL

Mr. J. Paul Pleasant

President,

Energy Frontiers International,

11472 Ehren St.,

Lake View Terrace, California 91

U.S.A.



*To Mr. J. Paul Pleasant,  
with the compliments of Kozo Furukawa*

## Thorium Molten-Salt Nuclear Energy Synergetics

Kazuo FURUKAWA, Alfred LECOCQ, Yoshio KATO  
and Kohshi MITACHI

Reprint

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## SUMMARY REPORT

## Thorium Molten-Salt Nuclear Energy Synergetics

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In the next century, the "fission breeder" concept will not be practical to solve the global energy problems, including environmental and North-South problems. As a new measure, a simple rational Th molten salt breeding fuel cycle system, named "Thorium Molten-Salt Nuclear Energy Synergetics [THORIMS-NES]", which composed of simple power stations and fissile producers, is proposed. This is effective to establish the essential improvement in issues of resources, safety, power-size flexibility, anti-nuclear proliferation and terrorism, radiowaste, economy, etc. securing the simple operation, maintenance, chemical processing, and rational breeding fuel cycle. As examples, 155 MWe fuel self-sustaining power station "FUJI-II", 7 MWe pilot-plant "miniFUJI-II", 1 GeV-300 mA proton Accelerator Molten-Salt Breeder "AMSB", and their combined fuel cycle system are explained.

**KEYWORDS:** energy demand, thorium, molten salts, fluorides, fission reactors, nuclear power plants, fissile producers, accelerator breeder, breeding fuel cycle, safety, research programs  
*R & D*

## I. INTRODUCTION

The next (21st) century will be a transient period from fossil fuel era to solar era through nuclear energy. The present fossil fuel technologies induce, not only severe global environmental problems, but also regional difficulties connected with the effective and economical energy supply, which is necessary to overcome poverty and desertification, i.e. North-South problem.

However, the future nuclear energy technology as a measure of global problems in the medium and long terms such as 2020~2070 will not be established merely by some extensions or improvements of present technologies, due not only to recent several troubles of nuclear facilities, but also to the huge increase in amount of nuclear energy capacity

such as 100 times more than the present, which means a need of 100 times safer technology<sup>(1)</sup>.

This might require a technological revolution or a new philosophy on the following issues keeping deep connections among each other: (a) nuclear resources, (b) breeding fuel-cycle, (c) safety, (d) radio-wastes and their incineration, (e) nuclear proliferation and terrorism and (f) public and institutional acceptances related not only with the aboves, but also with the technological simplicity, flexibility and economy in the global applications.

A "nuclear energy system" should be a

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"nuclear chemical engineering facility", and essentially a "chemical plant". Following on this sense, more rational nuclear energy system should be developed for the global energy measure of the next century, fully re-examining the scientific and engineering efforts devoted in this century.

## II. ENERGY PROBLEMS IN NEXT CENTURY

### 1. Global Energy Demand<sup>(1)</sup>

The growth rate of energy consumption in the world was about 2.3% per year in the past one hundred years. It means about 10 times increase after one hundred years. If this growth rate is also applied in the next one hundred years, the total energy demand surrounding the end of the next century will amount to about 115 TWth (th=thermal), which is about  $9 \times 10^{-3}$ % of the total solar energy input to the globe. The latter value is almost the limiting value of 0.1%, which is estimated

by some specialists considering the influence on the world climate. Thinking of the local abnormal weather, about 100 TWth seems to be a sound maximum heat emission to the atmosphere.

At the end of the next century, there is a consensus that the world population may be saturated at the value between 10 and 15 billion. This means about 10 kWth or 7 kWth per capita on an average corresponding to the 2 times (10 billion) or 3 times (15 billion) increase in the world population, respectively. This level is still less than that of the present USA, which is about 10 kWth per capita.

Therefore, at least, this energy demand should be satisfied in the next century of the world. This is the target of this report. An anticipating global energy demand in the next century is summarized in connection with the prediction of the population in Table 1<sup>(2)</sup>, which includes an average energy consumption per capita, too.

Table 1 World energy demands in next century

|        | population | energy*<br>[TWth]               | (nuclear)* <sup>3</sup><br>[GWe] | energy per capita<br>[KWth/cap] |
|--------|------------|---------------------------------|----------------------------------|---------------------------------|
| 1988   | 5.1 B      | 9.                              | (200)                            | 1.8                             |
| 2000   | 6. B       | 11.8                            | (300)                            | 2.0                             |
| 2035   | 8. B       | 26.                             | (2,700)                          | 3.3                             |
| 2050   | 10. B      | 37.                             | (6,000)                          | 3.7                             |
| 2065   | 12. B      | 52.                             | (13,000)                         | 4.3                             |
| [ 2100 | 10~15 B    | 115.                            | (30,000)                         | 12~7.6 ]                        |
|        |            | (=0.09% of solar)* <sup>2</sup> |                                  |                                 |

\*) assuming the average growth rate of 2.3 % per year.

\*2) assuming less than 0.1 % of total solar input energy to earth, which would be a limit allowable in climate and environmental influence.

\*3) assuming from the prediction by Marchetti et al., IASA [2].

If a sound industrial trend in energy supply is held in the next century, it will conform to the logistic prediction made by Marchetti *et al.* as shown in Fig. 1<sup>(3)</sup>, where the amount of primary energy is plotted as fraction "F" of the total energy market. The dotted curve of nuclear (fission) energy is added by the authors. The total electric capacity of the nuclear fission energy will become about 300 GWe in 2000, about 2,700 GWe in 2035, and about 13,000 GWe in 2065 as shown in Table 1.

### 2. Nuclear Proliferation and Terrorism

For the improvement of this issue the Pu

fuel cycle strategy should be criticized, and Th cycle would be recommended due to the high  $\gamma$ -activity of polluted fissile <sup>233</sup>U, which is effective for the safeguard and detection<sup>(4)</sup>.

### 3. Environmental Problem

This significant nuclear energy growth rate presented here seems to be necessary not only for securing the healthy, cultural and economical life, but also for reserving the sound environmental conditions in the world by the diminution of pollution including the "Greenhouse Effect"<sup>(5)</sup>, although the solar energy utilization could become more impor-



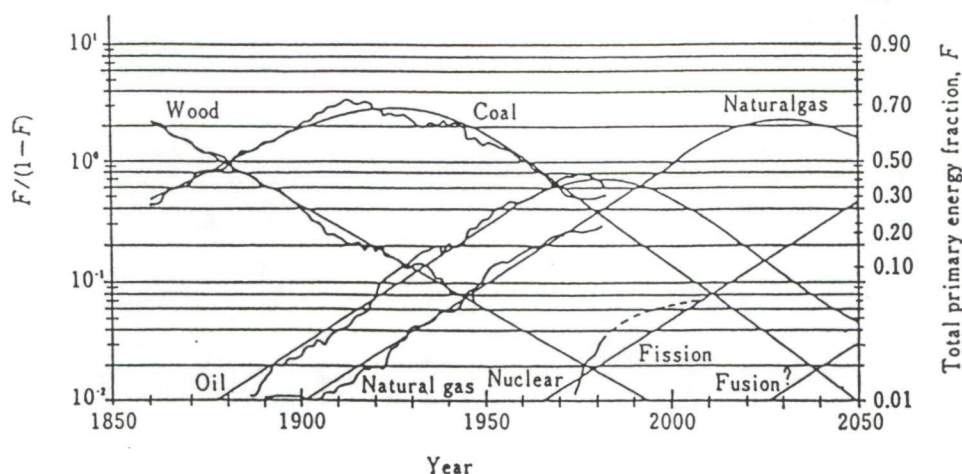


Fig. 1 Historical trend in energy substitution

tant toward the end of the next century because of the limitation on heat emission (*cf.* the item (\*2) in Table 1).

#### 4. Radio-waste

In this issue pure fusion technologies will have some advantages. However, it should be recognized as a long term program, because the energy gain even in the DT-fusion reaction is about one tenth of fission reaction which need not any essential energy input. In fission energy program, the following points should be considered for the radio-waste minimization:

- (i) Minimization of nuclear chemical productions such as fission and spallation products, and trans-uranium elements: A higher thermal efficiency in electric generation will contribute to minimize F.P. production. Thorium fuel cycle will have a big advantage to minimize or eliminate trans-uranium elements.
- (ii) Minimization of spent fuel materials: All irradiated fuel material should be fully used as far as possible and not be easily sent to graveyards. They should be fully burned out establishing a complete breeding fuel cycle (*cf.* Chaps. III & VIII).
- (iii) Minimization of fuel reprocessing steps and of reactor maintenance works.

#### 5. Doubt on "Fission Breeder" Concepts

It seems that the establishment of fission breeders such as LMFBR is a world's con-

sensus as one of the better solutions of energy and environmental problems. However, this concept might yield not only economical difficulty<sup>(6)</sup> but also several practical misfits related to public requirements<sup>(7)</sup>. Numerical examination is shown in APPENDIX.

- (a) The first problem is a doubt whether the reactor could achieve the necessary growth rate as shown in Table 1, due to its low breeding power. This has been examined applying the following scenario acceptable as a sound example: all reactors until the year 2019 are thermal LWR of 1 GWe producing 0.25 t/yr of Pu, and all renewed and added reactors after 2020 are 1 GWe LMFBR, which need 5 t of Pu for initial inventory. This concludes the necessity of a very short doubling time such as 6~8 years in fissile breeding, and fully prepared reprocessing plants. These seem to be impossible.
- (b) Power stations should be simple facilities, flexible in power size, responding the natural demand of world utilities. It would not be acceptable that all stations become sophisticated large high-performance LMFBR.
- (c) The integrated Pu inventory necessary for FBR in minimum would be 11,000 and 28,250 t at 2036 and 2049, respectively. Handling and transportation of such a huge amount Pu would be fatally trouble-

some. (In practice, the shortage of Pu will appear at 2037 even using FBR of 20 years in doubling time.)

Molten-Salt Breeder Reactors (MSBR) such as designed by Oak Ridge National Lab. (ORNL), USA<sup>(7)</sup> also will not be acceptable by the items of (a) & (b) due to the long doubling time of about 20 years.

#### 6. Establishment of More Practical

##### Breeding Fuel-cycle

The fission energy technology holds an unique position due to its nature of "energy rich" and "neutron poor". The latter will require helps from the other nuclear technologies such as nuclear spallation, D-T fusion, etc., to get enough fissile materials to establish real "breeding fuel cycle" (cf. Chap. VIII).

#### 7. Basic and Engineering Safety

The significant improvement such as 100 times better than the probability of the present level of  $10^{-4}$  severe accident per reactor-year operation will be required to avoid total refusal by public<sup>(8)</sup>. The following points are

essential: simplicity in operation and maintenance, flexibility in power size, approach to civilian life area, and essential improvement in economy.

This might be established only by the essentially new safe reactor concept composed of chemical inert fluid-fuel, which has no radiation-damage, negligible excess nuclear-reactivity (nearly no control-rods), and low power density in value without harming its economy. [High Temperature Gas-cooled Reactor or Pebble-Bed Reactor which are more acceptable in safety issue than the other solid fuel reactors would not be suitable for establishing a breeding fuel cycle, too.]

### III. NEW PHILOSOPHY: THORIMS-NES

#### THORIUM MOLTEN-SALT NUCLEAR ENERGY SYNERGETICS

Now, to solve the several energy problems shown in Chap. II and Fig. 2, a new philosophy should be proposed to the public. The

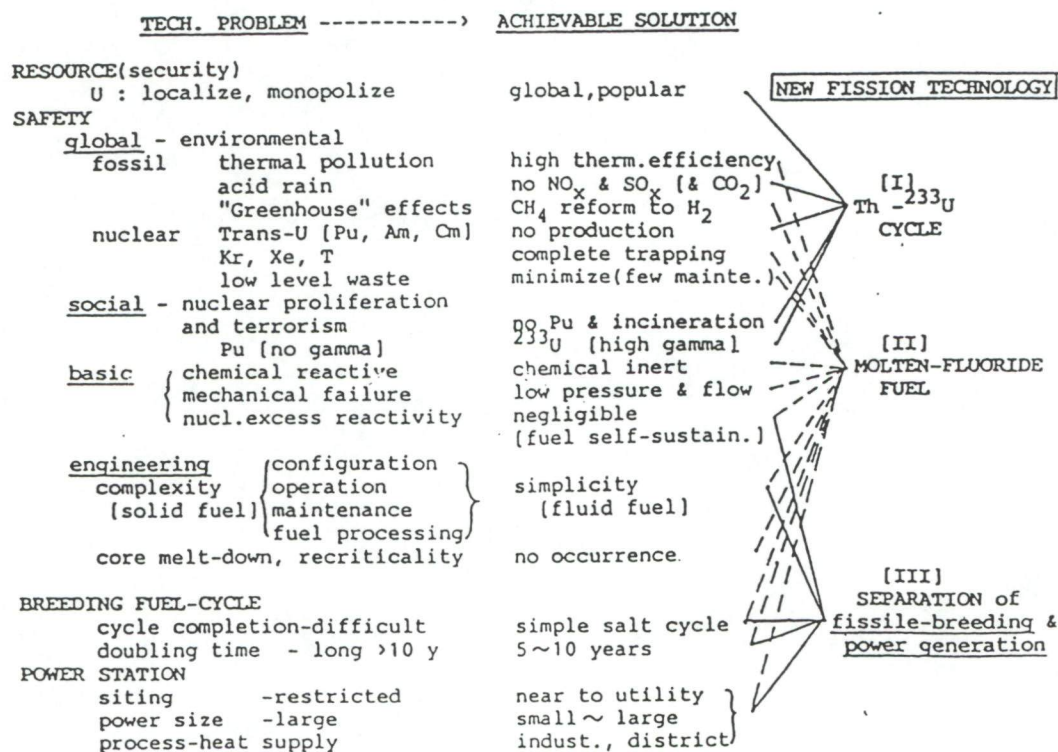


Fig. 2 Global energy problems and achievable solutions by  
New FISSION TECHNOLOGY [THORIMS-NES]



new proposal depends on the following three principles:

[I] Thorium utilization

Natural Th has only one isotope:  $^{232}\text{Th}$ , which can be converted to the fissile  $^{233}\text{U}$  in the similar manner as  $^{239}\text{Pu}$  converted from  $^{238}\text{U}$ . Thorium is more abundant and non-localized resource than U.

[II] Application of molten-fluoride fuel technology

The molten salt  $^7\text{LiF-BeF}_2$  (Flibe—named by ORNL) is the significantly low thermal-neutron capture cross section material (*cf.* Table 2) and the best solvent of fissile and fertile materials. This functions as one of the best liquids useful for nuclear fuel, blanket or target keeping coolant function in parallel.

Table 2 Natural elements and practically separable isotopes having tiny thermal neutron absorption cross-sections

|                           | (natural abundance) | cross-section<br>m barn (natural element) |
|---------------------------|---------------------|-------------------------------------------|
| 1. $^8\text{O}$           |                     | 0.19                                      |
| 2. $^2_1\text{H}$ [D]     | (0.0148%)           | 0.519 ( $^1_1\text{H}$ 332.6)             |
| 3. $^{12}_6\text{C}$      |                     | 3.53                                      |
| 4. $^{11}_5\text{B}$      | (80.0%)             | 5.5 ( $^{10}_5\text{B}$ 767,000)          |
| 5. $^4_2\text{He}$        |                     | 6.9                                       |
| 6. $^9_4\text{Be}$        |                     | 7.6                                       |
| 7. $^{19}_9\text{F}$      |                     | 9.6                                       |
| 8. $^{83}_{35}\text{Br}$  |                     | 33.8                                      |
| 9. $^{10}_{10}\text{Ne}$  |                     | 39.                                       |
| 10. $^7_3\text{Li}$       | (92.5%)             | 45.4 ( $^6_3\text{Li}$ 70,500)            |
| 15. $^{40}_{20}\text{Ca}$ | 185.                | 17. $^1_1\text{H}$ 332.6                  |
| 16. $^{13}_{13}\text{Al}$ | 231.                | 67. $^{17}_{17}\text{Cl}$ 33500.          |

[III] Separation of fissile producing breeders (process plants—MSB) and power producing reactors (utility facilities—MSR)

It will be essential for the global establishment of breeding fuel cycle flexibly applicable in any area.

This philosophy was named as "Thorium Molten-Salt Nuclear Energy Synergetics" [THORIMS-NES]<sup>(2)(8)(9)</sup>. Its main benefits will be briefly understood from the summary in Fig. 2.

## IV. SIGNIFICANT ASPECTS OF MOLTEM-SALT REACTOR TECHNOLOGY

### 1. Molten Fluoride Fuel Concept<sup>(7)(8)</sup>

Some brief historical presentation of significant studies on MSR concept are given in Fig. 3. MSR is classified to fast, epithermal and thermal reactors according to the kinds of neutron spectrum utilized. Fast or epithermal reactors not having any solid moderators might have more attractive due to the simple structure and high performance. However, it seems that no one has succeeded to present any practical designs yet. Fluoride salt fueled thermal MSR would be the most promising reactor concept.

The "Flibe ( $\text{LiF-BeF}_2$ ) base molten-salt fuel" concept has already been established its sound technological basis by the brilliant long effort of ORNL, throughout 1947~1976. It depends on the successful operation of MSRE (Molten-Salt Reactor Experiment, 7.5 MWth) in 1965~1969, and on their intensive R & D works on MSBR (1963~1976)<sup>(7)</sup>. The excellent final summary on ORNL works could be found in ORNL/TM-7207<sup>(10)</sup>. The short explanation will be given below.

However, the practical deployment of MSBR is not easy because of the following difficulties: (a) necessity of core-graphite exchange in every 4 years, (b) development of continuous chemical process *in situ*, and (c) necessity of improving doubling-time from the present estimation of 20 years, and (d) flexibility in power size (*cf.* Sec. II-5).

Now, the principle [III] should be accepted.

### 2. Flibe-base Molten-Salts

The molten  $^7\text{LiF-BeF}_2$ - $^{232}\text{ThF}_4$ - $^{233}\text{UF}_4$  system will be one of the better and idealistic nuclear materials as a carrier of Nuclear Energy Synergism due to the following characteristics:

- (1) A triple-functional medium working as
  - A. nuclear reaction medium—fuel, blanket and target
  - B. heat transfer medium—coolant
  - C. chemical processing medium.
- (2) No radiation damage as an idealistic

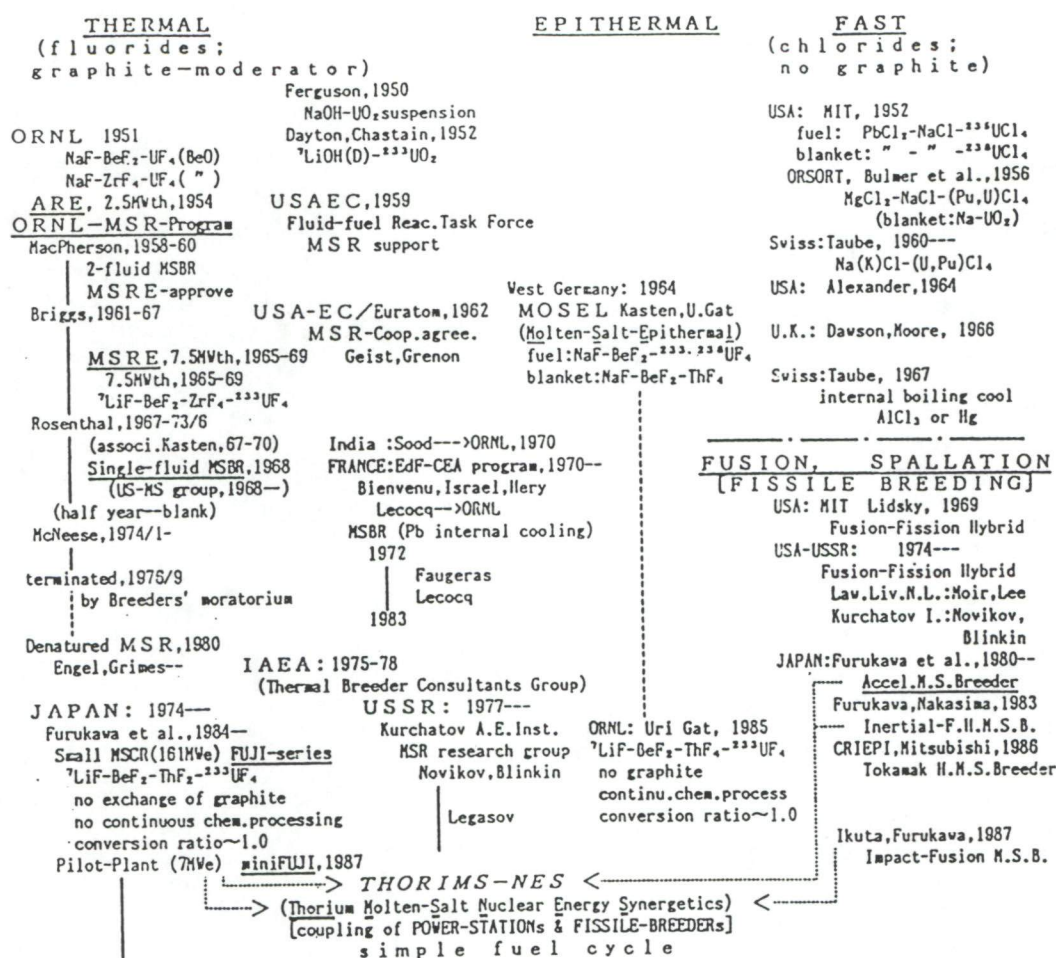


Fig. 3 Historical presentation of Molten-Salt Reactor concepts

"ionic liquid".

(3) High safety and economy assurance promised by chemically inert, low vapor pressure, moderate viscosity and thermal conductivity, and high heat capacity in fairly high working temperature (770~1,070 K).

Sodium technology has three severe disadvantages such as (i) high chemical reactivity, (ii) high thermal shock, and (iii) oxidized vapor condensation in gas spaces, different from molten salt technology.

Molten-Salt technology is much easier than water (high pressure, corrosive and reactive with Zircaloy) and Na technologies.

### 3. Graphite

Graphite is the best material for neutron moderator and reflector in MSR (cf. Table 2),

and is really compatible with molten fluorides in bare state. This is a great benefit in designing MSR. The satisfactory materials have been developed by the efforts of USA and France<sup>(11)</sup>.

### 4. Containment Materials

Fortunately, an easy manufacturable, weldable and high temperature resistant (till ca. 1,100 K) alloy compatible with molten fluorides has been developed basically according on the proposal of Dr. H. Inouye, ORNL. This alloy, Hastelloy N (Ni-(15~18)Mo-(6~8)Cr in %), has been modified by adding about 1% Nb for the protection of Te attack on surface. This was experimentally supported by Kurchatov Institute<sup>(12)</sup>.

This alloy needs not to be introduced in



with the advantages of MSR technology on the chemical inertness, low thermal shock, and no oxidized vapor condensation.

The MSRs including above mentioned small MSR might keep an excellent performance as effective partners of Fissile-producing MSBs in order to establish the practical THORIMS-NES all over the world including the developing countries and isolated areas.

#### 4. R & D for AMSB

In parallel, MSBs, especially AMSB will be developed by the rational procedure increasing the proton current in step-wise during 20 years, aiming the wide application from about 2020.

The first experimental research works on the spallation products and heat generation have to be recommended including the proton irradiation analysis of solidified salt targets in big size such as 50~80 cm in diameter and 150~250 cm in length. After these examinations our preliminary design features could be very much improved due to their big flexibility. As the technological basis of AMSB is clear except the proton injection-port, it will be able to develop within 20 years by the stepwise improvement of test facilities (*cf.* Chap. X). The economy of AMSB depends on the recovery of electricity.

Already 1 GeV-1 mA cw (continuous wave) class proton LINAC technology and basic molten fluoride reactor technology have been developed. The new items necessary for engineering developments of a small integral experimental facility AMSBE (Accelerator Molten-Salt Breeder Experiment) will be quite few, because we can start using pure molten Flibe ( $\text{LiF-BeF}_2$ ) of low melting point and low vapor pressure and using a low intensity 1 GeV pulsed proton beam initially. As a next stage nuclear material contents and beam intensity can be stepwise increased in the same facility, in the rational and economical mood. The general idea of R & D schedule including MSR is shown in Fig. 8.

The R & D of the spallation breeder AMSB would be surprisingly low in cost (\$4~8 B) and short in time (15~25 years) in comparison

with the other similar breeding system developmental projects, promising the wide global application in 2020~2070<sup>(22)(23)(18)(19)</sup>.

## XI. CONCLUSION

We have tackled one of the most promising approaches for establishing the simple and practical Thorium resource utilization program, which might be effective to solve the principal energy problems, concerning resource, safety, nuclear proliferation and terrorism, greenhouse effect, power size and fuel cycle economy, for the next century.

The first step will be the development of Small Molten-Salt Reactors (MSR). Its basic technology has been established by ORNL already, and, therefore, its R & D cost would be surprisingly low. The next is the development of Molten-Salt Fissile Breeders (MSB). Our proposed MSR is an effective partner of MSB for establishing the simplest and economical Thorium molten-salt breeding fuel cycle system named THORIMS-NES all over the world, including the developing countries and isolated areas, for solving poverty, *i.e.* North-South problem. This would be one of the most practical replies to the Lillienthal's appeal of "A NEW START" in Nuclear Energy by encouraging "a revival of positive and affirmative fighting spirit" of scientist and engineers<sup>(22)</sup>.

## ACKNOWLEDGMENTS

The author wish to express sincere thanks to many friends of Japan and the foreign countries for their kind cooperation and encouragement. Especially, Drs. J. R. Engel, U. Gat, F. Atchison, the late Prof. K. Tsukada, Drs. Y. Nakahara, N. Nakamura, K. Minami gave us their friendly helps or cooperation, and the late Dr. E. Nishibori, the late EmProf. S. Kaya, the late Dr. K. Kamei, EmProfs. E. Takeda, T. Mukaibo, T. Ishino, K. Husimi, N. Watanabe, Drs. A. M. Weinberg, H. G. MacPherson, C. Bienvenu, Prof. M. Chemla, Drs. M. Israel, R. Romano, J. J. Geist, R. Moir, H. Takahashi, V. M. Novikov, M. Ginatta, N. Irie, the late Dr. H. Murao gave their great interest and encouragement on our work. One

June 9, 1992

TO: Karl Erb  
FROM: Lee Schroeder *LS*  
RE: Furukawa visit with DAB (Molten-Salt Reactors)

Attended meeting between DAB and Prof. Furukawa. Furukawa presented his ideas about the concept (use thorium (molten salt) as U-plutonium fuel cycle replacement), sought U.S. support for joint Japan/U.S. demonstration project. He has had long term contacts with ORNL people and hopes to build on their expertise. He doesn't appear to be requesting funds at this point, but stresses that he is going around "educating" people (thru-out the world) on his concept/ideas. Gave seminar last week at ORNL (Weinberg and Trivelpiece in attendance).

DAB stressed that he should also contact University groups (e.g., MIT) and that DOE was the lead agency charged with carrying out R&D in the area of nuclear energy. In particular, DAB indicated that PS&E help Furukawa locate appropriate person at DOE for him to communicate with (regarding his ideas) and also at MIT (suggested contacting Michael Golay). I indicated to Furukawa in later private conversation that I would find appropriate name at DOE (possibly Sol Rosen) and send letter to him in Japan with the name and address. Do not expect DOE to be very receptive to his concepts. He left several articles with us outlining his approach.

Conclusion: Do not see this as viable concept (I also indicated to him that he would eventually have to sell concept to the nuclear power industry as ultimate user of his product)--but he has devoted over 30 years to this activity. Per DAB's request will follow thru on DOE and MIT contacts (he knows both Lidsky and Golay). It may be useful for you to contact A. Weinberg and get his impressions of Furukawa and his ideas (for future reference).



June 9, 1992

A Message to Dr. Allan Bromley  
by Kazuo Furukawa

Energy is the basis for solving the world environmental and economic problems including the "North-South" - (poverty) issue. Japan is poor in energy resources; therefore, very keen on Pu-utilization. However, the world (already) is shifting away from the U-Pu fuel cycle.

It is in everyones interest to achieve public acceptance of Nuclear Energy. A step in support of acceptance is the elimination of Pu with the associated Nuclear Terrorism and Safety and Radioactive Waste issues. This will enhance Japan, USA and the world situations.

For this purpose, we are recommending the development of Th-MSR (Thorium Molten Salt Reactor), "USA has a key of this Technology"! The MSR R&D had been done by ORNL (1947-1976-1980). The work was discontinued not for technological reasons.

32 years ago, I was impressed and convinced that MSRs have significant advantages so much that I decided to spend my life on it. The last 12 years, after the MSR work at ORNL was discontinued, but nevertheless with the assistance of ORNL experts, their original concept (MSBR) was further improved by simplification and making it flexible in size so that it is useful for the world-wide application.

However, its fundamental feasibility issues are resolved. Although the detail technology needs to be developed and demonstrated. And now, at first, we have to start from "Small-Reactors" development, not uselessly competing with "Proven Large Reactors" (co-existence) and fully using their technologies such as "Na reactor technology"(=same molten material reactor technology) in safer and easier, by no chemical-activity and thermal-shock.

Therefore, we need not so big MONEY and TIME on it.

At first, we should demonstrate the MSR pilot plant. This can be done easily by \$2~300M and 6 years, except licencing, if we can use ORNL site -- reserved fuel salts and their KNOW-HOW.

Please recognize, a few years later, these valuable basis would be disappeared, as the nearly-last man of MSR Program retired. Please consider the Urgent

Situation. Even could not decide the final decision of Th MSR, we have to retain this Technology for American, Japan and the World Future.

This is generally appreciated by ORNL related peoples, and several foreign groups:

France: Elect. de France, R&D direction

CIS: Russian: Kurchatov Inst. (Dr. Velikhov)

ITEP (Inst. (Theo. Exp. Phys) (Dr. Chuvis<sup>r</sup>o)

-leading inst. for N. weapons - heads  
incineration

Ukraine: Acad. Science -- Furukawa is a foreign member

Belarus: Inst. Phys Chem. P. (Dr. Chigrinov)

Turkish A.E. Authority, Italian, Indian, Indonesian, etc.

Short term goals: Pu-burner

RW-incinerator

Small Nucl. Power Station

Long term goals: Adequate Energy and conserving the Environment  
\$10<sup>14</sup> industry

Develop: 20 years (\$10B)



Situation. Even could not decide the final decision of Th MSR, we have to retain this Technology for American, Japan and the World Future.

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Dr. A. Weinberg

Dr. A. W. Trivelpiece

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Short term goals: Pu-burner

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Small Nucl. Power Station

Long term goals: Adequate Energy and conserving the Environment  
\$10<sup>14</sup> industry

Develop: 20 years (\$10B)

Japan : start the discussions on "New Nuclear Fuel Cycle Option"

• Top Academicians & University peoples — support Th-MSR.

• Opinion leaders : New fuel-cycle without Pu

Journalists : "ASAHI", "Nihon-Keizai" (Japan Economy), "YOMIURI",  
in editorials

Major Electric Company, CRIEPI, ---

• politicians : governmental- , non-governmental- parties

• AEC : Acting Chairman Prof. A. Ooyama ; Former A. Ch. Prof. T. Mukaibo, ---

• STA : Minister Mr. H. Tanigawa , Mr. Ishida (Atomic Enr. Div.)

• Research Association of Th Energy

IWAMOSARD (Int. Work. Associ. MSR Development)

25 countries

I hope to ask you that USA and Japan have to start a working committee for the Assessment of MSR potentials in the world of the next century.



DELEGATE'S NAME: Kazuo FURUKAWA

APPROXIMATE TIME LENGTH: 5 --- 30 min.

LEADER'S NAME: Anthony P. Toste

VISUAL EQUIPMENT REQUIRED: overhead

**TITLE OF PRESENTATION:**

ABST: New proposal of Rational Nuclear-Energy System for Next-Century  
-- Thorium Molten-Salt Nuclear Energy Synergetics [THORIMS-NES] --

Until the industrialization of Solar-Energy near the end of next century, the new global fission industry for the next century should be prepared perfectly and simultaneously solving the following issues all:

(A) resource and environmental problems, (B) safety, (C) nuclear-proliferation and -terrorism, (D) breeding fuel-cycle, chemical processing and radio-wastes, and (E) public and institutional acceptability and economy, including "North-South" problems. This would require a technological revolution.

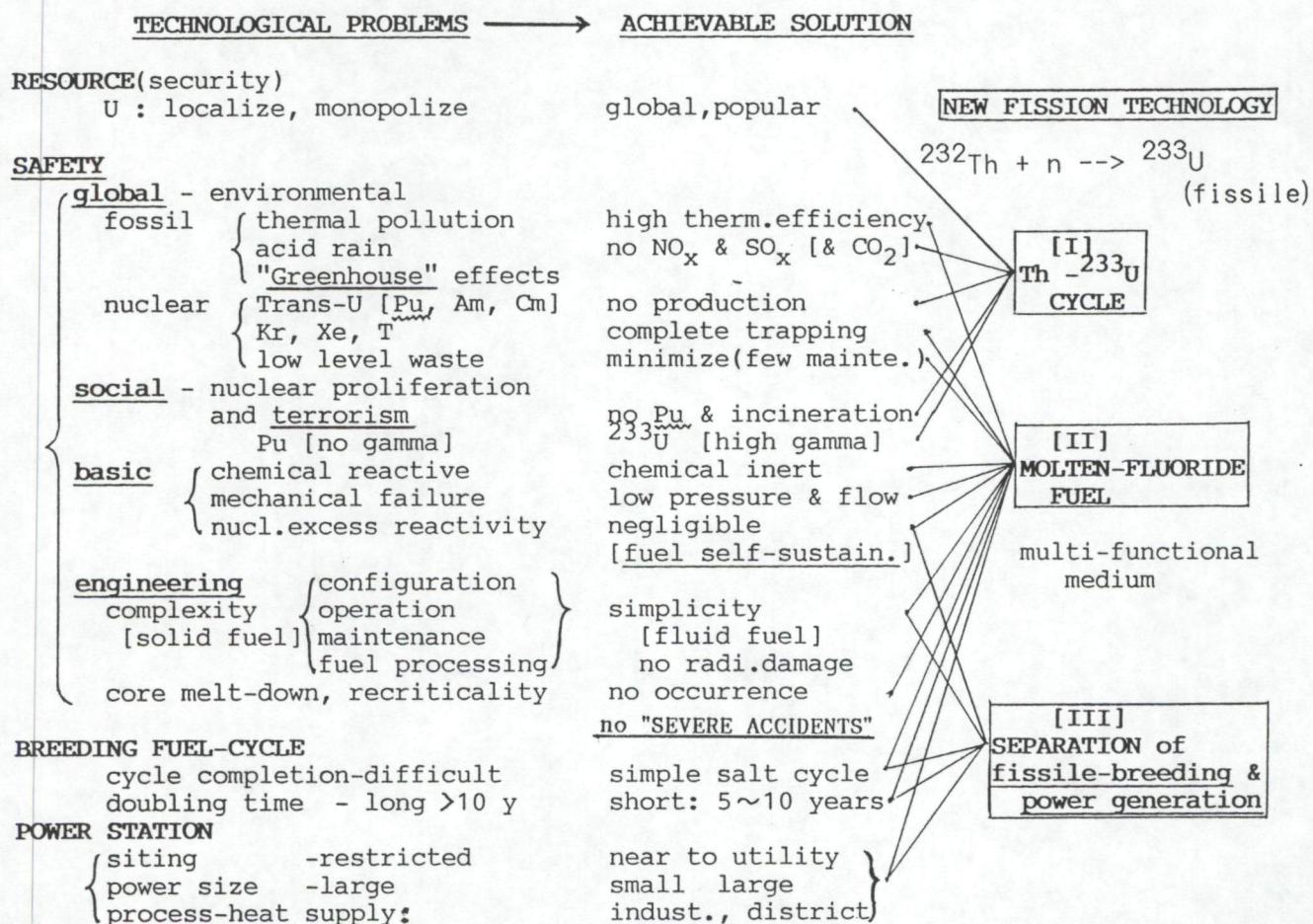
One of the most promising flexible systems to solve the above would be the Thorium Molten-Salt Nuclear Energy Synergetics [THORIMS-NES], which depends on the following three principles:

[I] Thorium utilization: refusing to use U-resource and Pu,

[II] Molten-salt fuel concepts: "Flibe (LiF-BeF<sub>2</sub>) based fluoride" concept basically established by the brilliant long effort of ORNL, USA, in 1947~76.

[III] Separation of fissile-breeding and power-generation: Molten-Salt power-stations are much simpler and size-flexible not similar as MSBR, ORNL.

Already several supports have been given by many foreigners, including ITEP, Moscow, etc.; and Japanese leaders are also starting to reconsider the past nuclear energy policy depending U-Pu fuel cycle.







A Program of  
People to People International  
Dwight D. Eisenhower, Founder  
President George Bush, Honorary Chairman

### Citizen Ambassador Program

## NUCLEAR FUELS MANAGEMENT DELEGATION TO THE COMMONWEALTH OF INDEPENDENT STATES

Dr. Anthony P. Toste, Delegation Leader

### PROPOSED SCHEDULE OF ACTIVITIES

#### Saturday, June 13, 1992

Delegation convenes in NEW YORK CITY. Welcoming reception and luncheon, followed by program orientation and cultural briefing with Citizen Ambassador Program officials and invited guests. Evening departure for MOSCOW. Overnight en route.

#### Sunday, June 14

Arrival in MOSCOW. Remainder of the day at leisure.

#### MOSCOW

*Moscow is one of the most populous cities in the world, as well as Russia's largest metropolis. Once the heart of Soviet political power, Moscow is now the nucleus of the current economic and political transformations taking place in the former Soviet Union. The formation of a new government and the accompanying changes in the distribution of power are among the fundamental issues discussed by the state leaders who meet in this center of reform. The various states are still entwined with Moscow, continuing to make it an important administrative, legislative, economic, and cultural city.*

#### Monday, June 15

Roundtable discussions with representatives from the **Academy of Sciences, the Ministry of Atomic Energy and the Nuclear Industry, and the Science and Technology Commission of the Moscow City Council.**

During these sessions, insight may be gained by all involved through the discussion of topics such as the Commonwealth's approaches and plans for disposal of both high- and low-level radioactive

wastes; the potential danger of radioactive contamination of the environment through possible accidents; scientific and technological progress in the field of nuclear fuels management; world energy output based on nuclear fuel; procedures and practices currently in place to treat, transport, dispose of, and manage nuclear fuels; types and sources of waste; and nuclear safety, engineering, and decommissioning.

#### Tuesday, June 16

Meetings with chemists and chemical engineers from the **I.V. Kurchatov Institute of Atomic Energy**, along with site visits to low-level and municipal waste disposal sites in the area.

Discussions to focus on the management of radioactive and chemically hazardous mixed waste; the relationship between municipal and radioactive waste disposal in Russia, including any safeguards currently in place to prevent comingling of these wastes; the storage of spent nuclear fuels; the training and certification of personnel who handle nuclear waste; the status of nuclear fuels management activities in Russia; and the current fuel cycle and waste management systems.

#### Wednesday, June 17

Transfer to CHELYABINSK. Remainder of the day free for individual activities.

#### CHELYABINSK

*Chelyabinsk, the second largest city in the industrial region of the Urals, is located on the Miass River, 930 miles from Moscow. The city is on the Commonwealth's major east-*

*west railroad route, making it an important transportation center for the region. The area's industrial enterprises include iron and steel plants, a steel-pipe mill, a ferroalloy plant, and a zinc refinery. Industrial development of the city began in the 1930s and was expanded during World War II, when the area became an "atomgrad," a sealed-off society devoted entirely to the process of constructing nuclear weapons and facilities.*

#### Thursday, June 18

Site visits to manufacturing enterprises that produce low-level waste, along with small-group discussion sessions with faculty of the chemistry and physics departments of **Chelyabinsk State University.**

Discussions to focus on the development of analytical methods for characterizing hazardous and radioactive wastes; technologies available or being developed for waste stabilization and isolation; programs for the storage of wastes generated by radiation technology in medicine and manufacturing; public sentiment regarding nuclear power plants; the construction of new nuclear power plants in the future; the various categories of nuclear fuels and wastes; and the current fuel cycle strategy, including reprocessing with recycled plutonium.

#### Friday, June 19

Visit to the site of the 1957 nuclear waste facility accident near Kyshtym, along with site visits to the **Beloyarskiy or Troitsk Nuclear Power Plant** and plutonium factories in the surrounding area.

Topics for discussion during these visits include the training of those who manage nuclear fuels; procedures used to safeguard facilities against intrusion and terrorism;



decontamination and decommissioning procedures for phased-out reactor vessels; the handling, transport, and storage of nuclear wastes; contingency plans in place for potential nuclear accidents; technologies developed after the nuclear accident to deal with both contamination and nuclear fuels; and past and present radiation protection measures.

#### **Saturday, June 20**

Cultural activities for the day to include viewing sites of interest in Chelyabinsk and the surrounding area.

#### **Sunday, June 21**

Transfer to MOSCOW. Remainder of the day reserved for cultural and leisure activities.

Sites of significance in Moscow include the Kremlin, with its walls that have encompassed some of the most important events in the history of the world's first socialist country; Red Square; Izmiliva, a market and park area outside of Moscow; and the Exhibition of National Economic Achievement, where one can gain insight into virtually all aspects of the contemporary life and economic and cultural progress of Moscow.

#### **Monday, June 22**

Transfer to KIEV. Balance of the day at leisure.

### **KIEV**

*Kiev, the capital of Ukraine, is an important industrial and cultural city. As a result of the development of capitalism in Russia during the mid-19th century, the number of industrial establishments in Kiev grew tremendously. Ukraine, with its highly developed and diverse industrial base, is well-known for its airplanes, electronic equipment, and various agricultural commodities. Ukraine also has extensive trade and economic ties with several countries, which keeps the city of Kiev in the forefront of financial activity in the former Soviet Union. Today, the city of Kiev is the political, administrative, cultural, and scientific heart of Ukraine.*

#### **Tuesday, June 23**

Meetings with representatives from the **Ukrainian Academy of Sciences**, Department of Chemistry and Chemical Engineering, and the **Institute of Nuclear Research**.

Topics of interest include the containment structure surrounding the damaged reactor at the Chernobyl Nuclear Power Station; the storage of waste materials; continued safety and fuel management procedures in place at the remaining Chernobyl units; decontamination of the area surrounding the site of the Chernobyl accident; rehabilitation efforts; a comparison of nuclear power plants' effects on the environment with those of a more traditional nature, such as thermal power stations, chemical enterprises, and metallurgical plants; and research and development efforts in the management of spent fuels.

#### **Wednesday, June 24**

Delegates to view sites of interest such as the Pecherskaya Lavra (Monastery of the Caves), which was discovered in 1051 by two monks and has since had several underground churches and monuments built within it; the Museum of Ukrainian Art, which houses a large collection of paintings, drawings, and sculptures covering the development of Ukrainian fine art; St. Vladimir's Cathedral, built to commemorate the 900th anniversary of Christianity in Russia; and Babi Yar, the site of mass murders during the occupation of Kiev, and now a place to honor those victims.

#### **Thursday, June 25**

Meetings with officials from the **Ukrainian Ministry of Health** and faculty from the **Kiev Polytechnic Institute** to discuss the impact of the Chernobyl accident on residents in the surrounding communities; subcritical parameters of the accumulations of nuclear fuels, both passive and active, after the Chernobyl accident; levels of radiation exposure after the nuclear accident; the actual health impact of the disaster for people still living in the region surrounding the Chernobyl AES; the extent and forms of radiation migration from Chernobyl fallout; and

methods and standards used to protect the health and safety of radiation workers and the public.

#### **Friday, June 26**

The day to be spent with representatives of the **Pripyat Research and Industrial Association**.

Site visits during the day to include the **Chernobyl Nuclear Power Station**, the evacuated town of **Pripyat**, and the more recently established town of **Slavutich**, located approximately 40 miles northeast of the Chernobyl Nuclear Power Station, where the plant's workers are now residing.

Discussions to focus on ensuring the safety of the more than 180 tons of nuclear fuels left within Unit No. 4 of the Chernobyl AES; assessing the loss of nuclear fuel after the accident, including how much and what type of radioactivity escaped from the damaged reactor; current risk factors; the creation of a unified system of radio-ecological information that will provide figures on radiation levels and the resultant effects on the general public; a look at the potential phasing out of the plant by 1995; and current monitoring of the remaining fuel reservoirs. Evening transfer to MOSCOW.

#### **Saturday, June 27**

Departure for NEW YORK CITY, with arrival in the afternoon of the same day.

---

*This itinerary represents the types of meetings and visits that will be arranged with the foreign hosts. As the delegation forms and the specialties of the individual delegates become more apparent, visits may be modified to accommodate the professional objectives of the delegation and arrangements made by the hosts.*

*The foreign hosts will arrange a supplementary cultural program that will be tailored to each region's unique cultural attributes. Additional cultural and educational activities will be provided for the accompanying guests who prefer not to participate in the professional program.*





Summit Business Center  
1919 Connecticut Avenue, N.W.  
Washington, D.C. 20009  
Voice (202) 232-0416  
FAX (202) 232-0438

FAX TO: Dr. Lee S. Schroeder

COMPANY: Executive Office of the President

FAX NUMBER: 202-395-3719

SENDER'S NAME: K. Furukawa

NO. OF PAGES SENT (INCLUDING COVER SHEET): 2

DATE SENT: 11th June

**Sender's Comments:**

Dear Dr. Schroeder,

Thank you very much for your kind help and hospitality for me. I am now starting to the next town.

May I ask you to pass my thanks and one attached memo to Dr. Allan Bromley?

Yours sincerely, Kazuo Furukawa

Dear Dr. Bromley

Thank you very much for your kind and friend-like acceptance for me, by which I <sup>was</sup> impressed deeply.

This is not only for me but also for the all of TH-MSR community. MSR had been invented by American. Therefore American should have initiative, and now you are really restarting.

I believe, it is so much important for human. I want to announce it to my colleagues all in the world.

Please help us for the world energy, environment and poverty in the next century.

Yours sincerely, Kazuo Furukawa

P.S. I <sup>was</sup> impressed by the fact that you were a member of ING prog  
(I knew it 30 years ago.)  
Please look at one glance my additive memo.

# GLOBAL NUCLEAR ENERGY in 2020 - 2070

K. Furukawa

PAST  
1965-1990  
2 TWe·year ) -----> ( FUTURE  
2000-2165  
900 TWe·year  
(400-500 times)

energy rich : FISSION --- breeding fuel-cycle  
--- separation of POWER-STATION & FISSILE-PRODUCER ---

neutron poor : supplmt by SPALLATION : Accel. M. S. B.  
or DT-, DD-FUSION

environmental: GREENHOUSE eff.; pollution

radio-waste : (few low-level r.w.  
no TRANS-U elements

Pu full-utilization & incineration

nucl. proliferation:  $^{232}\text{U}$  fatal gamma  
nucl. terrorism :

safety : NO SEVERE ACCIDENT

NORTH-SOUTH problem:

R & D cost : very small

Use of QRNL

Use of liq-Na tech

molten-salt tech. : (chem. inert,  
no thermal-shock

(site  
salt  
O. B. -- KNOW-HOW  
MOLTEN MATERIALS

THORIUM  
MOLTEN-SALT

THORIUM ----->  $^{233}\text{U}$  ----- thermal neutron

( $^{232}\text{U}$ ): intense 2.6 MeV-gamma --- fluid fuel

Out FISSION BREEDER

reasons ( x large only  
x complex --- continuous chem. processing  
x too long doubling -time --- core-graphite exchange  
> 20 years need <10 years

SYNERGETISM : "SPALLATOR" (MSB) process-plant  
fuel-cycle --- | ----- Molten-Salt

"POWER STATION" (MSR) utility facility  
(small and fuel-self-sustainable)

THORIMS - NES  
[THORIUM Molten-Salt Nuclear Energy Synergetics]



EXECUTIVE OFFICE OF THE PRESIDENT  
OFFICE OF SCIENCE AND TECHNOLOGY POLICY  
WASHINGTON, D.C. 20506

July 7, 1992

Dear Professor Furukawa:

I am sorry that I have taken so long in getting back to you but I had to return to California for personal reasons for several weeks and have just recently returned to OSTP.

As you remember from your conversation with Dr. Bromley and myself we indicated that the appropriate agency to continue your discussions of molten salt reactors would be the U.S. Department of Energy (DOE). Below is the name and address of the appropriate person at DOE to whom you should address future inquiries:

Dr. Sol Rosen  
Director, International Nuclear Programs Division  
U. S. Department of Energy  
NE-45/GTN  
Washington, D.C., 20585

It was a pleasure meeting you and I wish you the best of luck with your project.

Sincerely yours,

Lee S. Schroeder  
Assistant Director

Prof. Kazuo Furukawa  
Research Assoc. for Thorium Energy  
Business Center  
Four Seasons Hotel Chinzan-So, Tokyo  
10-8 Sekiguchi 2-Chome, Bunkyo-Ku  
Tokyo 112, JAPAN

EXECUTIVE OFFICE OF THE PRESIDENT  
OFFICE OF SCIENCE AND TECHNOLOGY POLICY  
WASHINGTON, D.C. 20506

July 9, 1992

Dear Dr. Rosen:

As I metioned in our telephone conversation of July 8th, Dr. Bromley and I met with Professor Kazuo Furukawa at the request of Deputy Chief of Staff Henson Moore and Senator Craig on June 9, 1992. Professor Furukawa was interested in discussing his ideas concerning the use of thorium (molten salt) as a uranium-plutonium fuel cycle replacement. During this meeting we indicated that the appropriate U.S. agency for such discussions was the Department of Energy and stated that we would provide him with a potential DOE contact. Enclosed is my letter to him indicating your office as an appropriate point of contact on the subject of molten salt reactors.

Please feel free to get in touch with me if there is any additional information that you might like to have concerning Professor Furukawa's visit to OSTP.

Sincerely,

Lee S. Schroeder  
Assistant Director

Dr. Sol Rosen  
Advanced Reactor Program Office  
U.S. Department of Energy  
NE-45/GTN  
Washington D.C., 20585



"Document Control"

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DIRECTORATE STATUS

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FROM: LONG, Robert L.: AMERICAN NUCLEAR SOCIETY

TO: DR. D.A. BROMLEY

APR 20 1992

DATE OF  
CORRESPONDENCE: 04/06/92

SUBJECT: THEY ARE WRITING TO OFFER THEIR SERVICES IN  
ASSISTING NUCLEAR PROFESSIONALS INVOLVED IN WEAPONS  
RELATED ACTIVITIES TO BE MADE AWARE OF OPPORTUNITIES  
IN PEACEFUL USES OF NUCLEAR TECHNOLOGY.

\*\*\*\*\*  
DIRECTORATE STAFF  
ASSIGNED: PHYSICAL SCIENCES ASSIGNED:

ACTION STAFF  
REQUIRED: DIRECT REPLY ACTION:

\*\*\*\*\*  
SENDER'S DUE DATE:  
OSTP DUE DATE: 05/01/92 STAFF DUE DATE  
DATE COMPLETED: DATE COMPLETED/DEPT:

\*\*\*\*\*  
COPIES TO: D. Allan Bromley

\*\*\*\*\*  
WHITE HOUSE TRACKING #: CONTACT PERSON:  
REMARKS: PHONE: EXT:

OSTP RECEIVED: 04/15/92  
FILE: P-PHYSICAL SCIENCES

DEPT RECEIVED:

CENTRAL FILES: NO CLEAR.



## AMERICAN NUCLEAR SOCIETY

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C000-92-1748

52 APR 15 4:23

MAIL ROOM  
April 6, 1992

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Telex: 4972673

The Honorable Allan D. Bromley  
Assistant to the President for  
Science and Technology Policy  
Old Executive Office Building  
17th Street & Penn Avenue, NW  
Washington, DC 20500

Dear Assistant Bromley:

The American Nuclear Society (ANS) supports the concept of continued development of the peaceful applications of nuclear science and technology throughout the world and assured safety, protection of the environment, and non-proliferation of nuclear materials. Nuclear professionals involved in weapons-related activities need to be made aware of and have available to them training, education and other opportunities which offer experience and, ultimately, employment in the peaceful uses of nuclear technology.

The Society is offering its services including professional placement activities to government, industry and academia to assist these professionals. Additionally, ANS urges its individual and organizational members to consider opportunities for joint international endeavors with foreign counterparts. These efforts will strengthen the international nuclear community and encourage the continued peaceful uses of nuclear science and technology.

Sincerely Yours,

Robert L. Long  
ANS President

/mrh



EXECUTIVE OFFICE OF THE PRESIDENT  
OFFICE OF SCIENCE AND TECHNOLOGY POLICY  
WASHINGTON, D.C. 20506

May 12, 1992

Dear Mr. Long:

I am responding to your letter to Dr. Bromley concerning the expertise of the American Nuclear Society, and the Society's activities to strengthen the international nuclear community and to encourage the continued peaceful uses of nuclear science and technology. The efforts of the Society are very much appreciated and will, I believe, help lead to a future in which nuclear energy plays its logical role in the worldwide energy technology portfolio.

Sincerely,



Karl A. Erb  
Associate Director--Designate  
for Physical Sciences and Engineering

Mr. Robert L. Long  
President  
American Nuclear Society  
555 North Kensington Ave.  
La Grange Park, IL 60525

*I would welcome the  
opportunity to discuss the  
Society's initiatives with  
you.*

"Document Control"

TYPE: ACTION  
ORIGINATOR: 02

DOCUMENT NUMBER: 9201010  
DIRECTORATE STATUS

STATUS 1

\*\*\*\*\*

FROM: BRIGGS, Doras

TO: DR. D.A. BROMLEY

DATE OF  
CORRESPONDENCE: 03/16/92

SUBJECT: SHE IS WRITING REGARDING THE USE OF FORMER SOVIET  
SCIENTISTS FOR RESEARCH ON NUCLEAR WASTE.

\*\*\*\*\*  
DIRECTORATE  
ASSIGNED: INTERNATIONAL/POLICY  
STAFF  
ASSIGNED:

ACTION  
REQUIRED: DIRECT REPLY  
STAFF  
ACTION:

\*\*\*\*\*  
SENDER'S DUE DATE:  
OSTP DUE DATE: 04/10/92  
DATE COMPLETED:  
STAFF DUE DATE  
DATE COMPLETED/DEPT: 4/6/92  
\*\*\*\*\*

COPIES TO: D. Allan Bromley  
PHYSICAL SCIENCES  
ENVIRONMENT

\*\*\*\*\*  
WHITE HOUSE TRACKING #:  
REMARKS: JFR asked KAC to respond to nuclear waste issue  
CONTACT PERSON:  
PHONE:  
EXT:

OSTP RECEIVED: 03/23/92  
FILE: INTERNATIONAL

DEPT RECEIVED:

CENTRAL FILES:



1010 A

MRS. DORAS BRIGGS  
116 Kenyon Avenue  
Kensington, CA 94708-1027  
(510) 525-5220

March 18, 1992

Mr. Allan Bromley  
White House Science Adviser  
The White House  
Washington DC 20500

Dear Mr. Bromley:

Last evening, on the MacNeil-Lehrer program, you talked about what the United States is doing to keep the expertise of former Soviet nuclear scientists out of unfriendly hands.

But I heard no mention of any thought being given to one of nuclear's biggest problems -- the wastes.

Why not pay these scientists to discover a way to either reverse the process by which the wastes are created or at the very least render them benign?

Such a discovery would allay a lot of the health fears and resulting turmoil in this country over where to put the waste. And by that so doing, we could stop taking land out of productive use at a time when the world's population is soaring and needs land on which to survive. Work of this kind might also solve another problem you mentioned -- that of the difficulty of moving military men into civilian work. These scientists would simply continue doing what they do best -- scientific research.

Sincerely,

*Doras Briggs*

cc: Senator Alan Cranston  
Senator Paul Sarbanes  
Senator John Seymour

OSTP  
MAIL ROOM

02 MAR 23 P 3 : 46

RECEIVED



## STAFFING SHEET

**EXTERNAL COORDINATION:**\_\_\_\_\_

**ACTION REQUESTED:**

[illegible]



EXECUTIVE OFFICE OF THE PRESIDENT  
OFFICE OF SCIENCE AND TECHNOLOGY POLICY  
WASHINGTON, D.C. 20506

April 6, 1992

Dear Mrs. Briggs:

Thank you for your letter to Dr. Bromley concerning nuclear waste. In my view, the primary technological issues associated with the safe management of nuclear waste have now been resolved satisfactorily, and what remains is to implement these advances to benefit our society. The evidence that geological repositories can provide safe and permanent storage is convincing. That, however, does not mean we should abandon R&D on alternative approaches, and you will be pleased to hear that we are instituting arrangements that will harness and redirect Russian expertise to this end.

Sincerely,



Karl A. Erb  
Associate Director--Designate  
for Physical Sciences and Engineering

Mrs. Doras Briggs  
116 Kenyon Ave.  
Kensington, CA 94708-1027

cc: D. Allan Bromley