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ANOTHER SETBACK ON TURKEY'S NUCLEAR DREAM

Good news from Turkey. The Akkuyu nuclear power plant tender has been cancelled.

The first response: good news for the anti nuclear activists and the environmentalists all around the world. One of the sunniest, windiest countries of Europe, with lots of energy efficiency and geothermal potential is remain to be a nuclear free state as we wished and campaign for a long time. However, it is expected new tenders will be started by the pro-nuclear government and the fight is far from over.

(698.5994) WISE-Amsterdam - The first signal of cancellation came with the offered high price by the only bidder which is a consortium of Russian Atomstroyexport, Inter Rao and their Turkish partner Park Teknik. The initial offered price was 21 cent per kWh to sell electricity but many experts thought that was a high price for a nuclear power plant. Then the consortium lowered the price to 15 cent per kWh during the private negotiations with the government but was not successful. Anti nuclear campaigners also complained that lowering the offered price after the official bid was not legitimate.

Later on Turkish State Council took a decision in favor of the TMMOB (Union of Chambers of Turkish Engineers and Architects) appeal and decided to declare a motion of stay for the three articles of the nuclear tender regulation. That was the second signal and on November 20, TETAS (Turkish Electricity Trade and Contracting Corporation) announced the cancellation at the end of the dispute. They must have seen that the current bid was going no where but to a difficult court battle.

There was a single consortium in the current bid which offered a price of 21 cent per kWh then lowered it to 15 cent per kWh to sell electricity. The price was also found high in Turkey and got many criticisms.

It is not expected the current government will give up its nuclear dreams but it will have a difficult time to change the regulation and find new bidders for the possible new tender. If they insist, there is also a price hurdle, the new offered price must be lower than 15 cent per kWh otherwise the government will have an explanation to the public.
On November 21, Energy Minister Taner Yildiz was quoted saying "The fact that the tender was scrapped does not mean that the process is scrapped. Our determination on nuclear power plants is persisting."

Sources close to the Energy Ministry say the ministry has already started plans to restart the tender for the plant in Mersin’s Akkuyu district, on the Mediterranean coast, and launch a second tender to build and operate a nuclear power plant in Sinop on the Black Sea in 2010. The government is said to guarantees 15 years of power purchases to encourage investment in the plant, and may have a stake of as much as 25 percent if it is necessary.

Turkey has cancelled four previous attempts to build a nuclear plant, with

plans stretching back to the late 1950s, due to the high cost and environmental concerns.
The decision to cancel also had another dimension as regards international politics. The plant was part of a major push of deals Turkey had agreed with Russia earlier this year to increase cooperation on energy, such as Turkey's permission for Russia's South Stream natural gas pipeline to pass through its territorial waters and Russia's promise to provide oil to Turkey's Samsun-Ceyhan oil pipeline project.

Turkish Energy Minister Yildiz is expected to visit Russia in December for talks on this matter.

Sources: Sunday's Zaman, 22 November 2009; Nuclear Street, 24 November 2009; emails; Ozgur Gurbuz; Ria Novosti, 24 November 2009
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RESTART GO-AHEAD FOR REFURBISHED CANADIAN UNITS

Two reactors at Canada's Bruce A nuclear power plant that have been out of service for over a decade have been given regulatory approval for refueling and restart. Units 1 and 2 at the Bruce A plant have been undergoing a major refurbishment to replace their fuel channels and steam generators plus upgrade ancillary systems to current standards. But refurbishment is over budget by almost $1 billion Canadian dollars, with work more than 12 months behind schedule.

(698.5995) WISE-Amsterdam - The announcement by regulator CNSC that refueling can go ahead means, according to a November 3, World Nuclear News report the project 'looks to be on line for the projected 2010 restarts'. But that was not the whole truth: operator Bruce Power originally hoped the two reactors would be back in service in late 2009 or early 2010. But one of the project's key investors, TransCanada Corp., disclosed on November 4, that the first of the two reactors now won't be online until mid-2011, with the second reactor following about four months later.

The original cost of the project was Can$ 2.75 billion (1 Can$ = 0.95 US$ and 0.63 euro), but an independent review revealed in April 2008 that costs had climbed at least Can$350 million and the overrun could reach Can$650 million. TransCanada then confirmed this past July that the project would cost at least Can$3.4 billion, adding it "may exceed that amount by approximately 10 per cent" – or another Can$340 million. This would bring the total overrun to nearly Can$1 billion, or 36 per cent above the original cost estimate.

TransCanada estimated that 75 per cent of the project is now complete and that Can$3.1 billion has so far been spent. The question is whether the remaining 25 per cent can be done over the next 20 months without hitting more hurdles. The government's original 2005 contract with Bruce Power stipulated that all cost overruns would be equally shared for the first Can$300 million. Beyond that, the province would be required to pay only a quarter of the added cost. That contract was amended in July so that the province wouldn't have to cover any costs beyond Can$3.4 billion. "Any potential cost overruns as a result of the delay are going to be covered by Bruce," said Tang. spokesperson for Ministry of Energy and Infrastructure. Industry critics, however, point out that Bruce may simply pass on those additional costs to crown-owned Atomic Energy, meaning taxpayers ultimately pick up the tab.
Bruce Power is co-owned by uranium miner TransCanada Corp., Cameco Corp., BPC Generation Infrastructure Trust, and two unions representing Bruce Power workers. Cameco, however, opted out of the Bruce A refurbishment project.

Units 1 and 2 at the four-unit Bruce A plant started up in 1977, but unit 2 was shut down in 1995 because a steam generator suffered corrosion after a lead shielding blanket used during maintenance was mistakenly left inside. In the late 1990s then-owner Ontario Hydro decided to lay up all four units at the plant to concentrate resources on other reactors in its fleet, and unit 1 was taken out of service in December 1997 with units 3 and 4 in following in 1998. The four units at sister power station Bruce B continued to operate. Bruce Power took over the operations of both Bruce plants from Ontario Hydro in 2001 and restarted units 3 and 4 by early 2004. Bruce A units 3 and 4 are likely to undergo a similar refurbishment once units 1 and 2 are back in operation.

Bruce Power decided to withdraw its application for a third nuclear power station at Bruce in July, saying it would focus on the refurbishment of the existing Bruce plants rather than building Bruce C. It also announced it was scrapping plans for a second new nuclear plant at Nanticoke in Ontario. On June 29, the government in Ontario announced that it has suspended the procurement of two new reactors for the Darlington nuclear site: the bids were 'shockingly high' (see Nuclear Monitor 691, 16 July 2009)

Sources: World Nuclear News, 3 November 2009; Toronto Star, 5 November 2009
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JAPAN'S TROUBLED PLUTONIUM PROGRAM

Japan's beleaguered 'pluthernal' program, MOX (mixed plutonium-uranium oxide) fuel use in commercial power plants, got off to a troubled start at Kyushu Electric's Genkai Unit 3 Nuclear Power Plant Unit 3 in Saga Prefecture on November 5, with the use of 16 MOX fuel assemblies. Full-time operation of the reactor is scheduled to begin December 2.

(698.5996) Green Action Japan - A round-the-clock sit-in began on the same day in front of Kyushu Electric headquarters in Fukuoka City and messages of support are pouring in from around the country. In less than two days 673 NGO groups signed on to protest and petition METI, Kyushu Electric, and Saga Prefecture demanding that use of MOX fuel at Genkai not go forward. The number of sign-on groups continue to grow.

Over 460,000 citizens are demanding that use of MOX fuel at Genkai be suspended. This and Kyu-shu Electricâ's rush to start use of MOX fuel caused an unprecedented move by the Saga prefectural legislature last month to demand that the utility rescind its original 2 October start-up date, which it did.

On 28 October Japan's nuclear regulator NISA (Nuclear Industrial Safety Agency) admitted that there are no legal grounds for the government's criteria for imported fuel assembly inspection of MOX fuel. This admission was made to an Upper House Diet office. Citizens, and national and Saga prefectural legislators demanded that NISA come to Saga to explain. NISA is yet to do so.

The 'pluthermal' program is one part of Japan's troubled plutonium program. The other two parts which are in deep trouble are the fast breeder program and reprocessing of spent nuclear fuel. Commercialization of the fast breeder reactor program has been delayed 8 times and is nearly 80 years behind original schedule (set for early 1970s, now set for 'by 2050'.) Commercial operation of the Rokkasho reprocessing plant has been delayed 17 times. Completion of active tests is now set for October 2010. However, with a dysfunctional high-level waste vitrification facility, the future of Rokkasho is murky.

On 7 October, NISA stated that it couldn't deny the possibility that the same quality fuel Kansai Electric rejected in August is in Genkai's MOX fuel. (Kansai Electric rejected one-quarter of the fuel that had been manufactured for use in its Takahama Unit 3 and 4 reactors.) Both utilities -- MOX fuel was fabricated at Areva -- MELOX plant in Marcoule, France.

Subsequently, Kyushu Electric refused to disclose pertinent information concerning its self-inspection criteria, stating that Mitsubishi Heavy Industries, their principle contractor for MOX fuel fabrication would not allow the disclosure. (The same kind of information has been released by Kansai Electric and their principle contractor Nuclear Fuel Industries, Ltd.) Kyushu Electric stated that MELOX as-sured them that Kyushu's MOX fuel had no problems like the one found in Kansai Electric MOX fuel, but the utility admitted they were not shown data to confirm this was correct. The concentration of plutonium in Genkai's MOX fuel is unprecedented and exceeds even that used in France.

German nuclear authorities (BMU) initiated an investigatation after Kansai Electric's rejection of Areva MOX fuel. BMU is reported to take the issue seriously. The status of the investigation is unknown.

'The Japanese government spends 64% of its R&D for energy on nuclear. This program to utilize plutonium is the biggest stumbling block to development of renewable energy and energy efficiency in Japan. Prime Minister Hatoyama is woefully ignorant about this reality. The new government must become aware that this detrimental program is merely a lobbyist and bureaucratic haven. It should shut down the program immediately,' stated Aileen Mioko Smith, executive director of Green Action, a Japanese citizens organization campaigning to stop Japan's plutonium program.

The shipment of MOX fuel for use at Genkai and two other plants which took place this spring did not meet MLIT (Ministry of Land, Transport and Infrastructure) requirements. On 26 February, twenty Diet members signed on to an open letter addressing this concern. One of them includes the current MLIT minister Seiji Maehara, and, two other ministers in the Hatoyama government. Future shipments can-not meet this requirement (MOX fuel cask drop test) at this point.

In April a report commissioned by 70 nuclear free local authorities in the UK found that the British-flagged vessels which transport the MOX fuel from Europe to Japan have serious design flaws. Japan's program is dependent on these shipments since there is no commercial MOX fuel plant in Japan to supply electric utilities. Japanese nuclear transports are protested by dozens of en route countries.

Japan's pluthermal program start-up is a decade behind schedule due to a quality control data falsification scandal of Kansai Electric MOX fuel in 1999, citizen protest, nuclear inspection data falsification by Tokyo Electric in 2002, etc. In June electric utilities announced a multi-year delay in the deadline to use MOX fuel in 16-18 reactors, originally scheduled for 2010.

Source: Green Action (Kyoto, Japan) news release, 5 November 2009
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FUSION ILLUSIONS

Nuclear fusion is often seen as a promising technology for large-scale base-load power production and ITER is the international research project that should prove nuclear fusion is possible. On November 18, the ITER Council, the Governing Body of the ITER Organization, convened for its fifth meeting in Cadarache in southern France. At the 4th ITER Council meeting in June it was announced that the date for the first Deuterium-Tritium experiments is now 2026. So, the original plans from 2005 are even before any serious construction has started, already delayed by four years. However, according to an October 13, 2009 article in Nature, construction at the site of ITER has been at a standstill since April this year. Construction won't begin until 2010.
What follows is a reproduction of part of a new publication and concludes that the accumulated knowledge about nuclear fusion is already large enough to conclude that commercial fusion power is not only 50 years away but that it will always be 50 years away

(698.5997) Michael Dittmar - After the Second World War, many nuclear pioneers expected that nuclear fusion would provide their grandchildren with cheap, clean and essentially unlimited energy. Generations of physicists and physics teachers have been taught at the university, and have gone on to teach others, a) that progress made in fusion research is impressive, b) that controlled fusion is probably only a few decades away and c) that - given sufficient public funding - no major obstacles stand between us and success in this field.

Here are some quotes from physics textbooks that reflect this sort of optimism:
* “The goal seems to be visible now” (Nuclear and Particle Physics; Frauenfelder and Henley 1974)
* “It will most likely take until the year 2000 to bring a laboratory reactor to full commercial utilization” (Energy, Resources and Policy; R.Dorf 1978)
*“As the construction of a fusion reactor implies a large number of unsolved practical problems, one can not expect that fusion will become a usable energy resource during some decades! Within a longer time scale however it seems possible!” (Physics, P.A. Tipler 1991)

Obviously this has not happened yet; the fusion optimists have become more modest saying “if everything goes well, the first commercial fusion reactor prototype might be ready in 50 years from now”

Such statements only hide the fact that today we have no idea how to solve the remaining problems. The uncritical media of today waxed enthusiastically about the recent decision by the “world’s leaders” to provide the ten billion dollars needed to start the ITER fusion project [see ITER box].

The public, worried about global warming and oil price explosions, seems to welcome the tacit message that “we - the fusion scientists, the engineers, and the politicians - do everything that needs to be done to bring fusion energy on line before fossil fuel supplies become an issue, and before global warming boils us all.”

In what follows we challenge the assumption that the ITER project has any relation to the energy problem and we quantify the arguments of fusion sceptics. We start our discussion with an overview of the remaining huge problems facing commercial fusion and give a detailed description of why the imagined self-sufficient tritium breeding cycle can not work. In fact, as we are about to see, it seems that enough knowledge has been accumulated on this subject to safely conclude that whatever might justify the 10 billion dollar ITER project, it is not energy research.

Remaining barriers to fusion energy
Producing electricity from controlled nuclear fusion would require overcoming at least four major obstacles. The removal of each obstacle would need major scientific breakthroughs before any reasonable expectation might be formed of building a commercial prototype fusion reactor. It should be alarming that at best only the problems concerning the plasma control, described in point one below, might be investigated within the scope of the ITER project. Where and how the others might be dealt with is anyone’s guess.

These are the four barriers:
***1.** Commercial energy production requires steady state fusion conditions for a deuterium-tritium plasma on a scale comparable to that of today’s standard nuclear fission reactors with outputs of 1 GW (electric) and about 3 GW(thermal) power. The current ITER proposal foresees a thermal power of only 0.4 GW using a plasma volume of 840 m3. Originally it was planned to build ITER with a plasma volume of 2000 m3 corresponding to a thermal fusion power of 1.5 GW, but the fusion community soon realized that the original ITER version would never receive the required funding. Thus a smaller, much less ambitious version of the ITER project was proposed and finally accepted in 2005.

The 1 GW(el) fission reactors of today function essentially in a steady state operation at nominal power and with an availability time over an entire year of roughly 90%. The deuterium-tritium fusion experiments have so far achieved short pulses of fusion power of 15 MW(therm) for one second and 4 MW(therm) for 5 seconds corresponding to a liberated thermal energy of 5 kWh [*1]. The Q value - produced energy over input energy - for these pulses was 0.65 and 0.2 respectively.

If everything works according to the latest plans [*2], it will be 2018 when the first plasma experiments can start with ITER. From there it will take us to 2026, at least another eight years, before the first tritium experiments are tried [The original plans from 2005 are now, even before any serious construction has started, already delayed by four years]. In other words it will take at best 20 years from the agreement by the world's richest countries to construct ITER before one can find out if the goals of ITER, a power output of 0.5 GW(therm) with a Q value of up to 10 and for 400 seconds, are realistic. Compare that to the original ITER proposal which was 1.5 GW(therm), with a Q value between 10-15 and for about 10000 seconds. ITER proponents explain that the achievement of this goal would already be an enormous success. But this goal, even if it can be achieved by 2026, pales in comparison with the requirements of steady state operation, year after year, with only a few minor controlled interruptions.

Previous deuterium-tritium experiments used only minor quantities of tritium and yet lengthy interruptions between successive experiments were required because the radiation from the tritium decay was so excessively high. In earlier fusion experiments, such as JET, the energy liberated in the short pulses came from burning (fusing) about 3 micrograms (3 × 10–6 grams) of tritium, starting from a total amount of 20 gr of tritium. This number should be compared with the few kilograms of tritium required to perform the experiments foreseen during the entire ITER lifetime and still greater quantities that would be required for a commercial fusion reactor. A 400 second fusion pulse with a power of 0.5 GW corresponds to the burning of 0.035 gr (3.5×10–2 grams) of tritium.

A very large number when compared to 3 micrograms, but a tiny number when compared with the yearly burning of 55.6 kilograms of tritium in a commercial 1 GW(therm) fusion reactor.

The achieved efficiency of the tritium burning (i.e., the amount that is burned divided by the total amount required to achieve the fusion pulse) was roughly 1 part in a million in the JET experiment and is expected to be about the same in the ITER experiments, far below any acceptable value if one wants to burn 55.6 kg of tritium per year.

Moreover, in a steady state operation the deuterium-tritium plasma will be "contaminated" with the helium nucleus that is produced and some instabilities can be expected. Thus a plasma cleaning routine is needed that would not cause noticeable interruptions of production in a commercial fusion plant.

Nuclear Fusion

Research into fusion for military purposes began in the early 1940s as part of the Manhattan Project, but was not successful until 1952. Research into controlled fusion for civilian purposes began in the 1950s, and continues to this day.
Nuclear fusion can happen once the short range nuclear force between nucleons becomes larger than the electrostatic repulsive force between two positively charged nuclei. This can happen if the protons involved either have large kinetic energies or if the protons are compressed by super large gravitational fields as observed in stars. Very high kinetic energies correspond to nucleus temperatures of many ten to hundred million degrees. Such high kinetic energies can be obtained for example in accelerators but only for small numbers. Larger amounts of fusion reactions can be obtained in special magnetic field arrangements.
The probability for a fusion reaction depends on the product of the plasma temperature and the fusion reaction cross section. The deuterium-tritium fusion is a factor of 100 to 1000 easier to achieve than the next two fusion reactions of deuterium and Helium-3 and deuterium-deuterium respectively.
As it is already extremely difficult to achieve even the lowest interesting plasma temperatures on the required large scale, it follows that the only possible fusion reaction under reactor conditions is the deuterium-tritium fusion into helium-4.

ITER proponents know that even their self-defined goal (a 400 second long deuterium-tritium fusion operation within the relatively small volume of 840 m3) presents a great challenge. One might wonder what they think about the difficulties involved in reaching steady state operation for a full scale fusion power plant.

***2.** The material that surrounds and contains thousands of cubic meters of plasma in a full-scale fusion reactor has to fulfill two requirements. First, it has to survive an extremely high neutron flux with energies of 14 MeV, and second, it has to do this not for a few minutes but for many years. It has been estimated that in a full-scale fusion power plant the neutron flux will be at least 10-20 times larger than in today's state of the art nuclear fission power plants. Since the neutron energy is also higher, it has been estimated that - with such a neutron flux - each atom in the solid surrounding the plasma will be displaced 475 times over a period of 5 years [*3]. Second, to further complicate matters, the material in the so called first wall (FW) around the plasma will need to be very thin, in order to minimize inelastic neutron collisions resulting in the loss of neutrons (for more details see next section), yet at the same time thick enough so that it can resist both the normal and the accidental collisions from the 100-million-degree hot plasma and for years.

The "erosion" for carbon-like materials from the neutron bombardment has been estimated to be about 3 mm per "burn" year and even for materials like tungsten it has been estimated to be about 0.1 mm per burn year [*3].

In short, no material known today can even come close to meeting the requirements described above. Exactly how a material that meets these requirements could be designed and tested remains a mystery, because tests with such extreme neutron fluxes can not be performed either at ITER or at any other existing or planned facility.

***3.** The radioactive decay of even a few grams of tritium creates radiation dangerous to living organisms, such that those who work with it must take sophisticated protective measures. Moreover, tritium is chemically identical to ordinary hydrogen and as such very active and difficult to contain. Since tritium is also a necessary ingredient in hydrogen fusion bombs, there is additional risk that it might be stolen. So, handling even few kg of tritium foreseen for ITER is likely to create major headaches both for the radiation protection group and for those concerned with the proliferation of nuclear weapons.

Both of these challenges are essentially ignored in the ITER proposal and the only thing the protection groups have to work with today are design studies based on computer simulations. This may not be of concern to the majority of ITER's promoters today, since they will be retiring before the tritium problem starts in something like 10 to 15 years from now [*4]. But at some point it will become a greater challenge also for ITER and especially once one starts to work on a real fusion experiment with many tens of kilograms of tritium.

***4**. Problems related to tritium supply and self-sufficient tritium breeding will be discussed in detail in section 'The illusion of tritium self-sufficiency'. But first it will be useful to describe qualitatively two problems that seem to require simultaneous miracles if they are to be solved.

* The neutrons produced in the fusion reaction will be emitted essentially isotropically in all directions around the fusion zone. These neutrons must somehow be convinced to escape without further interactions through the first wall surrounding the few 1000 m3 plasma zone. Next, the neutrons have to interact with a “neutron multiplier” material like beryllium in such a manner that the neutron flux is increased without transferring too much energy to the remaining nucleons. The neutrons then must transfer their energy without being absorbed (e.g. by elastic scattering) to some kind of gas or liquid, like high pressure helium gas, within the lithium blanket. This heated gas has to be collected somehow from the gigantic blanket volume and must flow to the outside. This heat can be used as in any existing power plant to power a generator turbine. This liquid should be as hot as possible, in order to achieve reasonable efficiency for electricity production. However, it is known that the lithium blanket temperature can not be too high; this limits the efficiency to values well below those from today's nuclear fission reactors, which also do not have a very high efficiency.

ITER

ITER began in 1985 as a collaboration between the European Union, the USA, the then Soviet Union, and Japan and on 28 June 2005, it was officially announced that ITER will be built in Cadarache, France. On November 21, 2006, seven participants (China, European Union, India, Japan, Korea, Russian and USA) formally agreed to fund the creation of the nuclear fusion reactor. The program is anticipated to last for 30 years – 10 for construction, and 20 of operation. ITER was originally expected to cost approximately €5billion (US$7.5 bn), but the rising price of raw materials and changes to the initial design may see that amount double. Site preparation has begun in Cadarache, France and procurement of large components has started. However, after 4 years there is already a four year delay, and construction stopped totally in April 2009 and will not resume before 2010.

ITER was originally an acronym for International Thermonuclear Experimental Reactor, but that title was dropped due to the negative popular connotation of "thermonuclear," especially when in conjunction with "experimental".

Once the heat is extracted and the neutrons are slowed sufficiently, they must make the inelastic interaction with the Li-6 isotope, which makes about 7.5% of the natural lithium. The minimal thickness of the lithium blanket that surrounds the entire plasma zone has been estimated to be at least 1 meter. Unfortunately, lithium like hydrogen (tritium atoms are chemically identical to hydrogen) in its pure form is chemically highly reactive. If used in a chemical bound state with oxygen, for example, the oxygen itself could interact and absorb neutrons, something that must be avoided. In addition, lithium and the produced tritium will react chemically - which is certainly not included in any present computer modeling – and some tritium atoms will be blocked within the blanket. Unfortunately, additional neutron and tritium losses can not be allowed as will be described in more detail in section 'The illusion of tritium self-sufficiency'.

• Next, an efficient way has to be found to extract the tritium quickly, and without loss, from this lithium blanket before it decays. We are talking about a huge blanket here, one that surrounds the few 1000 m3 plasma volume. Extracting and collecting the tritium from this huge lithium blanket will be very tricky indeed, since tritium penetrates thin walls relatively easily, and since accumulations of tritium are highly explosive. (An interesting description of some of these difficulties that have already been encountered in a small scale experiment can be found in reference [*5].)

Finally assuming we get that far, the extracted and collected tritium and deuterium, which both need to be extremely clean, need to be transported, without losses, back to the reactor zone.

Each of the unsolved problems described above is, by itself, serious enough to raise doubts about the success of commercial fusion reactors. But the self-sufficient tritium breeding is especially problematic, as will be described in the next section.

The illusions of tritium self-sufficiency

The fact is, a self-sustained tritium fusion chain appears to be not simply problematic but absolutely impossible. To see why, we will now look into some details based on what is already known about this problem.

A central quantity for any fission reactor is its criticality, namely that exactly one neutron, out of the two to three neutrons “liberated” per fission reaction, will enable another nuclear fission reaction. More than 99% of the liberated fission energy is taken by the heavy fission products such as barium and krypton and this energy is relatively easily transferred to a cooling medium. The energy of the produced fission neutrons is about 1 MeV. In order to achieve the criticality condition, the surrounding material must have a very low neutron absorption cross section and the neutrons must be slowed down to eV energies. For a self-sustained chain reaction to happen, a large amount of

U235, enriched to 3-5%, is usually required. Once the nominal power is obtained, the chain reaction can be regulated using materials with a very high neutron absorption cross section.

In contrast to fission reactions, only one 14 MeV neutron is liberated in the D + T - He + n fusion reaction. This neutron energy has to be transferred to a medium using elastic collisions. Once this is done, the neutron is supposed to make an inelastic interaction with a lithium nucleus, splitting it into tritium and helium.

Starting with the above reaction one can calculate how much tritium burning is required for continuously operating commercial fusion reactor assuming a power production of 1 GW(thermal)[This is relatively small compared to standard 3 GW(thermal) fission reactors which achieve up to 95% steady state operation]. One finds that about 55.6 Kg of tritium needs to be burned per year with an average thermal power of 1 GW.

Today tritium is extracted from nuclear reactors at extraordinary cost - about 30 million US dollar per kg from Canadian heavy water reactors. These old heavy water reactors will probably stop operation around the year 2025 and it is expected that a total tritium inventory of 27 kg will have been accumulated by that year [*6]. Once these reactors stop operating, this inventory will be depleted by more than 5% per year due to its radioactive decay alone -tritium has a half-life of 12.3 years. As a result, for the prototype “PROTO” fusion reactor, which fusion optimists imagine to start operation not before the year 2050, at best only 7 kg of tritium might remain for the start (Normal fission reactors produce at most 2-3 kg per year and the extraction costs have been estimated to be 200 million dollars per kg [*6].). It is thus obvious that any future fusion reactor experiment beyond ITER must not only achieve tritium self-sufficiency, it must create more tritium than it uses if there are to be any further fusion projects. The particularly informative website of professor Abdou from UCLA, one of the world’s leading experts on tritium breeding, gives some relevant numbers both about the basic requirements for tritium breeding and the state of the art today [*7].

But first things first: Understanding such “expert” discussions requires an acquaintance with some key terms:

- The “required tritium breeding ratio”, rTBR, stands for the minimal number of tritium nuclei which must be produced per fusion reaction in order to keep the system going. It must be larger than one, because of tritium decay and other losses and because of the necessary inventory in the tritium processing system and the stockpile for outages and for the startup of other plants. The rTBR value depends on many system and technology parameters.
- The “achievable tritium breeding ratio”, aTBR, is the value obtained from complicated and extensive computer simulations - so-called 3-dimensional simulations - of the blanket with its lithium and other materials. The aTBR value depends on many parameters like the first wall material and the incomplete coverage of the breeding blanket.
- Other important variables are used to define quantitatively the value of the rTBR. These include: (1) the “tritium doubling time”, the time in years required to double the original inventory; (2) The “fractional tritium burn up” within the plasma, expected to be at best a few %; (3) The “reserve time”, the tritium inventory required in days to restart the reactor after some system malfunctioning with a related tritium loss; and (4) The ratio between the calculated and the experimentally obtained TBR.

The handling of neutrons, tritium and lithium requires particular care, not only because of radiation, but also because tritium and lithium atoms are chemically very reactive elements. Consequently, real-world, large-scale experiments are difficult to perform and our understanding of tritium breeding is based almost entirely on complicated and extensive computer simulations, which can only be done in a few places around the world.

Some of these results are described in a publication by Sawan and Abdou from December 2005 [*8]. The authors assume that a commercial fusion power reactor of 1.5 GW (burning about 83 kg of tritium per year) would require a long-term inventory of 9 kg and they further assume that the required start-up tritium is available. They argue that according to their calculations, the absolute minimum rTBR is 1.15, assuming a doubling time of more than 4 years, a fractional tritium burn-up larger than 5% and a reserve time of less than 5 days. Requiring a shorter doubling time of 1 year, their calculations indicate that the rTBR should be around 1.5. Other numbers can be read from their figures. For example one finds that if the fractional burn-up would be 1% the rTBR should be 1.4 for a 5 year doubling time and even 2.6 for a 1 year doubling time. To compare: the fractional tritium burn-up during the short MW pulses in JET was roughly 0.0001%.

The importance of short tritium doubling times can be understood easily using the following calculation. Assuming these numbers can be achieved and that 27 kg tritium (2025) minus the 9 kg long term inventory, would be available at start-up, then 18 kg could be burned in the first year. A doubling time of 4 years would thus mean that such a commercial 1.5 GW(thermal) reactor can operate at full power only 8 years after the start-up.

And if anything these rTBR estimates are far too optimistic since a number of potential losses related to the tritium extraction, collection and transport are not considered in today’s simulations.

The details become even more troubling when we turn to the tritium breeding numbers that have been obtained with computer simulations.

After many years of detailed studies, current simulations show that the blanket designs of today have, at best, achieved TBR’s of 1.15. Using this number, Sawan and Abdou conclude that theoretically a small window for tritium self-sufficiency still exists. This window requires (1) a fractional tritium burn up of more than 5%, (2) a tritium reserve time of less than 5 days and (3) a doubling time of more than 4 years. But using these numbers, the authors believe it is difficult even to imagine a real operating power plant. In their words, “for fusion to be a serious contender for energy production, shorter doubling times than 5

years are needed”, and the fact is, doubling times much shorter than 5 years appear to be required, which means TBR’s much higher than 1.15 are necessary. To make matters worse, they also acknowledge that current systems of tritium handling need to be explored further. This probably means that the tritium extraction methods from nuclear fission reactors are nowhere near meeting the requirements.

Sawan and Abdou also summarize various effects which reduce the obtained aTBR numbers once more realistic reactor designs are studied and structural materials, gaps, and first wall thickness are considered. For example they find that as the first wall, made of steel, is increased by 4 cm starting from a 0.4 cm wall, the aTBR drops by about 16%. It would be interesting to compare these assumptions about the first wall with the ones used in previous plasma physics experiments like JET and the one proposed for ITER. Unfortunately, we have so far not been able to obtain any corresponding detailed information. However,
as it is expected that the first wall in a real fusion reactor will erode by up to a few mm per fusion year, the required thin walls seem to be one additional impossible assumption made by the fusion proponents.

Other effects, as described in detail by Sawan and Abdou [*8], are known to reduce the aTBR even further. The most important ones come from the cooling material required to transport the heat away from the breeding zone, from the electric insulator material, from the incomplete angular coverage of the inner plasma zone with a volume of more than 1000 m3 and from the plasma control requirements.

This list of problems is already very long and shows that the belief in a self-sufficient tritium chain is completely unfounded. However, on top of that, some still very idealized TBR experiments have been performed now. These real experiments show, according to Sawan and Abdou [*8], that the measured TBR results are consistently about 15% lower than the modeling predicts. They write in their publication: “the large overestimate (of the aTBR) from the calculation is alarming and implies that an intense R&D program is needed to validate and update .. our ability to accurately predict the achievable TBR.”

One might conclude that a correct interpretation could have been:
Today’s experiments show consistently that no window for a self-sufficient tritium breeding currently exists and suggest that proposals that speak of future tritium breeding are based on nothing more than hopes, fantasies, misunderstandings, or even intentional misrepresentations.

Ending the dreams about controlled nuclear fusion

As we have explained above, there is a long list of fundamental problems concerning controlled fusion. Each of them appears to be large enough to raise serious doubts about the viability of the chosen approach to a commercial fusion reactor and thus about the 10 billion dollar ITER project.

Those not familiar with the handling of high neutron fluxes or the possible chemical reactions of tritium and lithium atoms might suppose that these problems are well known within the fusion community and are being studied intensively. But the truth is, none of these problems have been studied intensively and, at best, even with the ITER project, the only problems that might be studied relate to some of the plasma stability issues outlined in section 'Remaining barriers to fusion energy'. All of the other problem areas are essentially ignored in today’s discussions among “ITER experts”.

Confronted with the seemingly impossible tritium self-sufficiency problem that must be solved before a commercial fusion reactor is possible, the “ITER experts” change the subject and tell you that this is not a problem for their ITER project. In their view it will not be until the next generation of experiments - experiments that will not begin for roughly another 30 years according to official plans - that issues related to tritium self-sufficiency will have to be dealt with. Perhaps they are also comfortable with the fact that neither the problems related to material aging due to the high neutron flux nor the problems related to tritium and lithium handling can be tested with ITER. Perhaps they expect miracles from the next generation of experiments.

However among those who are not part of ITER and those who do not expect miracles, it seems that times are changing. More and more scientists are coming to the conclusion that commercial fusion reactors can never become reality. Some are even receiving a little attention from the media as they argue louder and louder that the entire ITER project has nothing to do with energy research [*9].

One scientist who should be receiving more attention than he is, is Professor Abdou. In a presentation in 2003 that was prepared on behalf of the US fusion chamber technology community for the US Department of Energy (DOE) Office of Science on Fusion Chamber Technology he wrote that “Tritium supply and self-sufficiency are ‘Go-No Go’ issue for fusion energy, [and are therefore] as critical NOW as demonstrating a burning plasma” [capitalization in original]. He pointed out that “There is NOT a single experiment yet in the fusion environment that shows that the DT fusion fuel cycle is viable. He said that “Proceeding with ITER makes Chamber Research even more critical” and he asked *“What should we do to communicate this message to those who influence fusion policy outside DOE?”* [*10]. In short, to go ahead with ITER without addressing these chamber technology issues makes no sense at all. In light of everything that has been said in this section, it seems clear that this is what should be done:

Tell the truth to the tax payers, the policy makers and to the media; tell them that, after 50 years of very costly fusion research conducted at various locations around the world, enough knowledge exits to state:
1. that today’s achievements in all relevant areas are still many orders of magnitude away from the basic requirements of a fusion prototype reactor;
2. that no material or structure is known which can withstand the extremely high neutron flux expected under realistic deuterium-tritium fusion conditions; and
3. that self-sufficient tritium breeding appears to be absolutely impossible to achieve under the conditions required to operate a commercial fusion reactor.

It is late, but perhaps not too late, to acknowledge that the ITER project is at this point nothing more than an expensive experiment to investigate some fundamental aspects of plasma physics. Since this would in effect acknowledge that the current ITER funding process is based on faulty assumptions and that ITER should in all fairness be funded on equal terms with all other research projects, acknowledging these truths will not be easy. But it is the only honest thing to do.

It is also the only path that will allow us to transfer from ITER to other more promising research the enormous resources and the highly skilled talents that need now to be brought to bear on our increasingly urgent energy problems. In short, this is the only path that will allow us to stop “throwing good money after bad” and to start dealing with our emerging energy crisis in a realistic way.

References:
[*1] See for example John Wesson, The Science of JET, March 2000 at http://www.jet.efda.org/documents/books/wesson.pdf and chapter 14 and Appendix I
for the timeline of the JET experiments.
[*2] The new, four year delayed date for the first Deuterium-Tritium experiments in 2026 has been announced at the 4th ITER Council meeting in June 2009 as described at http://www.iter.org/proj/Pages/ITERMilestones.aspx. However, it seems that nothing goes as planned. According an article in Nature, October 13, 2009, ITER is at a standstill since April
[*3] For some more details see the presentation by B. D. Wirth, www.nuc.berkeley.edu/courses/classes/NE39/Wirth-FusionMaterials lecture2.pdf and by S. J. Zinkle (2004) page 47 http://fire.pppl.gov/aps dpp04 zinkle.pdf.
[*4] It seems that the ITER people are working on a new quantitative construction and operation timeline as details are currently not specified on the ITER homepage. However a qualitative overview can be be found at http://www.iter.org/PROJ/Pages/ITERAndBeyond.aspx. The original 50 year timeline towards the realization of the DEMO and PROTO fusion devices are described at http://www.fusion.org.uk/culham/fasttrack.pdf.
[*5] J. L. Anderson; Journal of fusion Energy, Vol 4, Nos. 2/3, 1985 and www.springerlink.com/content/m34445687252l544/.
[*6] See for example M. Abdou, Notes for Informal Discussion with Senior Fusion Leaders in Japan (JAERI and Japanese Universities”, March 24, 2003.
[*7] The website of Prof. M. Abdou; www.fusion.ucla.edu/abdou/.
[*8] M. E. Sawan and M. A. Abdou; Fusion Engineering and Design 81 (2006) 1131.
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[*10] M. Abdou, briefing to DOE Office of Science, Washington June 3, 2003 at www.fusion.ucla.edu/abdou/abdou%20presentations/2003/orbach%20pres%20(6-1-03)%20Final1.ppt.

Source and contact: The Future of Nuclear Energy: Facts and Fiction. Chapter IV: Energy from Breeder Reactors and from Fusion? (13 November 2009), Michael Dittmar, Institute of Particle Physics, ETH, 8093 Zurich, Switzerland.
The whole chapter is available at: http://arxiv.org/PS_cache/arxiv/pdf/0911/0911.2628v1.pdf

NIGER: AREVA FAILS TO ADDRESS RADIATION PROBLEM

A Greenpeace team visited Areva's two uranium mines in Niger from 1-9 November. During the visit Greenpeace found dangerous levels of radiation in the streets of Akokan, a mining city located close to both mines. Areva had earlier declared the streets safe.

(698.5998) Greenpeace International - On November 26, Greenpeace is releasing the first results of its survey to the authorities and companies involved, and calling for an independent inspection, followed by a comprehensive clean-up to address the impacts of the French nuclear company’s activities in Niger.

“Areva’s mining operation has created a radioactive threat to the people of Akokan; one that it has failed to address despite two years of effort.” said Dr. Rianne Teule of Greenpeace International, “It is time for a full and independent inspection of this area.”

In 2007 the independent French laboratory CRIIRAD identified the problem of radioactive debris from the mines being used as building materials in the streets of Akokan [1] and reported this to Areva and local authorities.

According to Areva, shortly afterwards Akokan was checked and 11 locations with high radiation levels were cleaned up [2]. A map made by Areva’s mining company after the clean-up shows that radiation levels at those 11 locations were close to or at normal background levels, implying the town was safe.
The Greenpeace team performed a small survey in the streets of Akokan, on and around the 11 locations. The survey identified seven locations with significant radiation levels [3]. At three locations, the Greenpeace measurements directly contradict the data on the Areva map. In one area the levels were as high as 63 microSv/hr at 5 cm, almost 500 times higher than normal background levels.

“These radiation levels represent a danger to human health. People spending time in the streets could be exposed to a significant dose of radiation. There is a further risk that radioactive dust could be released from the contaminated spots. Inhaling radioactive dust is a serious health risk.” says Dr. Paul Johnston from Greenpeace Science Unit at the University of Exeter. “The town should be cleaned up immediately.”

This scandal demonstrates again that the nuclear industry is a threat to the environment. Greenpeace calls for the whole town of Akokan to be thoroughly inspected, followed by an exhaustive clean-up, to ensure residents are safeguarded from the risks of the uranium mines.

Notes:

[1] Note CRIIRAD N°07-53, Présence de matériaux radioactifs dans le domaine public à ARLIT et AKOKAN (Niger), à proximité des mines SOMAÏR et COMINAK (AREVA), CRIIRAD, 14 May 2007.

[2] Greenpeace Briefing Nov 2009, http://www.greenpeace.org/raw/content/international/press/reports/briefing-radioactivity-in-ak.pdf

[3] "Correspondance en date du 6 octobre 2008 avec les Service Départemental des Mines sur le contrôle radiologique de la zone urbaine accompagnée d'une carte des travaux effectuées", document provided by Areva, 4 November 2009.

Source: Greenpeace International, Press Release, 26 November 2009

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IN BRIEF

Uranium important for Australia? Do you think uranium is an important factor for the economy of Australia? Well, in the ocean of Australia's mineral exports, uranium makes up little more than a drop. The minerals industry shipped about A$ 160 billion (US$150 bn, Euro 98 bn) in commodities last financial year, and less than 1 per cent of that was uranium. But the story of uranium has never been just about the money. A result of the country's long political unease with the uranium sector is the unique patchwork of regulations in different states. The federal Labor Party shed its 1984 ''three mines'' policy in 2007; this July, the former anti-nuclear campaigner and present Environment Minister, Peter Garrett, approved the country's fourth mine, FourMile, in South Australia. The policies of the states and territories, however, remain more ambivalent. South Australia permits both uranium mining and exploration, as does the Northern Territory. The Territory's resources minister, Kon Vatskalis, made much last week of his dedicated Chinese and Japanese investment strategy. ''We are expecting a number of significant announcements over the coming months,'' Vatskalis said, citing prospective investment deals across a number of commodities including iron ore, copper, lead, zinc, nickel, and uranium. In Western Australia, the state's Coalition Government has rescinded the ban on uranium mining. The Labor Opposition is committed to reinstating the ban. And in Queensland, the Labor Government permits exploration but not mining.
Sydney Morning Herald, 1 November 2009

Wanna have a laugh? South Africa, plagued by chronic power shortages, plans to have 20,000 megawatts new nuclear capacity up and running by 2020, Energy Minister Dipuo Peters told a nuclear conference on November 20. "It's a huge project, and in any project situation you plan with the end in sight, so we are looking at 2020," she said.
Last year, state-owned power utility Eskom, which operates Africa's sole nuclear power plant with a total capacity of 1,800 MW, reported record losses and has no money for its aggressive expansion program that also included at least two 1,200 MW light water reactors (LWR). Eskom postponed a contract award for the LWR units last December.
Besides that, the development of the High Temperature PBMR reactor was plagued by setbacks, and Speaking at the World Nuclear Association (WNA) on September 11, PBMR CEO Jaco Kriek said construction of a prototype plant has been "indefinitely postponed" due to financial constraints. According to the Energy Minister, the South African government has since taken the lead in developing the next power station, saying it wants to develop a local nuclear industry in partnership with a technology firm rather than adopt a commercial bidding process used by Eskom.
Laughed enough? Oke, one more…
The Energy Collective.com, 12 September 2009 / Reuters, 20 November 2009

Petten: flashlight missing results in near-meltdown. No, not a joke, or plot of the latest John Grisham book; it really happened at the research reactor in Petten, The Netherlands. It goes like this:
"On a winter night in December 2001 there was a power failure in North Holland, where Petten is located. The nuclear reactor is a research reactor, not a power reactor; it needs electricity to operate, for instance to pump cooling water. The reactor has a back-up cooling system to prevent meltdown of the core in case of a power failure. But this evening the back-up cooling system failed to come into action and the operators did not know what to do. There is an extra safety system by convection cooling for which the operators had to open a valve, but the control room was dark. When they reached for a torch that should have been there, it had been taken away by a colleague to work under his car. Trying their luck the operators put the valve of the convection cooling in what they thought was the `open position. But then the lights came back on and the operators discovered they had actually closed the back-up convection cooling system. Had the power failure lasted longer it would have meant meltdown and a major disaster. When I learned about this some months later - they thought they could keep it secret - I did not think I could take responsibility any longer and I resigned from the ECN."
This is one paragraph in a more philosophical book ('Darwin meets Einstein') which was published on November 23. Especially this section got some attention (although not as much as expected), also because the nuclear regulator (Kernfysische Dienst) did mention it on a list of accidents in 2001 (in December 2002), but was clearly not informed about the seriousness and possible consequences of the accident stating that "there has not been an unsafe situation".
Laughed enough now? Then back to work!
Laka Foundation, 24 November 2009to.

WISE/NIRS NUCLEAR MONITOR

The Nuclear Information & Resource Service was founded in 1978 and is based in Washington, US. The World Information Service on Energy was set up in the same year and houses in Amsterdam, Netherlands. NIRS and WISE Amsterdam joined forces in 2000, creating a worldwide network of information and resource centers for citizens and environmental organizations concerned about nuclear power, radioactive waste, radiation, and sustainable energy issues.

The WISE/NIRS Nuclear Monitor publishes international information in English 20 times a year. A Spanish translation of this newsletter is available on the WISE Amsterdam website (www.antenna.nl/wise/esp). A Russian version is published by WISE Russia and a Ukrainian version is published by WISE Ukraine. The WISE/NIRS Nuclear Monitor can be obtained both on paper and in an email version (pdf format). Old issues are (after two months) available through the WISE Amsterdam homepage: www.antenna.nl/wise.

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