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Desalination of Seawater Using Nuclear Energy

تحلية مياه البحر باستخدام الطاقة النووية

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Abstract: Desalination technologies have been well established since the mid 20th century and are widely deployed in many parts of the world having acute water scarcity problems. The energy for these plants is generally supplied in the form of either steam or electricity largely using fossil fuels. The intensive use of fossil fuels raises environmental concerns especially in relation to greenhouse gas emissions. The depleting sources and the future price uncertainty of the fossil fuels and their better use for other vital industrial applications is also a factor to be considered for sustainability. The desalination of seawater using nuclear energy is a feasible option to meet the growing demand of potable water. Over 150 reactor-years of operating experience of nuclear desalination have been accumulated worldwide. Several demonstration programs of nuclear desalination are also in progress to confirm its technical and economic viability under country specific conditions, with technical co-ordination or support of IAEA. Recent techno-economic feasibility studies carried out by some Member States indicate the competitiveness of nuclear desalination. This paper presents the salient activities on nuclear desalination in the Agency and in the interested member states. Economic research on further water cost reduction includes investigation on utilization of waste heat from different reactor types for thermal desalination, pre- heat reverse osmosis and hybrid desalination systems. The main challenge for the large-scale deployment of nuclear seawater desalination is the lack of infrastructure and resources in the countries affected by water scarcity problems which are however, interested in adoption of nuclear desalination for the sustainable water resources. Socio-economic & environmental aspects and the public perception are also important factors requiring greater information exchange.

Keywords: *Water scarcity, Potable water, Nuclear desalination, Accumulated experiences, IAEA.*

المستخلص: تأسست تقنيات تحلية مياه البحار منذ منتصف القرن العشرين ويتم تطبيقها على نطاق واسع في مناطق كثيرة من العالم، وخصوصاً تلك التي تعاني من مشكلة ندرة المياه الحادة. وبشكل عام، تُستمد الطاقة اللازمة لتشغيل محطات التحلية من الوقود الإحفوري، سواء على هيئة بخار أو كهرباء. إلا أن الاستخدام المكثف للوقود الإحفوري يثير من المخاوف البيئية، وخصوصاً تلك المتعلقة بانبعاث غازات ظاهرة الدفيئة المؤدية إلى تغير المناخ. كما أن نفاد هذه المصادر، وتقلب أسعارها، وامكانية استخدامها بصورة أجدى لتطبيقات صناعية حيوية أخرى، جميعها تمثل عوامل أخرى ينبغي النظر لها لتحقيق استدامة هذه العملية. حالياً تبدو عملية تحلية مياه البحار باستخدام الطاقة النووية خياراً عملياً ملائماً لمواجهة الطلب المستمر على المياه الصالحة للشرب. ولقد تراكمت خبرة تصل إلى أكثر من 150 مفاعل-سنة في مجال تشغيل محطات التحلية باستخدام الطاقة النووية على مستوى العالم، كما يوجد حالياً العديد من البرامج التوضيحية للتحلية باستخدام الطاقة النووية لتأكيد قابليتها للتطبيق من الناحية التقنية والاقتصادية تحت الظروف الخاصة لمختلف الدول، وبتنسيق تقني أو دعم من قبل الوكالة العالمية للطاقة الذرية (IAEA). ولقد أوضحت الدراسات التقنية-الاقتصادية الحديثة التي قامت بها بعض الدول الأعضاء تنافسية تحلية المياه باستخدام الطاقة النووية. توضح هذه الورقة أبرز البرامج والأنشطة التي تقوم بها الوكالة العالمية للطاقة الذرية في مجال التحلية النووية سواء في الوكالة أو في الدول الأعضاء التي لديها اهتمام في هذا المجال. كما توضح الورقة الأبحاث الاقتصادية القائمة لخفض تكلفة إنتاج المياه العذبة، والتي تشمل: دراسة سبل الاستفادة من الطاقة الحرارية الناتجة كعادم فائض من التحلية الحرارية، وتقنية التناضح العكسي، وتقنيات التحلية الهجينة. وتوضح الورقة بأن التحدي الرئيس الذي يواجه الانتشار الكبير لعملية التحلية باستخدام الطاقة النووية هو عدم وجود البنية التحتية والموارد في الدول التي تعاني من مشاكل ندرة الموارد المائية والتي ترغب في تبني هذه التقنيات. كما أن الجوانب الاجتماعية-الاقتصادية، والبيئية، ونظرة العامة وتقبلهم لهذه التقنيات تعتبر من العوامل المهمة التي تستدعي تبادل أكثر للمعلومات بهذا الخصوص. الناحية التقنية والاقتصادية تحت الظروف الخاصة لمختلف الدول.

كلمات مدخلية: *المياه، ندرة، مياه الشرب، تحلية نووية، خبرات متراكمة، IAEA.*

Introduction

Water, energy and environment are essential inputs for the sustainable development of society in the coming years and are therefore aptly mentioned as life support systems. These are therefore current issues of deliberations at national and international forums. Seventy percent of the planet is covered with water but only 2.5% of that is fresh water. Nearly 70% of this fresh water is frozen in the icecaps of Antarctica and Greenland. Most of the rest is in the form of soil moisture or in deep inaccessible aquifers, or comes in the form of monsoons and floods that are difficult to contain and exploit. Less than 0.08% of the world's water is thus readily accessible for direct human use, and even that is very unevenly distributed.

Recent statistics show that currently 2.3 billion people live in water-stressed areas and among them 1.7 billion live in water-scarce areas, where the water availability per person is less than 1000 m^3/year. In fact, the situation is going to worsen further, statistics show that by 2025 the number of people suffering from water stress or scarcity could swell to 3.5 billion and 2.4 billion of them are expected to live in water-scarce regions. Water scarcity is a global issue, and every year new countries are affected by growing water problems.

In the light of this, the Millennium Declaration by UN General Assembly in 2000 set up a target to halve, by the year 2015, the world population who are unable to reach, or to afford, safe drinking water. Vision 21, shared vision for Hygiene, Water supply and Sanitation has a target to provide water, sanitation & hygiene for all by 2025 (UNESCO, 2002).

Better water conservation, water management, pollution control and water reclamation are all part of the solution to projected water stress. So too are new sources of fresh water, including the desalination of seawater. Desalination technologies have been well established since the mid-20th century and widely deployed in the Middle East and North Africa. The contracted capacity of desalination plants has increased steadily since 1965 and is now about 36 million m^3/d worldwide, as shown in Figure 1 (Wangnick, 2004). This capacity could roughly cater 6 litres a day per capita of fresh potable water to the world's population.

Large-scale commercially available desalination processes can generally be classified into two categories: (a) distillation processes that require mainly heat plus some electricity for ancillary equipment, and (b) membrane processes that require only electricity. In the first (distillation) there are two major processes: multi-stage flash (MSF) and multi-effect

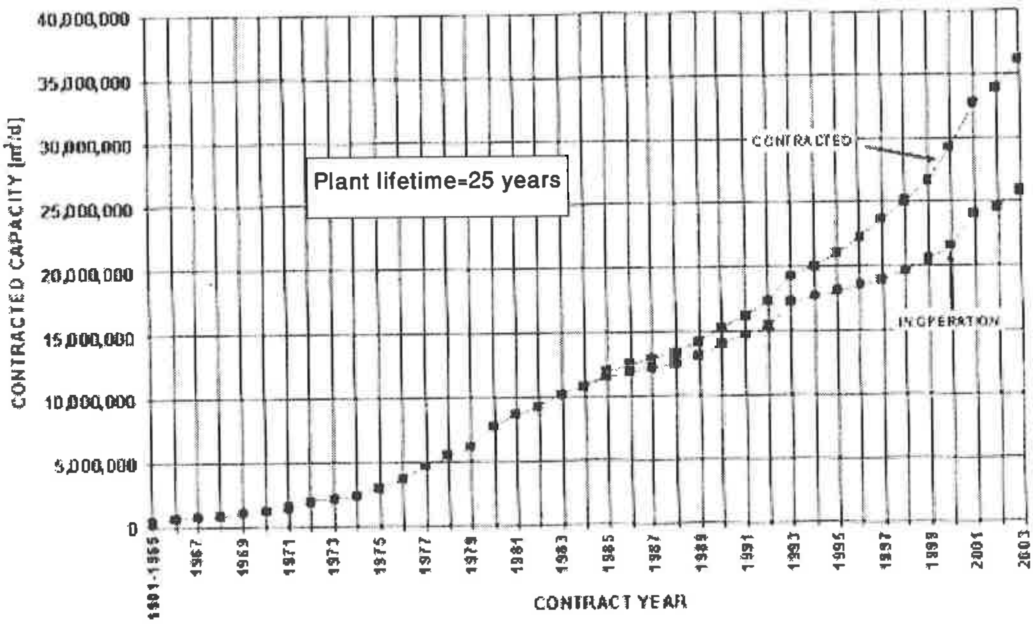

Fig. 1. Cumulative worldwide desalination capacity (Top line shows total operating and contracted capacity. Bottom line shows only the operating capacity).

distillation (MED). In both, seawater is heated; the steam that evaporates is condensed and collected as freshwater; and the residual brine is discharged. In the second category (membranes) is the reverse osmosis process (RO), in which pure water passes from the high-pressure seawater side of a semi-permeable membrane to the low-pressure freshwater permeate side. The pressure differential must be high enough to overcome the natural tendency for water to move from the low concentration freshwater side of a membrane to the high concentration seawater side, in order to balance osmotic pressures. The salient characteristics of various desalination processes are shown in Table 1.

The Role of Nuclear Power in Desalination

The world energy requirements are presently met from oil, coal, gas, hydro, nuclear and renewable in that order as shown in Table 2. There is general agreement that there will be an increase in the world's requirement for electricity over the next few decades. The present trend towards meeting this demand includes the building of fossil fuel plants, particularly combined cycle gas fired plants. The spiralling increase in greenhouse gas emissions has resulted in setting the emission targets in Toronto, Rio and the last one in Kyoto. The International Atomic Energy Agency (IAEA) predicts that emissions would be 36-50% higher by 2010 compared with those in 1990. Many commentators, therefore, feel that the only viable alternative to fossil fuel is nuclear energy to reduce the rate of increase of greenhouse gases, particularly, carbon dioxide. Another incentive for nuclear power is to maintain diversity of supply. A national strategy limited to one particular form of energy (fuel) will be vulnerable to reduction of other fuel costs.

Nuclear power is a proven technology, which has provided more than 16% of world electricity supply in over 30 countries. More than ten thousand reactor-years of operating experience have been accumulated over the past 5 decades. In recent years, the option of combining nuclear power with seawater desalination has been explored to tackle water shortage problems. The desalination of seawater using nuclear energy is a feasible option to meet the growing demand for potable water. Over 150 reactor-years of operating experience on nuclear desalination have been accumulated worldwide. Several demonstration programs of nuclear desalination are also in progress to confirm its technical and economical viability under country-specific conditions, with technical co-ordination or support of IAEA.

Table 1. Key data of desalination processes.

	MSF	MED	MED-TVC	MVC	RO	ED
Operating temperature (C°)	< 120	< 70	< 70	< 70	< 45	<45
Form of main energy	Steam (heat)	Steam (heat)	Steam	Mechanical (electrical energy)	Mechanical (electrical energy)	Electrical energy
Thermal energy consumption (kWh/m³)	12	6	21	Not applicable	Not applicable	Not applicable
Electrical energy consumption (kWh/m³)	3.5	1.5	1.5	8-14	4-7	1.0
Typical salt content of raw water (ppm TDS)	30,000–100,000	30,000 – 100,000	30,000–100,000	30,000–50.000	1,000–45,000	100 – 3,000
Product water quality (ppm TDS)	< 10	< 10	< 10	<10	< 500	< 500
Current, typical Single-train capacity (m³/d)	5,000–60,000	500–12,000	100 – 20,000	10 – 2,500	1 – 10,000	1 – 12,000

Table 2. Percentage of World Energy Use (Littington, 2004).

Fuel	%	Present trends
Oil	39	Building of more fossil fuel plants
Coal	25	
Gas	22	Short-term – greater burning of oil, coal and gas resulting in more CO_2
Hydro	7	
Nuclear	6	
Renewables	1	Greater energy efficiency increasedrenewablesources of energy: geothermal, wind, solar, bio-mass

There are many reasons which favour a possible revival of the nuclear power production in the years to come: the development of innovative reactor concepts and fuel cycles with enhanced safety features which are expected to improve public acceptance, the production of less expensive energy as compared to other options, the need for prudent use of fossil energy sources, and the increasing requirements to curtail the production of greenhouse gases (GHG), toxic gases, particulates and acid rain, which are all associated with the combustion of fossil fuels. It is thus expected that this revival would also lead to an increased role of nuclear energy in non-electrical energy services, which, at the moment, are almost entirely dominated by fossil energy sources. Among various utilizations of nuclear energy for non-electrical products, using it for the production of freshwater from seawater (nuclear desalination) has been drawing broad interest in IAEA Member States as a result of acute water shortage issues in many arid and semi-arid zones worldwide.

The issue has been repeatedly stressed at the General Conference and supported by many Member States including most members of a Group of 77. The support stems from their expectation of not only its possible contribution to the freshwater issue but has been motivated by a variety of reasons that include; likely competitiveness of nuclear desalination in areas lacking cheap hydropower or fossil resources, energy supply diversification, conservation of fossil fuel resources and spin-off effects of nuclear technology for industrial development.

1. Nuclear Desalination

Nuclear desalination is defined to be the production of potable water from seawater in a facility in which a nuclear reactor is used as the source of energy for the desalination process. Electrical and/or thermal energy may be used in the desalination process on the same site. The facility may be dedicated solely to the production of potable water, or may be used for the generation of electricity and production of potable water, in which case only a portion of the total energy output of the reactor is used for water production.

The design approaches for a nuclear desalination plant are essentially derived from those of the nuclear reactor alone, with some additional aspects to be considered in the design of a desalination plant and its integration with the nuclear system. All nuclear reactor types can provide the energy required by the various desalination processes. The amount of energy (heat or electricity) needed for desalination can be readily supplied by tapping the low-grade steam and/or electricity produced by the nuclear plant. In this regard, it has been shown that Small and Medium Reactors (SMRs) offer the big potential as coupling options to nuclear desalination systems. The development of innovative reactor concepts and fuel cycles with enhanced safety features as well as economics are expected to improve the public acceptance and further the prospect of nuclear desalination.

The coupling with nuclear system is not difficult but needs some consideration in (a) avoiding cross-contamination by radioactivity; (b); providing an alternative source in case the nuclear system is not in operation for refuelling and maintenance; and (c) providing certain limits (in case the reactor system is small) in the amount of heat supply to the desalination system considering its effect on the nuclear system from the abrupt shut down of the latter system.

2. Experiences and New Plans (Misra, 2004)

The desalination of seawater using nuclear energy is a demonstrated option having over 150 reactor-years of operating experience worldwide of which Japan now has over 125 reactor-years. Kazakhstan (Aktau fast reactor BN-350) had accumulated 26 reactor-years of producing 80,000 m3/day of potable water before shutting down in 1999.

Table 3 summarizes past experience as well as current developments and plans for nuclear-powered desalination based on different nuclear reactor types. Most of the technologies in Table 1 are land-based, but the table also includes a Russian initiative for barge-mounted floating desalination plants. Floating desalination plants could be especially attractive for responding to temporary demands for potable water. Figures 2, 3, and 4 show Pictures of nuclear desalination plants at Aktau (Kazakhstan), Ohi (Japan) and Kalpakkam (India), and Figure 5 shows the KANUPP site for the proposed nuclear desalination demonstration project in Pakistan. The followings provide additional detail on the new developments in the member states:

Argentina: has identified a site for its small reactor (CAREM), which could be used for desalination. Depending on financing, construction could begin in the near future.

Canada: has embarked on a three-year project to validate its innovative reverse osmosis (RO) system design concepts.

China: is proceeding with several conceptual designs of nuclear desalination using NHR type heating reactor for coastal Chinese cities.

France: is carrying out detailed nuclear desalination studies as part of CEA's own R&D programme or under international programmes with the EU, the IAEA and as bilateral arrangements with India and some other North African countries.

Egypt: has completed a two-year feasibility study for a nuclear co-generation plant (electricity and water) at El-Dabaa. Based on the results, government approval to proceed towards implementing the project is sought.

India: is building a demonstration plant at Kalpakkam using a 6300 m^3/d hybrid desalination system (MSF-RO) connected to an existing PHWR. The RO plant is already commissioned and operating successfully. India expects to commission the full plant in 2006.

The Republic of Korea: is proceeding with its System-integrated Modular Advanced Reactor (SMART) concept. Work is in the basic design phase. The project is designed to produce 40,000 m^3/d of potable water. Construction project for a SMART-P plant with one-fifth scaled power and a MED plant was launched in 2002 and it will be in operation by 2008.

Morocco: in June 2000, halted a demonstration project at Tan-Tan originally intended to produce 8000 m^3/d of potable water using an NHR-10

Table 3. Reactor Types and Desalination Processes.

Reactor Type	Location	Capacities (m^3 /d)	Status
LMFR	Kazakhstan (Aktau)	80,000	In service till 1999
PWRs	Japan (Ohi, Takahama, Ikata, Genkai)	1,000-2,000	In service with operating experience of over 125 reactor-years.
	Rep. of Korea	40,000	Under design
	Argentina	12,000	
	Russia		Under design (floating unit)
BWR	Japan (Kashiwazaki)		Never in service following testing in 1980s, due to alternative freshwater sources; dismantled in 1999.
PHWR	India (Kalpakkam)	6,300	Under commissioning
	Canada		Under design
	Pakistan (KANUPP)	4,800	Under design

of Chinesc dcsign. Possible next steps are being studied.

Pakistan: is considering coupling of a MED thermal desalination plant of 4800 m3/d capacity with existing PHWR at KANUPP.

Russia: is progressing with the design and licensing of a floating co-generation plant, based on a Nuclear Floating Power Unit (NFPU) with KLT-40C reactors and is looking for the international cooperation for setting such a plant.

Tunisia: has undertaken several studies to select a suitable desalination process and to identify what process could be coupled to a nuclear reactor. La Skhira site has been identified in the southeast part of the country for further study.

USA: will include in its Generation IV roadmap initiative a detailed discussion of potential nuclear energy products in recognition of the important role that future nuclear energy systems can play in producing fresh water.

Indonesia and Saudi arabia: further R&D activities are also underway.

Brazil, Iran, Iraq, Italy, Jordan, Lebanon, Libya, Philippines, Syria and UAE: in addition, interest has been expressed in the potential for nuclear desalination in their countries.

IAEA Activities on Nuclear Desalination

IAEA has been providing guidebooks technical documents, and computer programs on nuclear desalination as well as technical assistance through the framework of technical co-operation programs. A number of technical co-operation projects have assessed the feasibility of particular projects. In 1999 the IAEA launched an inter-regional technical co-operation project "Integrated Nuclear Power and Desalination System Design". The project is designed to facilitate international collaboration between technology holders and potential end-users for the joint development of integrated nuclear desalination concepts,

Fig. 2. Evaporators at Aktau, Kazakhstan.

Fig. 3. Operating plant: Ohi, Japan.

Fig. 4. Hybrid (MSF+RO) plant, Kalpakkam, India.

Fig. 5. SWRO Plant at KANUPP, Pakistan.

aiming at the demonstration of the viability of nuclear desalination at a specific site or sites. Under the IAEA regional technical co-operation framework, several international collaboration activities are underway, for example, between the Republic of Korea and Indonesia; and France and Tunisia.

A Coordinated Research Project (CPR) on "Optimization of the Coupling of Nuclear Reactors and Desalination Systems", (1998-2003) covered a review of reactor designs suitable for coupling with desalination systems, the optimization of this coupling, possible performance improvements and advanced technologies of desalination systems for nuclear desalination. A Technical Document (TECDOC) covering the salient studies of the CRP is under publication. A new CRP on "Economic Research on, and Assessment of, Selected Nuclear Desalination Projects and Case Studies" has started early 2002 with the participation of 11 institutions from 11 Member States. It will deepen the economic aspects of nuclear desalination plants and give more confidence in this option.

IAEA's DEEP computer code has been widely used by engineers and researchers for preliminary economic evaluation of desalination by a wide range of fossil and nuclear energy sources. A Web page on nuclear desalination, describing the current status of nuclear desalination activities in the Member States and the IAEA is available at http://www.iaea.org/nucleardesalination.

Economics of Nuclear Power/ Desalination

1. Current Trends

The economics of desalination using nuclear energy is obviously linked to the economics of nuclear power. Table 4 gives the average generation costs from nuclear, coal and gas based power plants. Nuclear generation costs are most sensitive to discount rates. Nuclear power is competitive at 5% discount rate but looses its competitive margin at 10%. Availability of funds on soft loan or grant would be helpful in considering a nuclear desalination project.

Table 4. Average generation cost ($US per KWh).

Generator	5% Discount	10% Discount
Nuclear	0.034	0.051
Coal	0.038	0.048
Gas	0.040	0.044

However, fuel costs for nuclear plants are generally low in comparison with other energy producers (Table 5). Further, the nuclear fuel cost is not affected by price uncertainties and of course is more sustainable.

Table 5. Fuel costs ($US per kWh).

Generator	Cost (% of generation)
Nuclear	< 25
Coal	~ 40-50
Gas	~ 75-80

In case of old reactors, the lifetime extension costs are known to be lower than building newer nuclear plants and these are comparable to the new combined cycle plants (Table 6). Attempts are therefore directed in some countries (India and Pakistan) to utilize the existing reactors for setting up demonstration desalination plants to produce fresh water from seawater economically.

Table 6. Lifetime extension versus new building ($US per kWh).

Lifetime extension	210 - 840
New nuclear plants	≡ 2000
New combined cycle units	700 - 900

A number of studies have been carried out on coupling of different types of reactors with desalination processes in many Member States. Preliminary techno-economic studies conducted in China for NHR-200 coupled 160,000 m^3/d VTE-MED plant estimated the desalted water cost to be around 0.80 US$/$m^3$. Similar economic evaluation of the integrated SMART-MED desalination plant of 40,000 m^3/d capacity indicate the water cost ranging from 0.70 to 0.90 US$/$m^3$. The projected cost of water from Russian KLT-40 floating reactor based nuclear desalination plants is also in the above ranges. These costs are comparable with desalination costs using locally available fossil fuels.

Economic comparisons thus indicate that water costs (and associated electricity generation costs) from nuclear seawater desalination are generally in the same range as costs associated with fossil-fuelled desalination. Given the conclusion that nuclear and fossil-fuelled desalination are broadly competitive with each other, any particular future investment decision will depend on site-specific cost factors and on the values of key parameters (fuel price, interest rate, construction time, etc.) at the time of investment. Higher fossil fuel prices would of course favor nuclear desalination; higher interest rates would favor less capital-intensive fossil-fuelled options.

Pre-feasibility studies have been carried out recently for the proposed nuclear desalination projects at Madura, Indonesia and La-Skhira, Tunisia under the IAEA technical cooperation inter-regional project (1999-2004). These indicate economic competitiveness of nuclear desalination over fossil based plants under the specific conditions in their countries (Tian, et al., in press).

2. Future Developments

There have been many improvements and innovations in the desalination technology in recent years. The energy requirement in the seawater reverse osmosis is reducing progressively due to better energy recovery systems and the membrane costs; resulting in low cost of water from RO plants. This is reflected in the installation of many large size RO plants worldwide in recent years. Pre-heat RO is another concept likely to further reduce the water cost from RO plants. Figure 6 shows the likely reduction in applied pressure in RO with increasing temperature of seawater of different salinities (35,000 to 45,000 ppm) and for different product recoveries, ranging from 40 to 50%. This results in reduced water cost due to savings in energy or membrane cost for a pre-heat RO plant (Wilf, 2005). Some studies suggest the use of the condenser cooling seawater in a contiguous RO plant installed in a nuclear reactor can make the process even more economical.

The water reuse after treatment of domestic effluents for agricultural and other uses is also being considered in recent years to augment the water resources for non-potable applications. These would bring further challenges on the economics of nuclear desalination, although care must be taken on the difference in the quality of water produced in the two cases.

Hybrid desalination systems are known to produce two qualities of water, which can be blended to make desired quality of potable water without any chemical addition. These plants have also the advantage of combined pre-treatment of seawater and the post treatment of product water. There also exists the advantage of pre-heat RO in hybrid systems. The life of the RO membranes could be augmented for a UF-RO hybrid system. These advantages are likely to improve the economics of seawater desalination (Helal, *et al.*, 2004)

The possibility of waste heat utilization from the PHWRs is being investigated in India for seawater desalination. Nearly 100 MW (th) of moderator waste heat is available in a 500 MWe PHWR. Research is being conducted to develop thermal processes, which can utilise such low-grade waste heat. The efficiency of these desalination systems is however lower

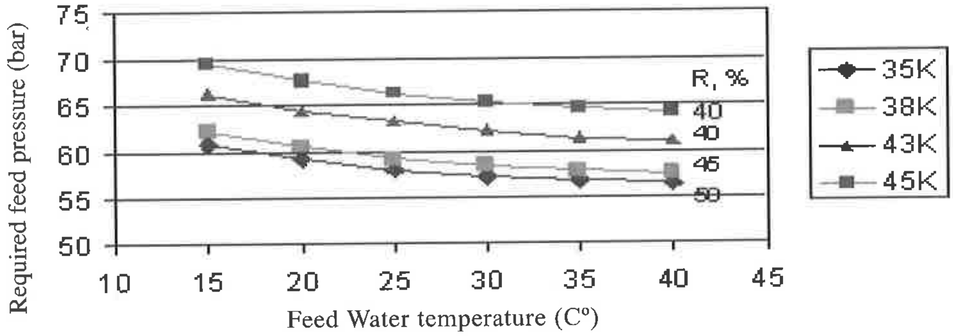

Fig. 6. Required feed pressure vs. salinity and temperature.

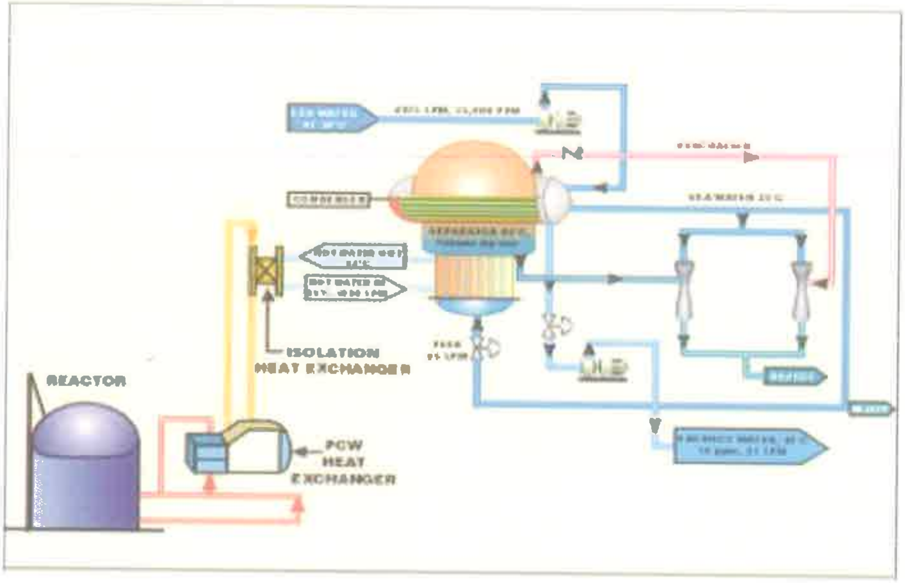

Fig. 7. Integrated LTE nuclear desalination system, Trombay (India).

requiring larger heat transfer area and hence higher investment even though energy cost is minimal. Figure 7 shows a desalination unit set up in 2004 at the CIRUS research reactor, Trombay, India, producing high quality water from seawater, meeting the reactor makes up water needs. Design of a large capacity desalination plant has been carried out for the proposed AHWR in India.

The use of reject heat from High-Temperature Gas-cooled Reactor (HTGR) design, one of the candidate reactor designs well suited for economical desalination, is being investigated. While traditionally, emphasis has been on HTGR suitability for high-temperature applications such as hydrogen production, the potential of this plant design for low-temperature applications such as nuclear desalination is attracting. According to French study, 300 MWth HTGR plant can produce 25,000 m^3/day of water without sacrificing electricity production.

Water production cost estimated for a MED plant located at the proposed high temperature gas cooled reactor is given (Methnani and Kendall, 2003) in Table 7. It shows the possibility of reducing the water cost to half compared to the present costs.

Table 7. Estimated water production cost for a MED plant located at a HTGR.

MED module cost (M$)	20
Annual water production (m^3)	6.935×10^6
Amortization rate (%)	8
Amortization (cents/ m^3)	23
Steam cost (cents/ m^3)	0
Electricity cost (cents/ m^3)	7
Chemical cost (cents/ m^3)	3
Operation & maintenance (cents/ m^3)	12
Total water production cost (cents/ m^3)	**45**

Challenges

The following lists possible challenges facing nuclear desalination:

1. Disparity

Countries suffering from scarcity of water are, generally speaking, not the holders of nuclear technology and infrastructure for product water distribution. The utilization of nuclear energy in those countries will require infra-structure building and other institutional arrangements for such things as financing, liability, safeguards, security and will also require preparation for the fuel cycle including upstream and downstream. The concept of multi-national fuel cycle centre, as is proposed by IAEA, could be used to assure a supply of nuclear material to legitimate would-be users under control of sensitive parts of the nuclear fuel cycle.

2. Public Perception

The design of nuclear desalination plants normally concern with various safeties related aspects. The possibility of radioactive contamination of product water, however, is a very important issue to be considered for the nuclear desalination plants. The dissemination of data from the existing co-generation facilities in many countries would go a long way to alleviate the concern and improve the public perception for the nuclear desalination plants. Sharing of relevant information in this area from Member States involved in nuclear desalination and co-generation facilities will be greatly welcome.

3. Socio-environmental Aspects

The socio-environmental aspects of nuclear desalination need greater attention for its large-scale adoption. Setting up of desalination plants at nuclear reactors for providing the much needed freshwater to the public will no doubt add to its social acceptance. However, this calls for providing assured quantity and quality of the fresh water round the year. The intake/ outfall of the nuclear desalination plants are to be designed keeping in view the locals use of the area for fishing and other socio-cultural activities. Protection of the marine environment near the desalination plant site, particularly the flora and fauna, need to be considered in great length. This would lead to enhanced acceptance of the nuclear desalination plants. The use of the reject brine from the desalination plants for pisciculture or other uses such as production of useful minerals is a possibility worth consideration.

Conclusion

The availability of vast resources of seawater on earth has attracted interest in seawater desalination as a possible source of fresh water in the water scarce arid and semi-arid areas of the world. The present desalination capacity of about 36 million cubic meters per day worldwide meets a very small fraction of the world's fresh water needs. There is however a significant potential of desalination and water reuse technology for rapid expansion in the future to augment the fresh water resources in water scarce areas. Use of fossil fuels for the large capacity desalination plants could lead to large emission of undesired green house gases into the environment. The future price uncertainties of fossil fuels and their sustainability is also an important issue. Use of energy from nuclear reactors for desalination is a demonstrated option and it is an environment friendly and a sustainable source. Feasibility studies carried out recently indicate that present costs of water produced from nuclear desalination plants are similar to that of fossil fuel based desalination plants. Use of future generation nuclear reactors, which would produce large amount of available heat for desalination in addition to providing cheaper power, is likely to reduce the water cost substantially. Nuclear desalination will be an important option for safe, economic and sustainable supply of large amounts of fresh water to meet the ever-increasing world-wide water demand.

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