

## **Workforce Development for the Nuclear Industry - A Global Issue – 11332**

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### **ABSTRACT**

The Department of Energy's Office of Environmental Management (DOE-EM) oversees one of the largest environmental restoration projects in the world. DOE-EM's labor statistics show that 91% of EM employees are 40 years old or older and only 1% of its workforce is under 30 years old. In addition, it is estimated that within the next three years, DOE-EM will lose as much as 30-35% of its technical workforce due to retirement. Likewise, a similar problem also affects other countries around the world such as the United Kingdom (UK). According to statistics provided by Whitmore et. al, in the UK, 70% of the decommissioning sector workforce will retire by 2025, thus creating a gap in the skilled workforce for the nuclear industry. This need in the UK translates to about 1,000 new recruits per year, mainly at the apprentice and college graduate level. At the same time, countries around the world are also experiencing a "renaissance" of the nuclear industry. The rebirth of the nuclear industry will require a new workforce, which compounds the aging workforce issue and increases the demand for skilled workers. The unfavorable public perception of nuclear power due to the Three Mile Island (1979) and Chernobyl (1986) accidents are becoming a thing of the past, and public confidence is building for the use nuclear energy. In the United States (US), DOE-EM is responding to the aging workforce problem by proactively partnering with universities to train and develop the new generation of environmental restoration workers. In 2007, DOE-EM and Florida International University's Applied Research Center established the DOE-FIU Science and Technology Workforce Development Program. This is an innovative program designed to train and mentor students in STEM (science, technology, engineering, and math) disciplines and provide them with career paths in environmental restoration and the nuclear industry. The selected students (called DOE Fellows) perform hands-on environmental remediation research and participate in internships at DOE sites, national laboratories, and DOE contractors. Upon graduation and completion of the DOE fellowship, DOE Fellows pursue employment opportunities with DOE and its contractors. By the same token, many universities and institutes in the US and UK are also establishing programs and centers in an effort to prepare a new generation of scientists, engineers, and students that will be the future of the nuclear industry. For example, the University of Manchester's Dalton Nuclear Institute (DNI) was established in 2005 and acts as the engine to drive the coordination and growth of the university's nuclear expertise. Besides the DNI's research capabilities in Nuclear Energy Technology, Radiochemistry and Materials, and engineering decommissioning and geological disposal, DNI also provides higher learning in nuclear related disciplines. DNI has also established a number of international strategic collaborations including US institutes and national laboratories such as Battelle Memorial Institute and DOE National Laboratories. In the US, Central Virginia Community College (CVCC) has developed nuclear technologies initiatives for STEM (science, technology, engineering, and math) disciplines under a grant from the National Science Foundation. China's nuclear energy ambitions will also require a massive workforce and universities such as South China University of Technology is already providing nuclear energy education and training programs. These programs are producing well trained young professionals

that will fill a gap in the US and UK aging workforce and provide the platform to launch a 21st century workforce for the nuclear industry. This paper will discuss efforts by these two listed institutions and other institutions around the world engaged in workforce development activities for the environmental restoration and nuclear power industries.

## INTRODUCTION

Well educated and trained professionals are needed to combat the shortage of a 21<sup>st</sup> century workforce that will continue the environmental restoration challenges faced by the US and other countries around the world that were involved in the research, development and production of nuclear weapons. At the same time, new well trained and educated professionals will be needed as various countries around the world continue to experience a “renaissance” of the nuclear industry and plan for the construction of nuclear power plants. The rebirth of the nuclear industry will require the development and training of a new workforce, which compounds the aging workforce challenges currently being faced by countries around the world.

For example, US Department of Energy’s Office of Environmental Management (DOE-EM) is responsible for conducting one of the largest environmental restoration programs in the world that involve a workforce of over 30,000 employees composed of federal and private contractors. This workforce is composed in majority of experienced, seasoned professionals with an average age of 50+ years old. The challenges of workforce development for the environmental remediation field are evident by recent number reported by DOE-EM. According to a survey conducted by DOE-EM’s Human Capital Office in 2008, 43% of its workforce was 50-59 years old and 37% of the workforce was between the ages of 40-49 years old. In contrast, 11% of its workforce was age 60 or older and only 1% of its workforce was 30 years old or younger (see Figure 1). As reflected in Figure 1, 91% of EM workforce is 40 years old or older [4]. Similar trends are reflected in the private contractor and DOE National Laboratory workforce. The aging of a workforce for environmental management is not only a problem in the US but is also an issue being faced by other countries conducting large environmental restoration programs such as the United Kingdom.

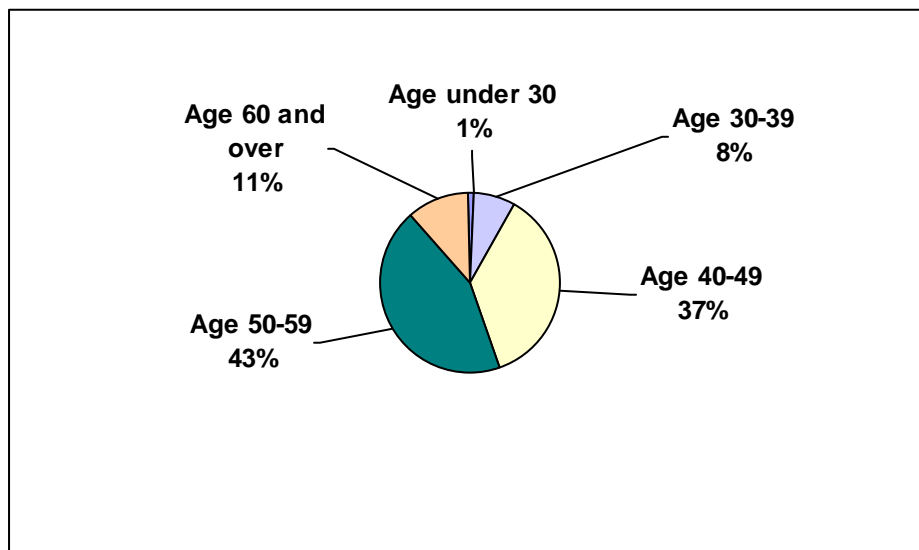


Figure 1. DOE-EM Employee Age Profile as of April 2008 [4].

The need for workforce development not only affects the environmental restoration industry, but also will be a major issue with the construction of new nuclear reactors as more and more countries consider nuclear energy as part of their energy security strategy. The rebirth of the nuclear industry will require a new workforce, which compounds the aging workforce issue and increases the demand for skilled workers. For example, according to the Energy Collective, over the next five years, 38 percent of the current nuclear industry workforce employed at the nation's 104 operating plants will be eligible for retirement, leaving a shortfall of more than 25,000 skilled workers. In addition, each new nuclear plant to be built in the US will create up to 2,400 temporary and highly-paid positions over the five-year construction period and 400-to-800 new permanent careers [10].

At an international level, in November 2010, China's National Development & Reform Commission announced its plans for construction of new nuclear reactors with a capacity of 114 GWe by 2020. The new target represents a significant increase from a prior target of 70 GWe issued in May 2010 by the head of China's National Energy Administration (Zhang Guobao). Chinese officials later scaled back their estimate of the revised target from 114 GWe down to 80 GWe. China has a reported 23 reactors under construction and another 140 on drawing boards in various stages of readiness to proceed. Based on these announcements and estimates, China will have to create an infrastructure to be able to handle the development and execution of its ambitious plans. To achieve these targets, China will have to become self-sufficient in reactor design, fuel cycle, and construction as well as reprocessing of spent fuel and activities related to waste management [8]. These activities will required the education and training of new professionals in China and the development of a workforce that China currently does not have. Also, last year, the World Nuclear News (WNN) reported that preparations are at an advanced stage for building China's first Nuclear Power City in the coastal city of Haiyan, on the Yangtze Delta. The construction of the Nuclear City is expected to "start soon" [9]. In Chinas' Zhejiang province itself, there are currently five nuclear power reactors in operation and two under construction at Qinshan. There are also two reactors under construction at the Fangjiashan plant [9].

According to the International Atomic Energy Agency (IAEA), the potential demand for nuclear talent in China is "huge" because of the rapid development of the nuclear power industry. Because of the long time needed to acquire the necessary expertise, many Chinese students choose to study computer science, business, manufacturing, and other disciplines rather than nuclear sciences. The IAEA reported that major universities have introduced changes in nuclear engineering programs, as part of educational reforms, to attract more students. These include greater on-the-job training opportunities for students. In the short term, China expects to have more and extensive interaction with foreign universities and institutions associated with nuclear engineering and technology, through professional and information exchange programs [8].

## **RESULTS AND DISCUSSION**

As discussed in previous sections, the aging workforce phenomena not only impacts the environmental restoration program in the US and other countries but will also have an impact in the rebirth of the nuclear industry. Based on current and future needs, some institutions are

already preparing and training well qualified young scientists and engineers to alleviate this impending workforce shortage. This section will provided a short summary of existing programs in the US and countries around the world. As a point of discussion, the DOE-FIU Science and Technology Workforce Development program will be discussed in more detailed to highlight efforts by the US Department of Energy and Florida International University in the preparation and training of STEM minority students.

## **Educational and Training Programs in the United States and Abroad**

### **Environmental Remediation and Restoration:**

#### DOE and FIU's DOE Fellows Program:

The DOE-FIU Science and Technology Workforce Development Program is an innovative program developed between the US Department of Energy's Office of Environmental Management (DOE-EM) and Florida International University's Applied Research Center (FIU-ARC). The program is designed to create a “**pipeline**” of minority STEM (science, technology, engineering, and math) students specifically trained and mentored to enter the Department of Energy workforce in technical areas of need. This innovative program was developed to help address DOE's future workforce needs and to comply with DOE-EM's strategic goals by ensuring *that DOE-EM's workforce is capable of meeting the challenges of the 21st Century by attracting, motivating, and retaining a highly skilled and diverse workforce to perform one of the largest and the most challenging environmental restoration programs in the world.*

Students selected to this program are inducted as **DOE Fellows** and perform DOE-EM related “hands-on” applied research at FIU's Applied Research Center. Since 1995, ARC has been supporting DOE-EM's environmental cleanup mission and currently has 16 full-time staff dedicated to EM's environmental research. In addition, the DOE Fellows perform work assignments (internships) at DOE Headquarters in Washington DC, and at DOE sites and DOE national laboratories across the country. Upon graduation and completion of this fellowship, the students apply to DOE-EM via DOE-EM's Professional Development Corps.

Since the inception of the program in 2007, the DOE Fellows have completed 44 internships across the DOE complex and 48 presentations at DOE-EM's largest conference – Waste Management Symposia. At this conference, the performance of our DOE Fellows has been excellent. Our DOE Fellows have won the Student Poster Competition for the past two years (Denisse Aranda and Denny Carvajal) and last year, one of our DOE Fellows (Leydi Velez) was awarded best professional poster for the entire conference (over 400 technical poster were presented by scientists and engineers from across the globe). In October 2010, one of our DOE Fellows (Rinaldo Gonzalez Galdamez) also won the First FIU Library Undergraduate Research Poster competition. His research entailed the development of a computer model to simulate and predict the movement of highly radioactive contaminated waste at DOE's Hanford site. This program has also attracted the attention and interest of DOE-EM's top officials such as Assistant Secretary for Environmental Management (Dr. Ines Triay and former Assistant Secretary – Mr. Jim Rispoli) who have traveled from Washington, DC to participate in our annual DOE Fellows Induction Ceremony in 2010 and 2008, respectively [3].

## **Workforce Development for the Nuclear Power Industry:**

### Central Virginia Community College – Nuclear Technologies Initiatives:

The National Science Foundation (NSF) awarded the Central Virginia Community College (CVCC) a grant to develop nuclear technologies initiatives for STEM (science, technology, engineering, and math) disciplines. The program provides students in the region's middle schools and high schools with the relevant STEM skills needed to have a successful career in the nuclear energy support technologies industry, and provides the middle school and high school teachers in the region with the resources and professional development opportunities needed to successfully teach these STEM skills. This project will contribute to the economic strength of the region, and eventually to the state and the nation, by strengthening the critical STEM workforce skills required by the nuclear energy industry.

CVCC will be a national center for energy production and transmission technologies that provides and promotes a comprehensive educational continuum from middle school through four-year universities throughout the nation for students entering the energy production and transmission industry. It is the aim of the program that preparatory and educational opportunities at the middle school and high school level in support of nuclear energy technologies will lead to the development of young professionals to enter the nuclear energy industry [6].

### The Dalton Nuclear Institute in the United Kingdom:

The University of Manchester has set out ambitious plans encapsulated in its 2015 vision to become one of the world's leading academic institutions, ranked in the global top 25. As part of its vision, the university has identified nuclear research as one of its major growth disciplines. The University already has the UK's largest concentration of nuclear research, training and educational activities and, in 2005, formed the Dalton Nuclear Institute (DNI) to drive forward its ambitions. Over the past few years, the portfolio of nuclear research educational activity has ramped up significantly in the UK and, over the next few years, the program will include the involvement of over 200 researchers [5].

The Dalton Nuclear Institute and the School of Chemistry at the University of Manchester has created the Dalton Fellow in Radiation Science, including Radiation-induced Damage and Radiation Chemistry. The appointment is part of the University of Manchester and selected Fellows will conduct research at various universities' facilities and laboratories. The fellowship is a fully funded five-year appointment. It is supported by a cooperative initiative between the Dalton Nuclear Institute of The University of Manchester and the Nuclear Decommissioning Authority (NDA) to revitalize nuclear energy sciences in the United Kingdom, in conjunction with the Centre for Nuclear Energy Technology (C-NET) project of the Dalton Nuclear Institute of The University of Manchester and the North West Development Agency (NWDA) [5].

### South China University of Technology:

The South China University of Technology is one of the many universities facilitating nuclear education in China. South China University of Technology (SCUT) is one of China's key universities operating under the direct leadership of the State Ministry of Education. The university, which has a total area of 294 hectares, is situated in Guangzhou, a southern metropolis in China. The nuclear program is offered under the School of Electrical Power. One

of the programs is “power engineering,” established in 1994. It includes 2 aspects: thermal and power engineering, and nuclear engineering and technology (nuclear power plants). The school offers master and doctorate programs in power engineering and engineering thermo physics. Each year, the department of power engineering enrolls 6 doctoral students, 20 postgraduate students, 25 postgraduate students in engineering, and 135 undergraduate students [12].

### **Specific Example - DOE-FIU Science and Technology Workforce Development Program:**

A specific example is the DOE-FIU Science and Technology Workforce Development Program established by the US Department of Energy and Florida International University in 2007. Since its inception in 2007, the DOE-FIU Science and Technology Workforce Development Program (also known as the DOE Fellows program) has formally recruited, selected and inducted a total of 54 students.

### **Recruitment Efforts**

Formal recruitment efforts of FIU minority STEM students are conducted in the April/May (Spring Semester) and September/October (Fall Semester) timeframes each year since the program’s inception. Recruitment efforts included the development of a dedicated program web site ([www.arc.fiu.edu/intern](http://www.arc.fiu.edu/intern)), in-class room presentations, recruitment tables at the College of Engineering and the College of Arts and Sciences, booths at FIU Job Fairs, information sessions, and presentations at student societies such as the Society of Hispanic Professional Engineers, the Society of Women Engineers, and the Society of Black Engineers.

Students are required to turn in application packages that included a complete application, three letters of recommendation from FIU faculty, an updated resume, and unofficial FIU transcripts. A DOE Fellows selection committee was formed with the participation of DOE’s EM personnel (including DOE-EM HR), FIU faculty members, and ARC staff members. Applications are reviewed by the committee and selected students were called for formal interviews. A total of 54 students have been selected and inducted as DOE Fellows (20 in 2007, 13 in 2008, 10 in 2009, and 11 in 2010).

### **DOE Fellows Induction Ceremony**

FIU students that are recruited and selected for this program are formally inducted as DOE Fellows. The selected students are vested with this name at a special ceremony conducted each Fall semester (during the month of November). The DOE Fellows Induction Ceremony is an event that is attended by DOE Officials (HQ), DOE National Laboratory officials, FIU administration, faculty, staff, students and, of course, our DOE Fellows. A total of four formal induction ceremonies have been conducted since 2007. These ceremonies have included the participation of several DOE officials including: Dr. Ines Triay (Assistant Secretary for Environmental Management) and Dr. Paul Deason (Deputy Director Savannah River National Lab) in 2010, Ms. Yvette Collazo (Acting Director, Office of Technology Innovation and Deployment), Mr. Desi Crouther (Director EM’s Office of Human Capital), and Mr. Tim Walsh (DOE EM’s Professional Development Corps Program Director) in 2009, Mr. James Rispoli (former Assistant Secretary for Environmental Management), Mr. Mark Gilbertson, and Ms. Yvette Collazo in 2008, and Mr. Mark Gilbertson (Acting Deputy Assistant Secretary for



Engineering & Technology) in 2007. In addition, FIU’s Provost (Dr. Berkman and Dr. Wartsok), FIU’s Vice Presidents of Research (Dr. Gil, Dr. Salas, and Dr. Walker), and FIU’s Dean of College of Engineering (Dr. Mirmiran) have participated as well. In addition, awards were presented to the DOE Fellows that won the DOE Fellows Poster Exhibition and Competitions. Also, the Mentor of the Year Award, and the DOE Fellow of the Year Awards are presented at these ceremonies.



**Figure 2. Dr. Ines Triay and DOE Fellows Class of 2010.**

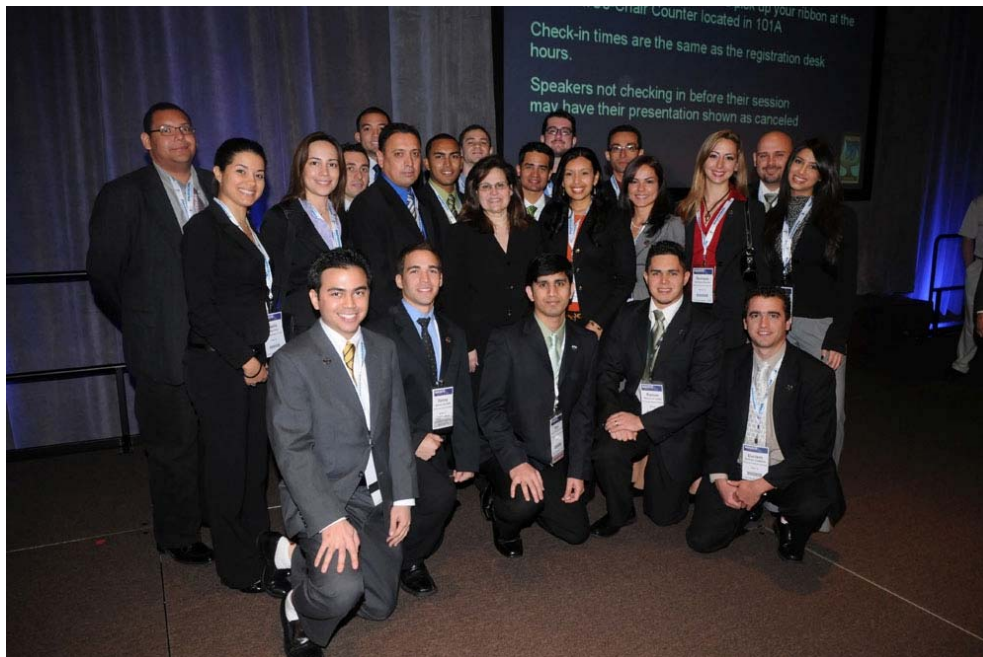
### **DOE Fellows Conducting Office of Environmental Management “Hands-On” Research**

Since the program started in 2007, all DOE Fellows inducted into the program have been engaged in DOE-EM applied research activities being conducted at FIU-ARC. DOE Fellows are involved in soil and groundwater EM projects being conducted by ARC scientists in collaboration with Oak Ridge National Laboratory (i.e. developing computer models for fate and transport of mercury contamination) and Pacific Northwest National Laboratory (i.e. investigating uranium sequestration issues due to polyphosphate injection). DOE Fellows have also participated in decontamination and decommissioning (D&D) activities including the evaluation of D&D technologies (i.e. evaluation of a robotic platform capable of spraying fixatives inside hot cell facilities, and the evaluation of an innovative technology developed by the Y-12 National Security Complex – SIMWyPES<sup>®</sup>), and are actively involved and supporting in-situ decommissioning efforts along with Savannah River Site scientists and engineers. DOE Fellows are also supporting the design and development of a remote stack characterization system for EM-30 (working with engineers at Oak Ridge National Laboratory), and the development of an innovative D&D Knowledge Management Information Tool (KM-IT) for DOE-EM. Also, DOE Fellows have collaborated with our researchers in the development of innovative technologies for the detection and measurement of high level waste at Hanford’s Tank Farm (i.e. ARC’s Solid-Liquid Interface Monitor technology) and designing, developing, and prototyping a “pipe” crawler mechanism for Hanford’s Tank Farm.

In addition, since 2007, our DOE Fellows have participated in a total of 44 internship appointments at DOE sites (Hanford, Oak Ridge, Savannah River, Idaho), DOE-HQ (Forrestal and Germantown offices), and DOE contractors (NuVision Engineering and Columbia-Energy Environmental Services). The DOE Fellows have developed a total of 44 summer internship technical reports and numerous posters presented at FIU, national laboratories, and Waste Management Symposia conferences. The reports are available at the DOE Fellows website ([www.arc.fiu.edu/intern](http://www.arc.fiu.edu/intern)).

### **Waste Management Symposia Participation**

DOE Fellows have also actively participated and presented at national conferences such as the Waste Management (WM) Symposia. For example, a total of 48 posters and papers have been presented by DOE Fellows at WM08, WM09, and WM10. DOE Fellows have presented their work at WM's Student Poster Competition, professional poster tracks, and oral paper presentations. Furthermore, DOE Fellows have won the WM09 and WM10 Student Poster Competitions (Denisse Aranda and Denny Carvajal respectively) and best overall professional poster presentation at WM09 (Leydi Velez) [2]. It is expected that about 20 DOE Fellows will participate in WM11. A total of eight Fellows have already submitted professional papers and approximately 14 Fellows will present student posters.



**Figure 3. Dr. Ines Triay and DOE Fellows at Waste Management Symposia 2010.**

### **DOE Fellows Obtaining Graduate Degrees in the Areas of Science, Technology, Engineering, and Math (STEM) Education**

Thus far, a total of 18 DOE Fellows have obtained bachelor's degrees at FIU and continued to pursue master's or Ph.D. degrees. The research conducted at the Applied Research Center, DOE sites, national laboratories, and DOE contractors' sites serve as the basis topic for their master's thesis or Ph.D. dissertations. Currently, 16 DOE Fellows are pursuing master's degrees and 2



DOE Fellows are pursuing a Ph.D. degree. In addition, undergraduate DOE Fellows make use of their EM applied research to satisfy their Senior Design or Capstone Projects.

### **The “Pipeline” is Working**

In its short existence, this program has been able to train and mentor FIU minority students on DOE-EM related applied research. FIU-ARC has 16 full-time researchers dedicated to EM's environmental restoration mission. This infrastructure makes an ideal place for the mentoring and training of students. In total, ten DOE Fellows have applied to DOE EM's Professional Development Corps Program. DOE Fellow Rosa Ramirez was selected to participate in this prestigious program and she is currently working at DOE EM's Office of Groundwater and Soil (former EM-32). Rosa is an excellent example of the quality students this program is training and mentoring. In addition, Mr. Duriem Calderin was hired by Columbia-Energy Environmental Services in summer 2010 immediately after he obtained his masters degree at FIU. Duriem conducted an internship at Columbia-Energy in summer 2009. In addition, additional federal employment programs such as STEP and SCEP are being pursued by EM and FIU so that DOE Fellows can participate in these programs as an entry to permanent employment with the US Department of Energy.

### **CONCLUSION**

The need for trained and qualified young professionals for the environmental restoration program in the US and the rebirth of the nuclear power industry around the world will require the development and training of a new 21<sup>st</sup> century workforce. Many institutions around the globe already have established programs for the development of new talents. Programs such as the DOE-FIU Science and Technology Workforce Development Program, the Central Virginia Community College's Nuclear Technologies Initiative, and international educational programs such as the Dalton Fellow in Radiation Science at the Dalton Nuclear Institute in the UK have already been established to confront the impending workforce shortage. Specifically, the DOE-FIU Science and Technology Workforce Development Program created between US DOE-EM and Florida International University's Applied Research Center located in Miami, Florida, has already created a “pipeline” of STEM minority students entering the DOE-EM's workforce. Since its inception, the program has inducted 54 DOE Fellows. Under this program, 44 internships have been conducted across the DOE Complex and 48 presentations have been given at the Waste Management Symposia.

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