As nuclear education and training (E&T) stakeholders deliberate and discuss to identify suitable syllabus and courses to offer for education and training to support NPP, it is critical that the nuclear fuel cycle (See Fig 1) as well as the nuclear new build supply-chain (see Fig 2) is taken into consideration in the selection and introduction of relevant courses by Universities and Institutions to nurture and educate skilled manpower for the nuclear power industry.

![Fig 1: Nuclear Fuel Cycle](image1)

![Fig 2: Nuclear New Build Supply Chain](image2)

The main elements of the nuclear new build supply chain are shown in the diagram below:

**Introduction:**

As nuclear education and training (E&T) stakeholders deliberate and discuss to identify suitable syllabus and courses to offer for education and training to support NPP, it is critical that the nuclear fuel cycle (See Fig 1) as well as the nuclear new build supply-chain (see Fig 2) is taken into consideration in the selection and introduction of relevant courses by Universities and Institutions to nurture and educate skilled manpower for the nuclear power industry.

![Fig 1: Nuclear Fuel Cycle](image1)

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The main elements of the nuclear new build supply chain are shown in the diagram below:

**Managing Human Resources in the Field of Nuclear Energy-IAEA**

The IAEA Nuclear Energy Series NG-G-2.1 titled “Managing Human Resources in the Field of Nuclear Energy”, IAEA, 2009 has outlined a diverse and multitude of organizations that require competent human resources to support a Nuclear Power Programme and for new NPP builds (see Fig 3).

![Fig 3: Human Resources for a Nuclear Power Programme (NPP) and for new NPP Builds- by IAEA](image3)

This paper strives to share with the education and training stakeholders, that the task of educating and training students is not solely to prepare them to work in a nuclear power plant, but importantly also to train human resources to support other organizations that require skilled and competent personnel in nuclear related field including Government agencies and Ministries, Business and Industry, Financial sector, International agencies and media agencies, amongst others.

**Sources for Human Resources to Support NPP**

It is critical for countries preparing Nuclear HRD to support NPP to recognize that in addition to training and educating students at colleges and universities who will graduate to become scientists, engineers, and other professionals offering training for professionals via continuing professional development courses (CPD), is also essential. (see Fig 4 and Fig 5)

![Fig 4: Nuclear Human Resources - Wide and Diverse Category of Skills required to support NPP](image4)

![Fig 5: Professionals required to support a Nuclear Power Programme (NPP)](image5)

In terms of professionals required to support a nuclear power programme (NPP), countries must prepare a nuclear workforce to include not only scientists and engineers but very importantly also other specialists and professionals including economists, financial experts, PR and journalists, amongst others (see Fig 5)

![Fig 6a: Nuclear Power Programme (NPP) needs workforce covering Professionals,Technicians as well as craftsmen](image6a)

High priority must also be accorded for apprenticeship training of technicians as well as craftsmen to support a safe and successful implementation of NPP (see Fig 6a). Additionally it is fundamental to introduce and provide special courses for leaders and senior management with responsibility in NPP.

![Fig 6b: Nuclear Power Programme (NPP) needs workforce covering Professionals,Technicians as well as craftsmen](image6b)
Professionals, Technicians and Craftsmen has important roles to assume in the different stages of nuclear power development (see Fig 6b)

**Fig 6b : Roles and Opportunities for Professionals, Technicians as well as craftsmen**

<table>
<thead>
<tr>
<th>Source: Management Development to Nuclear Power Plant</th>
<th>Nuclear Personnel</th>
<th>Professionals (%)</th>
<th>Technicians (%)</th>
<th>Craftsmen (%)</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>i) Pre-project activities</td>
<td>38</td>
<td>35</td>
<td>2</td>
<td>5</td>
<td>40</td>
</tr>
<tr>
<td>ii) Project management</td>
<td>99</td>
<td>87</td>
<td>15</td>
<td>13</td>
<td>114</td>
</tr>
<tr>
<td>iii) Project engineering</td>
<td>240</td>
<td>56</td>
<td>44</td>
<td></td>
<td>430</td>
</tr>
<tr>
<td>iv) Procurement</td>
<td>28</td>
<td>70</td>
<td>12</td>
<td>30</td>
<td>40</td>
</tr>
<tr>
<td>v) Quality assurance/quality control</td>
<td>50</td>
<td>42</td>
<td>70</td>
<td>58</td>
<td>120</td>
</tr>
<tr>
<td>vi) Plant construction</td>
<td>100</td>
<td>3</td>
<td>40</td>
<td>13</td>
<td>270</td>
</tr>
<tr>
<td>vii) Commissioning</td>
<td>55</td>
<td>22</td>
<td>60</td>
<td>26</td>
<td>120</td>
</tr>
<tr>
<td>viii) Operation maintenance (SMR)</td>
<td>55</td>
<td>20</td>
<td>180</td>
<td>67</td>
<td>35</td>
</tr>
<tr>
<td>viii) Safety and security</td>
<td>55</td>
<td>20</td>
<td>180</td>
<td>67</td>
<td>35</td>
</tr>
<tr>
<td>ix) Maintenance</td>
<td>55</td>
<td>20</td>
<td>180</td>
<td>67</td>
<td>35</td>
</tr>
<tr>
<td>x) Nuclear licensing and regulation</td>
<td>17</td>
<td>12</td>
<td>123</td>
<td>88</td>
<td>140</td>
</tr>
<tr>
<td>Total Numbers of Engaged</td>
<td>742</td>
<td>15</td>
<td>929</td>
<td>20</td>
<td>2853</td>
</tr>
</tbody>
</table>

**Nuclear Education & Training – The United Kingdom’s Best Practice**

Cogent and the National Skills Academy – Nuclear (NSAN) had reported that the UK's Civil Nuclear Industry in 2009 comprise a total of 43,690 personnel in a diverse work scope highlighted in Fig 7.

**Fig 7: UK’s Civil Nuclear Industry- Job Context Population 2009**

This paper outlines best practices in nuclear education and training offered by the United Kingdom which trains students, professionals, technicians across the whole new build supply chain (see Fig 8-Fig 12)

**i) Pre-build Stage**

With reference to the Pre-build Stage, several universities in the United Kingdom offer courses covering Planning and Licensing, Legal and Financial Services, Nuclear Consultancy Services as well as Engineering and Design Services (see Fig 8)

**Fig 8 : Nuclear Courses offered in the UK which support Pre-Build Stage**

**ii) Construction Stage**

With reference to the Construction Stage, several universities in the United Kingdom offer courses covering Project Management, Building & Construction, Plant & Equipment, On-site Erection (Fabrication), Nuclear Fuel Supply and Commissioning (see Fig 9a-Fig 9e)

**Fig 9a : Nuclear Courses offered in the UK which supports Construction Stage - Project Management**

**Fig 9b : Nuclear Courses offered in the UK which supports Construction Stage - Building & Construction**

**Fig 9c : Nuclear Courses offered in the UK which supports Construction Stage - Nuclear Fuel Supply**
iii) Operation Stage

With reference to the Operation Stage, several universities in the United Kingdom offer courses covering Operation & Site Management, Nuclear Fuel Supply, Engineering/Technical Services and Waste Management & Disposal (see Fig 10a-10b)

Fig 10a and Fig 10b. Nuclear Courses offered in the UK which supports Operation Stage

iv) Decommissioning Stage

With reference to the Decommissioning Stage, Several universities in the United Kingdom offer courses to support work required for this stage (see Fig 11)

Fig 11. Nuclear Courses offered in the UK which supports Decommissioning Stage

UK Universities forming a Consortia to offer Post graduate Nuclear courses as well as Professional Development Courses (PDC)

A consortia of UK universities – NTEC (Nuclear Technology Education Consortium) and other institutions are providing postgraduate education in Nuclear Science & Technology as well as CPD (Continuing Professional Development) courses (see Fig 12a and Fig 12b)

Fig 12a-12c. NTEC providing postgraduate education in Nuclear Science & Technology as well as CPD courses
Nuclear HRD

Fig 12b

Fig 13: Networks of Nuclear Education at Global, Regional and National Levels

Recommendations

1. Set up a Task Force on Nuclear Education & Training, could be chaired by Minister of Education with membership of all Nuclear HRD stakeholders

   Invite Universities, Industry, Government Agencies & Others to sit & talk TOGETHER on the way forward for Nuclear Education & Training

   Partnership or Consortium may be established for offering Degree courses, Continuing Professional Development. May refer to UK & French Best Practices - Avoid Duplication & Competition (resources wasted - people, time & money!!!)

2. Identify Nuclear Education & Training Needs for stakeholders:

   eg a) Government – Planning/ Policy/ Governance/Risk/ Export Control
   b) Industry – Business opportunities: manufacturing, construction etc
   c) Regulatory body – Law & Regulations
   d) Academia & R&D Agencies – Nuclear S&T, R&D

3. Critical to remember – Manpower trained is NOT JUST to work in a nuclear power plant or station but in other organizations in the nuclear power sector value-chain eg Government, Industry & Businesses, Media, Finance etc

4. Prepare Nuclear HRD Roadmap to outlining areas/fields/number of personnel/timeframe/funds required

5. It may not be strategic for a number of universities to be offering same or similar courses on nuclear engineering

   It may be more relevant for each university to identify its strengths and then offer the selected courses to support nuclear power eg University A offers Nuclear Engineering
   University B offers Nuclear Safety and Security
   University C offers Nuclear Law and Policy
   University D offers Nuclear Energy incorporating Business

6. For institutions currently offering only Nuclear Engineering courses it may be relevant to introduce other related courses - independently or as part of an existing module covering Nuclear Energy, Law, Governance, Risk, Business, Finance, Economics etc

7. Apart from the offer of Nuclear Engineering courses for undergraduates/graduates, institutions of Higher Education as well as private E&T Centres could consider also offering courses to:

   a) Working professionals   b) Technicians
c) Craftsmen

8. In view of the great importance of public opinion and the significant role of the media must be given due recognition

   - Open/ Introduce & offer Nuclear Education & Training to representatives from the Banking & Financial Sector
     i) Develop specialized topics/curriculum to encourage media participation and
     ii) consider inviting foreign media to share their views and experiences on nuclear power with local media and the general public

9. As Financing is amongst the critical factors for Nuclear Power Projects to be realistically implemented,

   - Open/ Introduce & offer Nuclear Education & Training to representatives from the Banking & Financial Sector
     i) Develop specialized topics/curriculum for financiers and
     ii) consider foreign investors in NPP to share their views & experiences

10. As Nuclear Leadership is fundamental to ensure the safe, secure and profitable operations of nuclear power plants (to the NP plant owners as well as national economy) the IAEA, independently or in partnership with other relevant Nuclear E&T Agencies/ organizations (including the WNA/WNU NEA/OECD and others) could consider introducing Nuclear Training Programmes (short courses) for Nuclear Leaders covering:

       i) Politicians
       ii) Policy & Decision Makers
       iii) Senior Management of Nuclear Power Plants
       iv) CEOs of Nuclear Businesses

in place of ENEL which had just closed down.

[Note: As the World Nuclear University (WNU) ’s 6 weeks summer course targets young professionals up to the age of 40 years the Nuclear Leadership course could cover Politicians, Policy & decision makers as well as Professionals above 40 years who are given leadership roles in Nuclear related initiatives/organizations]

Recommendations for enhancing cooperation in nuclear education and training aimed at building synergy amongst the international member countries - Part Six

Presently there are a number of Nuclear Education and Training Networks covering the Global Level, Regional Level as well as National Level (see Fig 13)

Fig 13: Networks of Nuclear Education at Global, Regional and National Levels

Networks of Nuclear Education at Global, Regional and National Levels

- Open/ Introduce & offer Nuclear Education & Training to representatives from the Banking & Financial Sector
  i) Countries planning for the introduction and implementation of NPP are recommended to review the Nuclear Education and Training Best practices offered at the Global level by the World Nuclear University (WNU), at the regional level such as that offered by ENEN and ANENT as well as specific programs provided at national level including INSTN in France, NTEC in the UK, FINEN in Finland and NKS in Sweden amongst others, to use as strategic inputs for the formulation of local /national Nuclear E&T within the country. Relevant and related syllabus and courses can be adopted and adapted for specific country-use and introduction.
  ii) In cases where it may not be beneficial for countries to introduce particular courses due to lack of resources and critical mass, these countries may wish to establish partnerships and cooperation with the global, regional and national Nuclear E&T networks to harness the currently available expertise and resources