Practical aspects of achieving sustainability: human resources and training system for an NES

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### User Requirement UR4 – Human Resources

<table>
<thead>
<tr>
<th>User requirement</th>
<th>Criteria</th>
<th>Indicators (IN) and Acceptance limits (AL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>UR4 Human resources: The necessary human resources should be available to enable all responsible parties involved in a nuclear power programme to achieve safe, secure and economical operation of the NES during its lifetime.</td>
<td>CR4.1: Human resources</td>
<td>IN4.1: Availability of adequate human resources to establish and operate a NES. AL4.1: Sufficient according to international experience.</td>
</tr>
</tbody>
</table>

- **Evaluation parameter EP4.1.1: Educational and training system for manpower needed in a nuclear power programme**
  - **Acceptability:** Evidence is available that a (qualitatively) adequate educational system exists (is planned)

- **Evaluation parameter EP4.1.2: Adequate staff in nuclear institutions**
  - **Acceptability:** Evidence is available that the necessary human resources are available (or planned) for the nuclear power programme

- **Evaluation parameter EP4.1.3: Attractiveness of the nuclear power sector for future employees**
  - **Acceptability:** Evidence is available that attractive workplace conditions exist (are planned) comparable to those in other high-tech industries in the country
Outline:

- Diversity of HR
- Several practical observations
- Establishing a Training System
- A brief visual tour
- Planning – a cornerstone
- Recurring problems & success factors
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Human Resources for a Nuclear Power Programme

- Nuclear facilities (including NPPs, Research Reactors)
- NEPIO & Government Agencies (Ministries, etc.)
- Regulators (including Nuclear)
- Owners, Operating Organizations, Corporations (e.g. Headquarters)
- Personnel involved in economic planning
- Environmental protection organizations
- Personnel of Legislative system
- Design organizations
- Architect-Engineer (A/E)
- Emergency Response and Civil Defence organizations
- Fire fighting
- Other (many!) organizations involved in Nuclear Security
- Specialized organizations involved in public information and other activities related to SI
- NFC front-end organizations (if any)
- Educational institutions
- Technical support organizations
- R&D organizations
- Specialized training organizations
- Specialized contractors (e.g. maintenance, NDT)
- Environmental protection organizations
- Transportation of nuclear and rad materials
- Construction and commissioning organizations
- Radwaste and SF management organizations
- National industry including manufactures and equip. suppliers
- Decommissioning personnel
- Representatives of finance institutions
- Specialized contractors (e.g. maintenance, NDT)
- Non-proliferation institutions
- Professional organizations (e.g. Nuclear Society, Junior Nuclear Professionals)
- Emergency Response and Civil Defence organizations
- Electricity transmission organizations
- Specialized organizations involved in public information and other activities related to SI
- Owners, Operating Organizations, Corporations (e.g. Headquarters)
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Education and/or training alone can never produce competent staff and adequate performance (when we are planning to acquire adequate staff)

In general, the adequate Management System as a foundation

- Workforce planning
  - Performance goals
    - Performance analysis and design
      - Organizational development
        - Recruitment and selection
    - Organization of work activities and HP support
  - Organizational, process and individual performance improvement
- Succession Management
- Employee development
  - Career development
    - Motivation incentives
      - Performance feedback
        - Teambuilding
          - Knowledge management
    - Education
  - SAT-based training
  - Qualification and authorization
- Experience
  - Self-assessment
Role of Organization in Human Performance

(when we are planning to achieve adequate performance of the staff)
Key factors impacting maintenance personnel performance (percentage of survey responses)
The data of the survey (23 responses) indicated that nuclear power plants that use lower rate of supplemental personnel to perform maintenance have in general a lower rate of reportable events.
One of important factors to ensure sustainability – the appropriate competence of management staff

Significant time, expertise and efforts are needed to establish a system for management training and development, and to achieve adequate competence of managers.
Leaders should be chosen, developed and promoted when they are identified to be committed to nuclear safety and security cultures.

- Too many “Leadership Development Programmes” are creating clones of today’s leaders rather than leaders who are ready for the future.

- Leadership Development:
  - 70% of the development comes from On-Job Learning, not just the daily job but special projects, assignments, cross functional job moves, working in other environments/cultures, etc.
  - 20% comes from Coaching and Mentoring (although could be much more)
  - 10% comes from training and reading
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Establishment of a Training System

1. Project Management
2. Organizational Structure & Staffing
3. Policy, Regulations & Procedures
4. Training Centres
5. Systematic Approach to Training (SAT), Training Programmes & Material
6. Simulators (full-scope and compact)
7. E-learning systems
8. Instructor selection & training
9. Management Training
10. Interfaces with the nuclear facility, suppliers, and external educational and training organizations
Systematic Approach to Training is recommended in the IAEA Safety Standards Series, Nuclear Security Series, Nuclear Energy Series and other technical publications.
Vital Role of Analysis & Evaluation

Level of Effort:
- 80% - Design, Development, and Implementation
- 20% - Analysis and Evaluation

Value-Added to Training Quality:
- 20% - Design, Development, and Implementation
- 80% - Analysis and Evaluation
Source Documents to Perform Analysis

- Facility safety analysis reports
- Technical specifications
- Facility design information pertinent to the job (including plant logic diagrams, plant structures, systems and components descriptions)
- Vendor manuals
- Normal, abnormal condition and emergency operating procedures
- Equipment technical manuals
- Maintenance manuals
- Operating experience reports
- Job descriptions
- Job analyses completed at other nuclear facilities including available task lists for similar jobs at other nuclear facilities

- Regulatory documents
- Description of the facility Management System and organizational processes
- Facility policies (e.g. regarding Safety, Security, Quality, Environmental Protection, Human Resources, Training)
- Facility administrative or management procedures
- Facility Quality Assurance Programme (or Quality Manual)
- Applicable safety standards series, nuclear security series and technical series documents of international organizations (such as IAEA and WANO)

However, while planning quality and reliable training system, think in advance and evaluate how to timely acquire the needed source documents, especially for FOAK or new innovative designs!
Key Participants in SAT Process

- Operating Organization
- Senior and line managers
- Trainees
- Instructors
- Subject Matter Experts (SMEs)
- Regulatory Body(ies)
- Nuclear facility Vendor
- National technical support organizations
- National SAT Project Team
- External SAT consultants to the national training programme

**Development of each SAT-based training programme requires involvement of:**

- Job incumbents and SMEs
- Instructors
- Facility managers and supervisors

However, while planning quality and reliable training system, think in advance and evaluate how to achieve involvement of these entities and individuals, especially for FOAK or new innovative designs!
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Real Equipment Used in Maintenance Training Centre (Paks NPP, Hungary)
Maintenance Training Center, Steam Generator Hall (Paks NPP, Hungary)
Maintenance Training Center, Reactor Head (Paks NPP, Hungary)
Specialized Maintenance Training Centre being constructed at the Zaporozhzhie NPP (Ukraine)
Training Course “SKF PROGRAM FOR FAULTLESS OPERATION OF ROLLING BEARINGS” (Kozloduy NPP, Bulgaria)
I&C Workshop (EdF, France)
Mechanical Fluid Workshop (EdF, France)
Mechanical Maintenance Training (Safety Valves) (Zaporozhzhzhie NPP, Ukraine)
Electrical Workshop (EdF, France)
Chemistry Workshop (EdF, France)
Ventilation Training Workshop (EdF, France)
Turbine Mock-up (Rostov NPP, Russia)
Training on Foreign Material Exclusion (FME) (Bruce Power, Canada)
Simplified power plant (EdF, France)
Simulators for the training on the maintenance of pumps (Rostov NPP, Russia)
Technological training circuit (Kozloduy NPP, Bulgaria)
Training Flow Loop (Krsko NPP, Slovenia)
Training Hydraulic Loop (EdF, France)
Training Technological Loop (Bruce Power, Canada)
Training Heat Exchanger Loop (Bruce Power, Canada)
Welding Simulator (South-Ukraine NPP, Ukraine)
Balakovo NPP Training Centre (RF)

PTC occupies two buildings with the total area of more than 9000m², comprising:

- 7 classrooms for theoretical training;
- 16 training labs and workshops;
- 7 classrooms to study safety regulations and rules;
- 4 computer classrooms;
- 2 rooms for psychological training
- 1 classroom for self-study;
- Library with the book stock of over 16 thousand copies and a reading room for 20 seats;
- Archive with a full set of NPP technical, regulating, training and methodological documentation (over 1900 copies)

Source: IAEA workshops
Mockup of Reactor Upper Unit And a Column For Control Rod Drives Trial Run

- A piece of reactor upper unit metal structure

Reactor Maintenance Training (Balakovo NPP, Russia)  

Source: IAEA workshops
Balakovo NPP Training Centre (RF)

Benches For Work With Thermal Mechanical Equipment

- Samples of pipelines with flange joints with automatic control of torque and joint integrity

Source: IAEA workshops
Balakovo NPP Training Centre (RF)

Benches For Work With Thermal Mechanical Equipment

- Pump equipment and isolation valve

Source: IAEA workshops
Balakovo NPP Training Centre (RF)

VVER-1000 Mock-up

Source: IAEA workshops
Balakovo NPP Training Centre (RF)

Radiological Control and ALARA Training Tools

Source: IAEA workshops
Balakovo NPP Training Centre (RF)

Classroom For Training Related to Industrial Safety Regulations and Rules

*medical robot-simulator «Gosha-N»*

Source: IAEA workshops
Full-scope replica simulator

FSS for Kalinin NPP (Russia), Unit 3

(VNIIAES & ENIKOTSO, Russia)

Source: eniko.ru
Full-scope replica simulator

FSS for the Olkiluoto 3, EPR-1600, Finland

(L-3 MAPPS, Canada)

Source: L-3 MAPPS
AP1000 control room simulators, such as the one above, have been installed at Sanmen and Haiyang (China) (GSE Systems, USA)

Source: Westinghouse
Ningde Unit 1 Full Scope Simulator (China)
(Western Services Corporation, USA)

Source: WSC
Full-scope simulators

Tianwain NPP (China)  
Kudankulam NPP (India)  
Bushehr NPP (Iran)

FSS for VVERs supplied to various countries (VNIIAES, Russia)

Source: ATOMEXPO-2012
For the training on:
- Fundamentals
- VVER-1000 operation

(General Energy Technologies, Russia)

Source: GET
Simulators / Analyzers for Training on Severe Accidents, and EP & SAMG Development

Simulator / Analyzer TOMAS, VVER-1000, Russia (General Energy Technologies, Russia)

Source: IAEA workshops
Severe accident module, France
(CORYS TESS, France)

Source: CORYS TESS
Simulators / Analyzers for Training on Severe Accidents, and SAMG strategy verification

Severe Accident Interactive Graphic Simulator
(Tecnatom, s.a., Spain)

Source: Tecnatom
Generic PWR simulator
(GSE Systems, USA)

Source: GSE Systems
Basic Principles / Generic Simulators

Generic Pressurized Water Reactor simulator (GPWR) (Western Services Corporation, USA)

Source: Western Services Corporation
VVER-1000 simulator for training on basic principles and also for in-depth training on operation, Russia
(ENIKO TSO, Russia)

Source: ENIKO TSO
Educational Laboratory “Reactor Physics, Control, and Safe Operation of NPPs” (VVER) for education on nuclear engineering in technical universities (ENIKO TSO, Russia)

Source: ENIKO TSO
E-learning systems

Computer-based training systems (Balakovo NPP, Russia)

Source: IAEA workshops
Computer-aided Training Systems

CBT system (Balakovo NPP, Russia)

Source: IAEA workshops
E-learning

Example of E-learning course on maintenance of centrifugal pumps (Spain)

Source: IAEA workshops
E-learning

Interactive systems and virtual mock-ups (Russia, Spain and Ukraine)

Source: IAEA workshops
Multifunctional computer-based training system (Zaporozhzhe NPP, Ukraine)

Multi-functional system: for formal training, assessment, pre-job briefings / just-in-time training, performance support during operation and maintenance, preservation of critical knowledge

- Pressurizer safety valves
- Steam generators
- Spent fuel dry storage facility
- Automated Process Control System
- Controllers
- Turbo-generator
- Pumping equipment
- Outdoor switchyard
- Hydrogen preparation system
- Soldering

Technology, know-how, development tools, h/w & s/w, training of local staff – for the whole industry

Hundreds of personnel trained

Hazardous works during transportation

Knowledge base, hundreds of training objectives and test questions
Blended learning of maintenance personnel using E-learning system (Zaporozhzhie NPP, Ukraine)

Source: IAEA workshops
CBT on maintenance of "Sempell" safety valves

Source: IAEA workshops
E-learning on open area distribution facility
OPU-750 KB

Source: IAEA workshops
E-learning on the hydrogen preparation and distribution to the units

Source: IAEA workshops
E-learning - Maintenance of Electrical Generator TBB-1000-4У3

Source: IAEA workshops
E-learning on Basics of Pump Maintenance

Source: IAEA workshops
E-learning on the Refuelling machine

Source: IAEA workshops
E-learning on Steam Generator maintenance ПГВ-1000М

Source: IAEA workshops
E-learning for New Builds
E-learning System on Basics of NPP Policies, Management and Technology (Belarus)

- Basics of Nuclear Infrastructure
- NPP Safety Concepts
- Requirements for Siting
- NPP technology
- Integrated Management Systems
- NPP Policies
- Hazards and Risks during performance
- Emergency Preparedness
- Fire Protection
- Industrial Safety
- Radiation Protection and Radiological Control
- Waste Handling and Housekeeping
- NPP Construction Management
- Human Resource Development, Training System, SAT
- NPP operation
- Knowledge Management

Source: IAEA workshops
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### Examples of some important activities and milestones in the development of a Training System and staffing

<table>
<thead>
<tr>
<th>Activity to establish Training System</th>
<th>Approx. duration</th>
<th>Start</th>
<th>End</th>
</tr>
</thead>
<tbody>
<tr>
<td>Create national task force on HRD. Train task force in programme and project management, HRD, WFP and training basics.</td>
<td>Approx. 3 months</td>
<td>At the very beginning of Pre-project</td>
<td>As soon as possible at the beginning of Pre-project</td>
</tr>
<tr>
<td>Acquire and use generic e-learning systems and basic principle simulator(s) for educational purpose</td>
<td>Approx. 1 year</td>
<td>At the beginning of Pre-project</td>
<td>Before development of FS</td>
</tr>
<tr>
<td>Develop the first (preliminary) WFP for Operating Organization and NPP</td>
<td>Approx. 2 months</td>
<td>During Pre-project (pre-FS)</td>
<td>Before FS developed</td>
</tr>
<tr>
<td>Develop overall structure of NPP staffing related regulations</td>
<td>Approx. 1 month</td>
<td>During Pre-project (pre-FS)</td>
<td>FS approved</td>
</tr>
<tr>
<td>Create HR task force in Operating Organization. Hire HR Manager for Operating Organization and Training Manager for NPP, and key staff. Establish and train a core project team for Training System development.</td>
<td>From 2 to 3 months</td>
<td>During Project decision making</td>
<td>Before BIS development starts</td>
</tr>
<tr>
<td>Develop overall qualification requirements and generic job descriptions for NPP personnel</td>
<td>From 3 to 4 months</td>
<td>During Project decision making</td>
<td>Before BIS issued</td>
</tr>
<tr>
<td>Develop and approve basic regulations on selection, training, qualification and authorization of NPP personnel</td>
<td>From 3 to 6 months</td>
<td>During Project decision making</td>
<td>Before BIS issued</td>
</tr>
<tr>
<td>Develop and approve Training Policy and Training System Concept</td>
<td>Approx. 8 months</td>
<td>During Project decision making</td>
<td>Before BIS issued</td>
</tr>
<tr>
<td>Develop General Requirements for Training Centre</td>
<td>Approx. 3 months</td>
<td>During Project decision making</td>
<td>Before BIS issued</td>
</tr>
<tr>
<td>Adopt a standard for FSS</td>
<td>From 1 to 3 months</td>
<td>During Project decision making</td>
<td>Before BIS issued</td>
</tr>
<tr>
<td>Develop and include in BIS requirements for the Vendor to supply major elements of NPP training system including (but may be not limited to these): training procedures, training programmes and materials, training centre documentation, training of NPP operating personnel, training of instructors</td>
<td>2 months</td>
<td>During Project decision making</td>
<td>Before BIS issued</td>
</tr>
<tr>
<td>Establish HR and Training Department in Operating Organization</td>
<td>Approx. 6 months</td>
<td>During Project decision making</td>
<td>Before tender proposals received</td>
</tr>
<tr>
<td>Acquire the initial set of SAT-based training procedures</td>
<td>Approx. 6 months</td>
<td>Contract award</td>
<td>Before the start of NPP specific training programmes’ development</td>
</tr>
<tr>
<td>Acquire technical specification and design documentation for Training Centre</td>
<td>Approx. 1 year</td>
<td>At the very beginning of Deployment phase</td>
<td>Approx. in 1 year after contract award</td>
</tr>
<tr>
<td>Develop job descriptions for Training Centre staff</td>
<td>Approx. 2 months</td>
<td>At the beginning of Deployment phase</td>
<td>Before staffing the first set of Training Centre instructors</td>
</tr>
<tr>
<td>Select and train the first set of instructors</td>
<td>Approx. 1 year</td>
<td>After job descriptions have been developed</td>
<td>Before commissioning of the first stage of Training Centre</td>
</tr>
<tr>
<td>Build and commission the first stage of Training Centre for the use of construction personnel training and basic training of operating personnel</td>
<td>Approx. 1 year</td>
<td>During site development and construction phase</td>
<td>About 5 years before COD</td>
</tr>
<tr>
<td>Develop / revise and approve detailed regulations on selection, training, qualification and authorization of NPP personnel</td>
<td>Approx. 1 year</td>
<td>After NPP Vendor selected and NPP contract awarded</td>
<td>Before the start of selection and training of operating staff</td>
</tr>
<tr>
<td>Acquire NPP specific training programmes for the first set of NPP personnel</td>
<td>Approx. 1 year (if the Vendor is capable to do it)</td>
<td>Contract award</td>
<td>Before the start of NPP personnel training programmes</td>
</tr>
</tbody>
</table>
Examples of some important activities and milestones in the development of a Training System

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<tr>
<td>Equip training centre with training tools for NPP operating personnel training, such as graphics interface simulator, e-learning systems, main laboratories and workshops</td>
<td>Approx. 3 years</td>
<td>During construction phase</td>
<td>About 3-4 years before COD</td>
</tr>
<tr>
<td>Acquire a full-scope replica simulator (FSS)</td>
<td>Approx. 3 years</td>
<td>Approx. in 5 years before fuel loading</td>
<td>Not later than in 2 years before fuel loading</td>
</tr>
<tr>
<td>Acquire (hire and ensure competence of) FSS instructors</td>
<td>Approx. 6 months</td>
<td>Approx. 2 years before fuel loading</td>
<td>Approx. in 1.5 years before fuel loading</td>
</tr>
<tr>
<td>Obtain a licence / certification of the FSS</td>
<td>Approx. 6 months</td>
<td>Approx. 2 years before fuel loading</td>
<td>Approx. in 1.5 years before fuel loading</td>
</tr>
<tr>
<td>Develop the complete set of initial and continuing training programmes for the operating phase</td>
<td>Approx. 2 years</td>
<td>During construction</td>
<td>Before applying for the operation licence</td>
</tr>
<tr>
<td>Ensure availability of all documentation for Training System</td>
<td>From 4 to 5 years</td>
<td>During construction</td>
<td>Before applying for the operation licence</td>
</tr>
<tr>
<td>Perform the first update of FSS</td>
<td>Approx. 6 months</td>
<td>Approx. 6 months after COD</td>
<td>Approx. 1 year after COD</td>
</tr>
<tr>
<td>Update the initial set SAT-based training procedures</td>
<td>Approx. 1 year</td>
<td>Approx. 6 months after COD</td>
<td>Approx. 1.5 year after COD</td>
</tr>
<tr>
<td>Complete Training Centre</td>
<td>From 1 to 3 years</td>
<td>Immediately after COD</td>
<td>In 1 to 3 years of NPP operation</td>
</tr>
</tbody>
</table>


"Those who fail to plan, plan to fail."
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- Diversity of HR
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Examples of HR Related Lessons Learned and Risks

- Inadequate workforce planning
- Inadequate staff (numbers, competence) in various organizations (e.g. Operating Organization, Regulators, TSOs) involved in NP programme
- Regulations for personnel licensing are not available timely
- The Owner has an illusion that all training issues will be resolved by the Vendor
- Concept of a Training System not defined
- Requirements for a Training Centre not available
- Establishment of the Training Centre does not start timely
- Job-specific requirements for the competencies are not defined
- Insufficient resources for Training System development
- Lack of data for training development
- National Team is not prepared to establish Training System
- Lack of Quality Assurance in training
- Qualified instructors are not available
- Owner and/or Operating Organization Managers do not provide support as needed
- NPP personnel do not acquire needed experience
- NPP staff not timely trained and not qualified
Factors helping achieve sustainability (examples)

✓ Capacity building strategy at the national level.

✓ Long-term staffing and development plans for all main organizations and activities.

✓ Careful planning the development of a Training System. It may require from 7 to 10 years at minimum for its establishment.

✓ At the very beginning:
  ➢ Strategic vision – Conceptual document on the Training System
  ➢ Training Policy
  ➢ Objectives and criteria to evaluate Training System

✓ To achieve adequate competence and performance - an integrated approach. Investments in Management system, in organizational and process development and improvement are essential. Education and training alone cannot guarantee the success and sustainability.

✓ Collaboration between the Government, Education, Training, Regulators, Industry, Designers and Vendor, and international cooperation and benchmarking are crucial.
Our cooperation, joint knowledge and experience, and dedication will make the success inevitable!

Thank you for your attention
Merci de votre attention
Спасибо за внимание
Gracias por tu atención