



*The Abdus Salam  
International Centre for Theoretical Physics*



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**Joint ICTP-IAEA School of Nuclear Energy Management**

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**Case Study on Knowledge Loss Risk Assessment**

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**The IAEA/ICTP School of Nuclear Energy Management  
August 2011, Trieste, Italy**

# ***Risk Management of Knowledge Loss in Nuclear Industry Organizations***

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Nuclear Knowledge Management Unit*

# Content

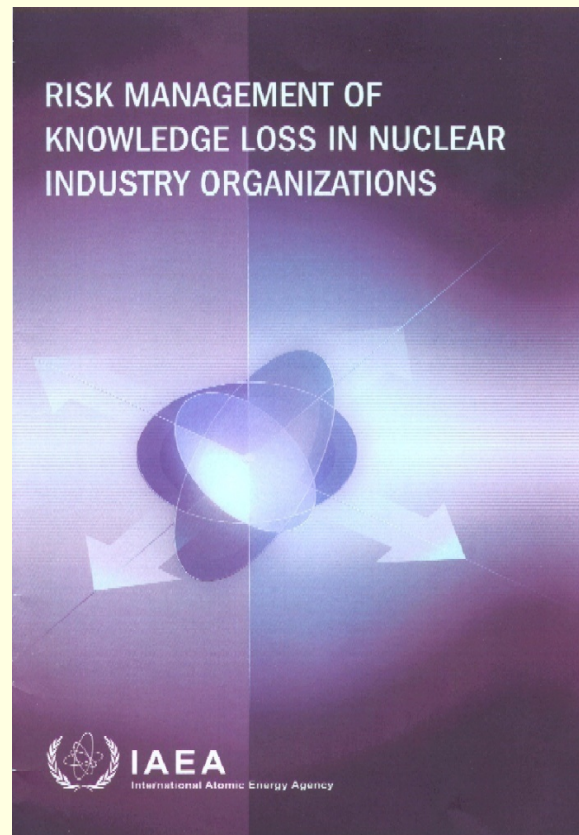
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- Risk Management of Knowledge Loss
  - A three step process IAEA Publication 1248
  - “Mission Critical Knowledge”
- A Case Study - TVA’s program to managing the risk of knowledge loss
  - Who is TVA?
  - The Attrition Challenge
  - Retaining Critical Knowledge (just 3 steps)
  - Results and Lessons Learned
  - Questions

# IAEA Publication 1248

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**“Risk Management of  
Knowledge Loss in Nuclear  
Industry Organizations” –  
Published July 2006**



**Knowledge Loss Risk  
Assessment  
Processes and Tools**

## Knowledge Retention Process - Retaining Critical Knowledge

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Three main sub-processes/activities:

**Step 1.** Conduct a *Knowledge Loss Risk Assessment*

**Step 2.** *Determine Approach* to capture critical knowledge

**Step 3.** *Monitor* and *Evaluate*

## Three Step Process

# Knowledge Retention

Step 1:

Step 2

Step 3

## **“Knowledge Loss Risk Assessment”**

- ☐ “Knowledge Loss Risk Assessment” is designed to identify workers where the potential for knowledge loss is greatest and most imminent
- ☐ Assessment ratings are based on two factors:
  - ☐ Time until retirement (Attrition Risk Factor)
  - ☐ Position criticality (Position Risk Factor - assigned by management)
- ☐ Step provides focus by Identifying workers where actions to mitigate knowledge loss may be needed

# Knowledge Retention

Step 1 Step 2 Step 3

**Attrition Risk  
Factor**

×

**Position Risk  
Factor**

=

**Total Risk  
Factor**

**Attrition Risk Factor** -- Projected retirement dates will be assigned a risk factor as follows:

- 5 - Within 2 years
- 4 - Within 3 years
- 3 - Within 4 years
- 2 - Within 5 years
- 1 - Within or greater than 6 years

# Knowledge Retention



Position Risk Factor -- An estimate of the difficulty or level of effort required to replace the position based upon the following criteria:

- 5 **Mission-critical knowledge/skills. Knowledge undocumented - unique, no duplication - requires 3-5 years of training.**
- 4 Critical knowledge and skills. Some limited duplication exists at other plants/sites and/or some documentation exists - requires 2-4 years of focused training.
- 3 Important, systematized knowledge and skills. Documentation exists and/or other personnel on-site possess the knowledge/skills.
- 2 Procedure based or non-mission critical knowledge and skills. Training programs are current and effective and can be completed in less than one year.
- 1 Common knowledge and skills.



# Knowledge Retention

## "Knowledge Loss Risk Assessment"

Step 1:

Step 2

Step 3

**Attrition Risk  
Factor**

X

**Position Risk  
Factor**

=

**Total Risk  
Factor**

**Total Risk Factor** -- An estimate of the effort and urgency necessary to effectively manage the attrition.

- 20-25 **High Priority - Immediate action needed.** Specific replacement action plans with due dates will be developed to include: method of replacement, knowledge management assessment, specific training required, on-the-job training/shadowing with incumbent.
- 16-19 **Priority** - Staffing plans should be established to address method and timing of replacement, recruitment efforts, training, shadowing with current incumbent.
- 10-15 **High Importance**- Look ahead on how the position will be filled/ work will be accomplished. College recruiting, training programs, process improvements, reinvestment.
- 1-9 **Important** - Recognize the functions of the position and determine the replacement need.

# Knowledge Retention

Step 1 Step 2 Step 3

## “Knowledge Loss Risk Assessment”

		Position Risk Factor				
		1	2	3	4	5
Attrition Risk Factor	5	5	10	15	20	25
	4	4	8	12	16	20
	3	3	6	9	12	15
	2	2	4	6	8	10
	1	1	2	3	4	5

# Knowledge Retention

Step 1

Step 2

Step 3

## “Determine Approach to Capture Critical Knowledge”

- ☐ Conduct interview to identify potential knowledge loss areas
- ☐ Assess consequences of loss using interview results and organization specific critical skills inventories (**What**)
- ☐ Prioritize and identify options to retain or mitigate (**So What**)
- ☐ Develop and implement action plans (**Now What**)

# Knowledge Retention

Step 1

Step 2

Step 3

## Conduct Interview to identify potential Knowledge Loss Areas

### Interview Questionnaire

- General questions
- Task questions (how....)
- Fact or information questions (what...who...)
- Pattern recognition/ lessons-learned questions

#### C. Questions About Facts or Information

1. Geographic info. – Describe any special geographic information you may have about where things are located and how to get to particular locations. This includes the easiest way to get to locations. Also describe any such information that may be common to an experienced employee but would prove to be critical if not known by an inexperienced employee.

#### A. General Questions

1. What kinds of knowledge or skills do you now have that TVA will miss most when you leave?
2. If you had to leave TVA suddenly and only had one day left to brief your replacement, what would

#### Questionnaire

#### Identifying At-Risk Knowledge

#### Instructions

The purpose of this questionnaire is to help you identify your critical skills and knowledge, especially those unique knowledge items and skills that might be lost when you leave TVA.

Some things to think about as you work through these questions:

- Knowledge or skill can mean several different things. We want to use a very broad definition that could include anything that new employees would need to know to do a job like yours (except for the exclusions noted below).
- Do not include standard skills that are common to your particular job or that are assumed for a particular certification or degree (e.g., journeymen electricians are expected to be able to read a blueprint, etc.). If you're not sure it is common, include it here.
- Some of the questions will appear to ask the same thing several different ways. We do this on purpose to make sure we do not miss valuable information. When the answer is something you have already discussed, simply say so rather than repeat the information again.
- When we ask you to describe or list things, give us a general description and not a detailed description. Don't try to tell us how to do something. We will come back and gather this level of detail later. For now we are just trying to build lists to evaluate and prioritize.
- For each major piece of knowledge, try to give us some sense of how important it is and how much trouble we may be in due to attrition. Tell us if the knowledge is written down somewhere or not, who knows it besides you, what would likely happen if no one knew this, how long it takes someone to learn it, etc.
- The questions under section B will produce lists. In many cases these lists will already exist in job descriptions, training programs, PM procedures, and/or in various databases. If so, simply refer to the appropriate source or list and tell us how to find it. In other words, there is no need to try to rewrite the list in the interview.

at the location or existence of information that may be critical if not known by an

ut key contacts for expert advice. Describe any such information that may be critical if not known by an experienced employee.

may have about where to go for parts, etc. Describe any information that may be critical if not known by an experienced employee.

ut how to order parts, materials, etc. Describe any information that may be critical if not known by an experienced employee.

#### Knowledge

h-standard (i.e., uncommon) knowledge items or complex problems. Name the components. Name the

t you may have about the type of failure or fix.

think you may have about system failures. In other words, are there things that you must know how to do that are missed by inexperienced employees? Are there things that you must know how to do that are missed by inexperienced employees?

have about failure patterns or preventive inspection or the type of failure or fix. Are

ns-learned) you have that the type of failure, related

# Knowledge Retention

Step 1

Step 2

Step 3

## Identify Options to Retain or Mitigate Knowledge Loss

### Codification

- Documentation & Procedures
- Checklists, Inventories, etc.
- Performance Support Systems
- Concept Mapping

### Alternative Resources

- Agency/site/department expert
- Rotational or “Visiting” Staff
- Multi-skilling or Cross-training
- Contractors, part-timers, retirees

### Engineer It Out

- Process Improvement
- Update Equipment
- “Smart” tools and technology
- Eliminate task, product or service

### Education & Training

- Classroom and Simulator Training
- CBT, Video-based, and alternative delivery
- OJT and Targeted Work Assignments
- Coaching, Shadowing & Mentoring
- Apprenticeship Programs

# Knowledge Retention

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## Monitor and evaluate knowledge retention plans

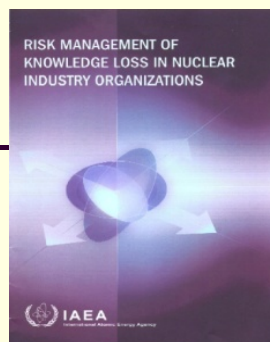
Step 1

Step 2

Step 3

- Review updated Projected Attrition Data
- Monitor previous Knowledge Retention Plans
- Identify areas that need to be reassessed
- Coordinate with appropriate organizations and repeat three step process where necessary

# Practical Approach



**Step 1. Conduct a *Knowledge Loss Risk Assessment***

**Step 2. *Determine Approach*** to capture critical knowledge

**Step 3. *Monitor* and *Evaluate***

Step 1 identifies the experts where the risk of losing knowledge import (critical) to the company – **IDENTIFIES THE POPULATION OF EXPERTS**

Step 2 develops the approach that will be take to capture, maintain, and share the critical knowledge – **A DOCUMENTED KNOWLEDGE RETENTION PLAN** is developed

Step 3 **ensures that the Knowledge Retention Plan has been followed and was effective**

Questionnaire  
Identifying At-Risk Knowledge

**Instructions**

The purpose of this questionnaire is to help you identify your critical skills and knowledge, especially those important knowledge items or skills that might be lost when you leave TUV.

Some things to think about as you work through these questions:

- Knowledge or skill can mean several different things. We want to use a very broad definition that could include anything that new employees would need to know to do a job like yours (except for the education you received).
- Do not include standard skills that are common to your particular job or that are assumed for a particular certification or degree (e.g., programmer qualifications are expected to be able to read a blueprint, etc.). If you're not sure it's common, include it here.
- Some of the questions will appear to ask the same thing several different ways. We do this on purpose to make sure we do not miss valuable information. When the answer is something you have already discussed, simply say so rather than repeat the information again.
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- The questions on the second half will provide lists. In many cases these lists will already exist in job descriptions, training programs, PM procedures, and/or in various databases. If so, simply refer to the appropriate source or list and tell us how to find it. In other words, there is no need to re-invent the wheel.

# Two examples

## Position: Specialist, Electrical Installation and Cables

- Knowledge and experience related to wiring and cable at all NPP sites
- Known as industry expert
- Represents company on IEEE's Insulated Conductors Committee
- Maintains a volume of journals that log experiences in Technical Library.
- Maintains list of industry experts and vendor contacts.
- Only go to guy that can do failure analysis on wire and cable

## Position: Specialist Structural Dynamics

- Knowledge and experience dealing with structural dynamics and integrity
- Covers analysis and testing (vibrations fatigue, fracture mechanics, hydrodynamics, etc.) for all site NPP structures and containments, piping, fuel racks, etc.
- Incumbent serves as TVA's representative on EPRI's Structural Reliability & Integrity Utility Advisory group and NEI's Environmental Fatigue Task Force, Seismic Shutdown
- Most of knowledge and expertise shared with two peers



# Mission Critical Knowledge?

## Positions Titles

- Specialist, Containment Leak Rate & Integrity
- Unit Operator, at two unit PWR NPP
- Site Vice President, NPP
- Instrumentation & Control Specialist
- Professor Reactor Physics
- Chief Engineer
- Personnel Services Consultant
- Modification Manager
- Electrical Engineer
- NDE Level III inspector
- Plant Manager
- IAEA Technical Secretary
- Electrical Maintenance Apprentice/Trainee
- Welding Specialist/Inspector
- President and CEO

# Mission Critical Knowledge?

## Positions Titles

- Specialist, Containment Leak Rate & Integrity ✓
- Unit Operator
- Site Vice President, NPP
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- Professor Reactor Physics
- Chief Engineer ✓
- Personnel Services Consultant
- Administrative Assistant
- Modification Manager
- Electrical Engineer
- NDE Level III inspector ✓
- Maintenance Manager
- IAEA Technical Secretary
- Electrical Maintenance Apprentice/Trainee
- Welding Specialist/Inspector
- President and CEO ✓

# KNOWLEDGE RETENTION ROLES AND RESPONSIBILITIES

	Line Organization			Human Resources (HR)	
	Employee	Manager / Supervisor	Sr. Leadership	HR Consultant	Work Force Planning (WFP)
<b>STEP 1: Conduct knowledge loss risk assessment</b>					
Prepare management team and appropriate managers and supervisors		Reviews process and roles	Reviews process and roles Involves appropriate staff	Briefs and Consults	
Assess the Total Risk Factor for each position	Communicates anticipated retirement date to HR and/or manager	Notifies HR of known plans or changes in employee's anticipated retirement  Assesses position risk factor	Reviews and approves factors	Consults as needed Facilitates timely review Notifies WFP of revised factors	Maintains attrition projections and factor ratings  Computes Total Risk Factor  Provides reports
Prioritize Positions		Identifies targeted positions and notifies HR/WFP	Reviews and approves	Consults as needed Notifies WFP of targeted positions	Records targeted positions Provides reports
<b>Step 2: Determine and implement plans to capture critical knowledge or adapt to its loss</b>					
Inventory knowledge and skills 'clusters' of the identified employee.	Participates in inventory as requested	Conducts inventory  Requests support as needed		Consults as needed  May provide/broker support for interviews & initial inventory	

# KNOWLEDGE RETENTION ROLES AND RESPONSIBILITIES

	Line Organization			Human Resources (HR)	
	Employee	Manager / Supervisor	Sr. Leadership	HR Consultant	Work Force Planning (WFP)
Assess the criticality of each of these knowledge/skill clusters	Supports assessment as requested	Assesses criticality  Requests support as needed		Consults as needed  May provide/broker support for initially assessing criticality	
Develop knowledge retention plans	Supports plan development as requested	Develops KR plans  Requests support as needed		Consults as needed  Provides support for initial KR plan dev.	
Coordinate and review knowledge retention plans		Coordinates planned actions  Revises KR plans and provides HR/WFP with current plans  Requests support as needed	Reviews and approves KR plans  Facilitates coordination as needed	Facilitates timely review & revision of plans  Provides WFP copies of final plans	Maintains a record of what KR plans have been developed.  Maintains copies of KR plans
Implement knowledge retention plans	Supports implementation as requested	Implements KR plans	Supports implementation as requested	Supports implementation as requested	
<b>Step 3: Monitor and evaluate</b>					
Monitor and Evaluate Action Plans and Priorities		Provides updates and current status of plans to management and HR/WFP  Identifies issues	Reviews progress  Provides support, redirection and coordination as needed	Facilitates review at least semi-annually  Coordinates plans, issues, etc. as needed	Updates records  Reports metrics

## GUIDE TO IDENTIFYING AT-RISK KNOWLEDGE

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- ☐ **Instructions**
- ☐ **General questions**
- ☐ **Question about tasks**
- ☐ **Questions about facts or information**
- ☐ **Questions about pattern recognition knowledge**

See the handouts

## KNOWLEDGE RETENTION PLAN

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- ☐ **Directions**
- ☐ **Options**
- ☐ **Coordination**

See the handouts

# Questions

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# **CASE STUDY**

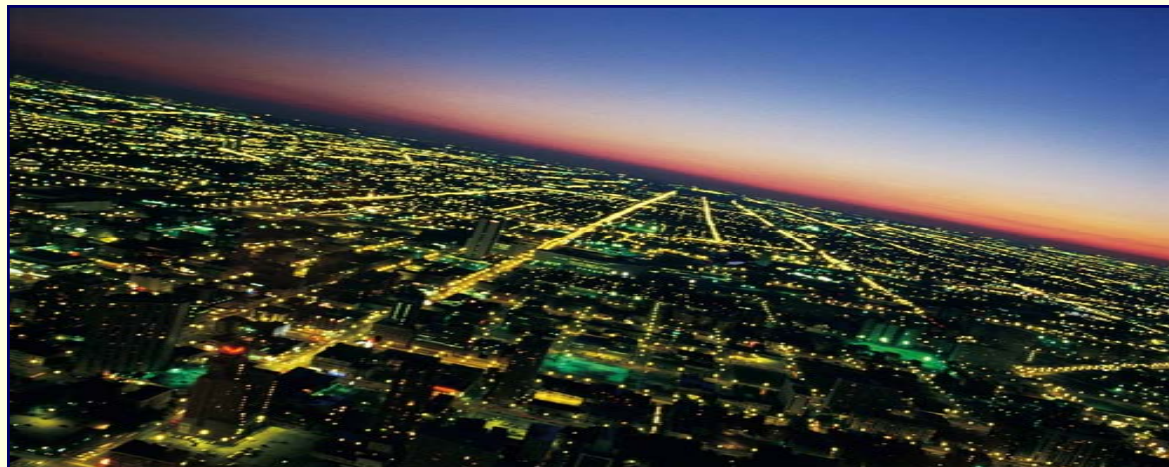
## **Tennessee Valley Authority**

### **An approach to retain “critical knowledge”**

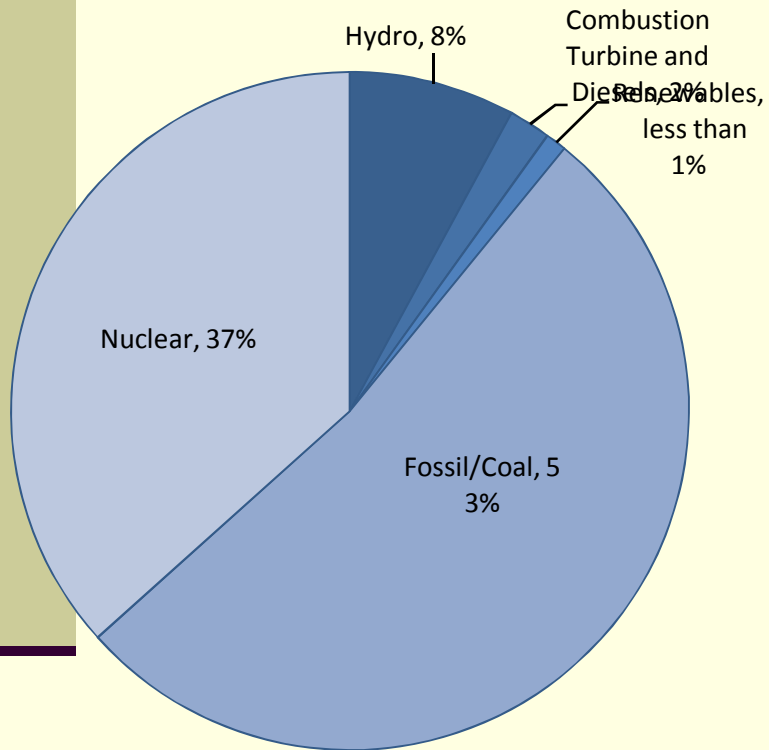


# Who is TVA .....

- 158 local distributors
- 58 directly served customers
- 9 million people in an 80,000 sq mile service area
- Serve public users of land and recreational facilities
- Assist communities with economic development assistance



# TVA's Diversified Generation Portfolio



Generation(Capacity)

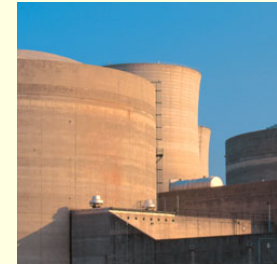
**Fossil Plants**



**Combustion Turbines**



**Nuclear Plants**



**Hydroelectric Dams**



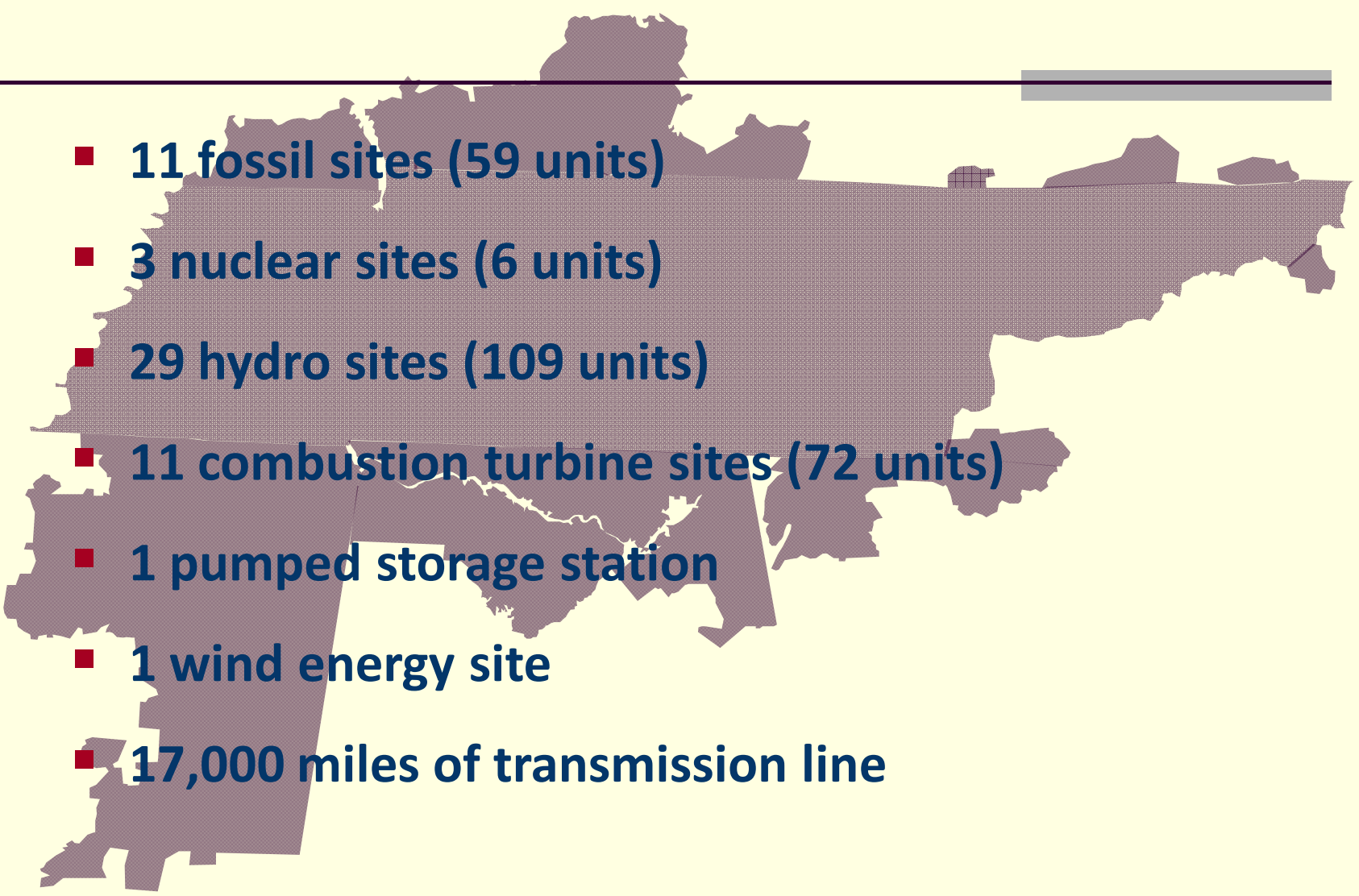
**Pumped-Storage**



**Green Power**



# TVA Generating Facilities

- 
- 11 fossil sites (59 units)
  - 3 nuclear sites (6 units)
  - 29 hydro sites (109 units)
  - 11 combustion turbine sites (72 units)
  - 1 pumped storage station
  - 1 wind energy site
  - 17,000 miles of transmission line

# TVA's Current Nuclear Portfolio



Sequoyah Nuclear Plant



Watts Bar Nuclear Plant



Browns Ferry Nuclear Plant



# TVA Nuclear – Industry Leader in Nuclear Generation Development

**Actual**



**Browns Ferry 1**

2007

Total Units      6  
Megawatts      6,800

**Under  
Construction**



**Watts Bar 2**

2012

7  
8,280

**Under  
Study**



**Bellefonte**

2017-2019

8  
9,500

# Watts Bar

*Completing Unit 2 Will Provide an Additional 1,180 MW of Generating Capacity to the TVA System*



High Pressure Turbine for Unit 2  
being delivered



Watts Bar Nuclear Plant



Moisture Separator Reheaters  
being lifted in the Turbine Building

- Five year project
- Budget of \$2.5 Billion
- Current staffing – 3,200
- Licensing process on schedule

# Bellefonte Project Status

## *Developing Two Nuclear Options For Future Generation*

**BLN 1 and 2**



**Babcock & Wilcox (Areva)**

- Construction permits reinstated in deferred status
- Preserving existing asset

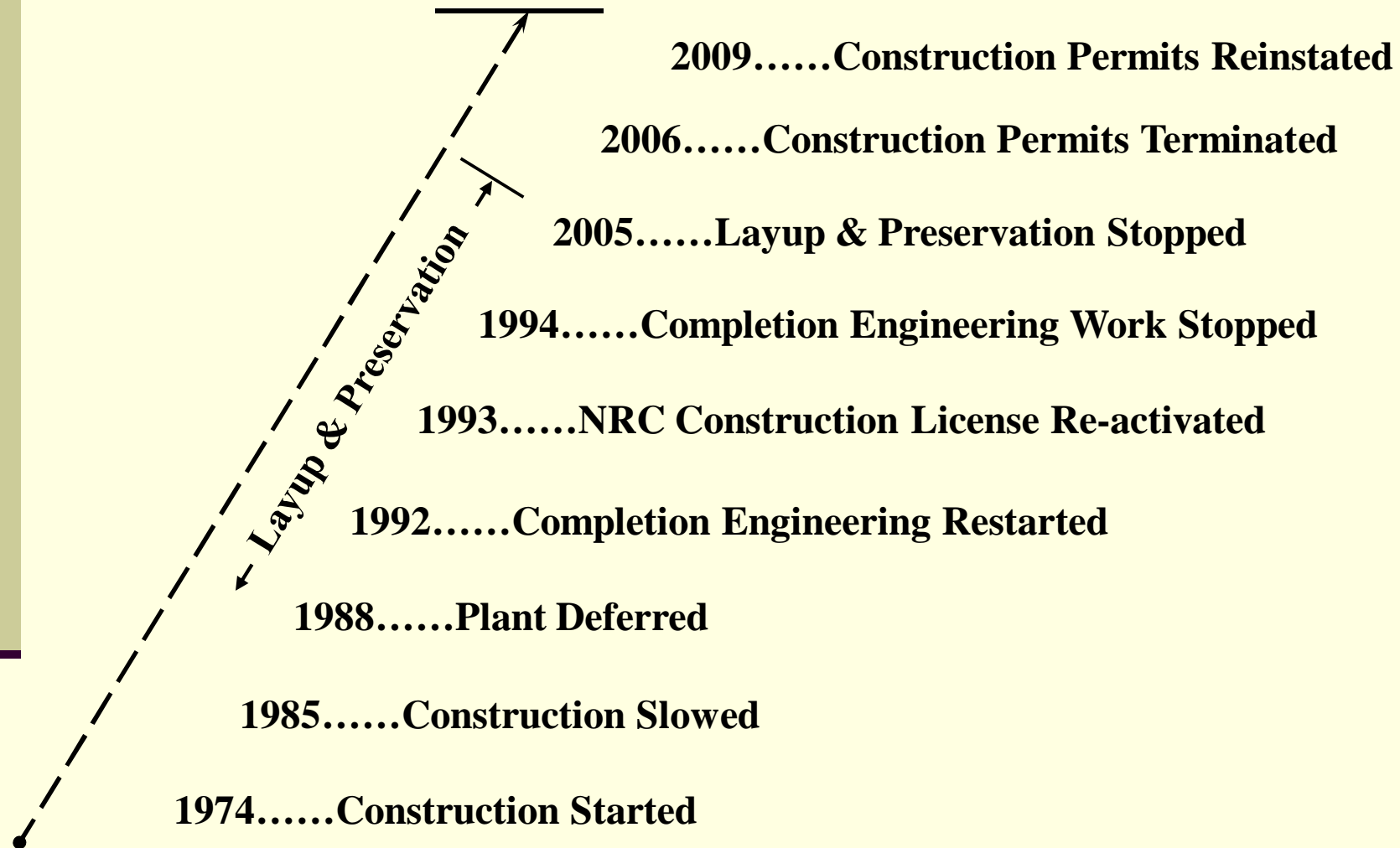
**BLN 3 and 4**



**Westinghouse**

- Pursuing combined operating licenses
- Standardization of plant design and licensing

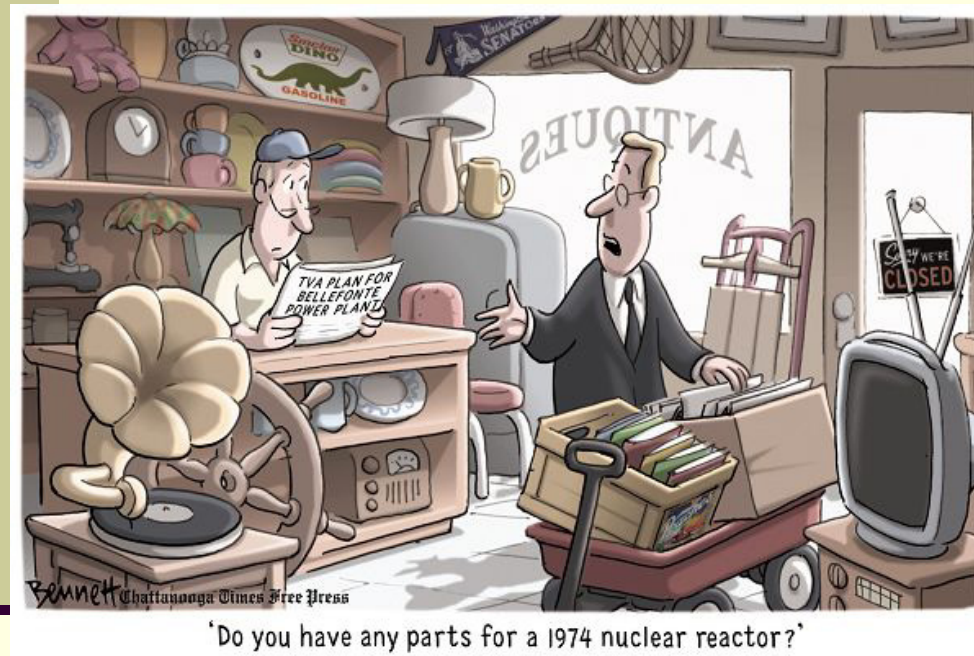
# Bellefonte Timeline





# Bellefonte Existing Units

## Perception



## Reality

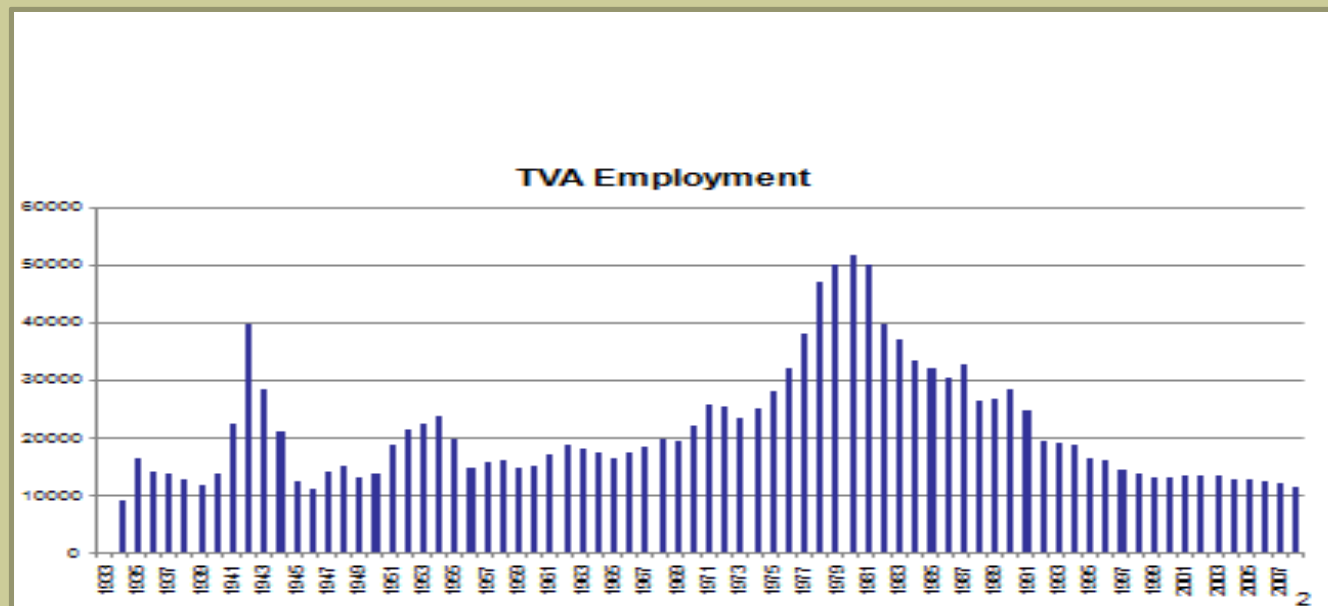
- Full digital upgrade of instrumentation and control (I&C) system
- Evaluation and application of current NRC regulations
- Evaluation and refurbishment and/or replacement of active plant components
- Systems, structures and components (SSCs) will be verified to meet all applicable design basis requirements

*If completed, Bellefonte will be the most modern US operating nuclear facility.*

# Tennessee Valley Authority

A program to manage the risk of knowledge loss as experts near retirement

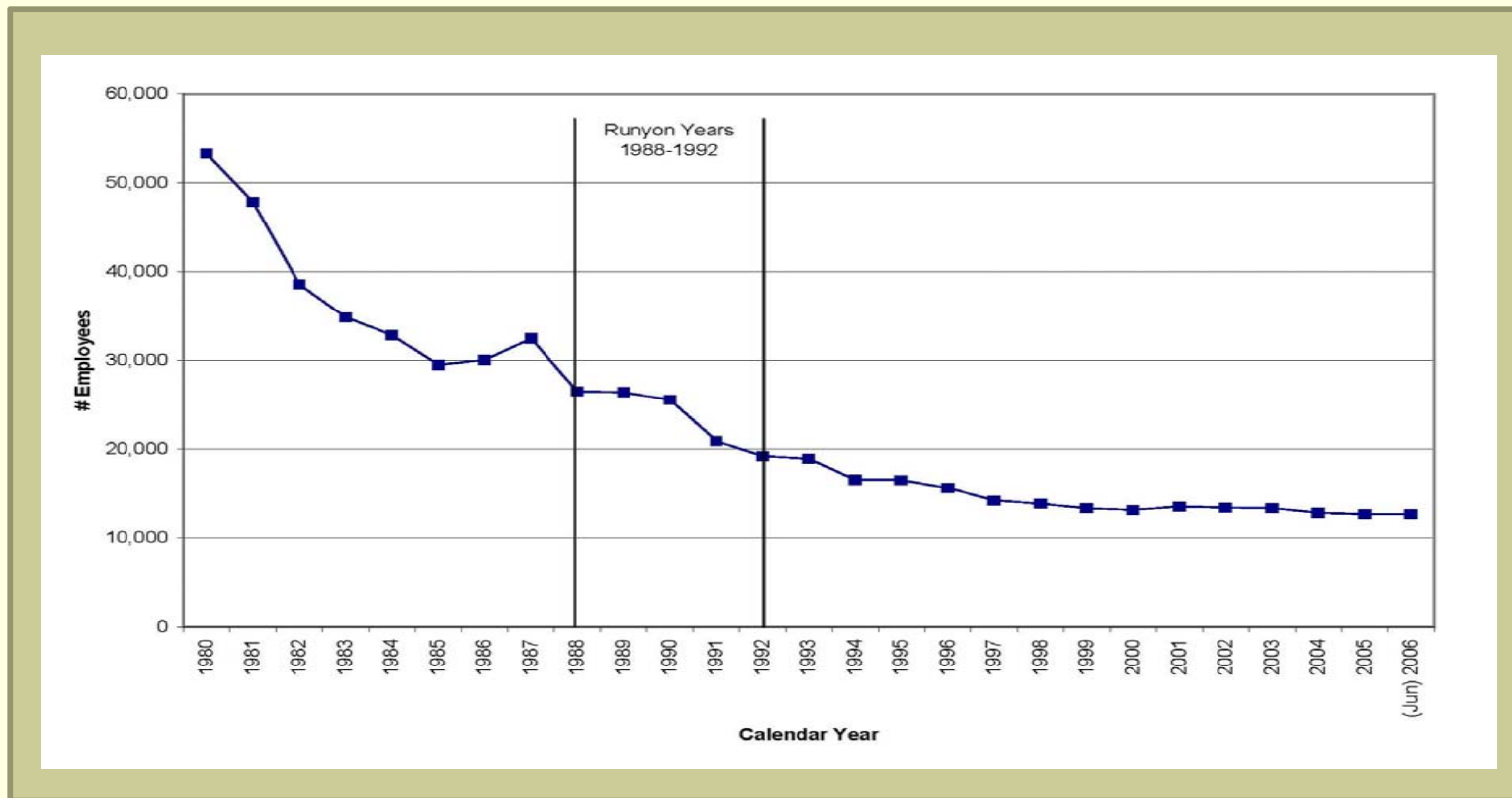
An attrition challenge



# Attrition Challenge

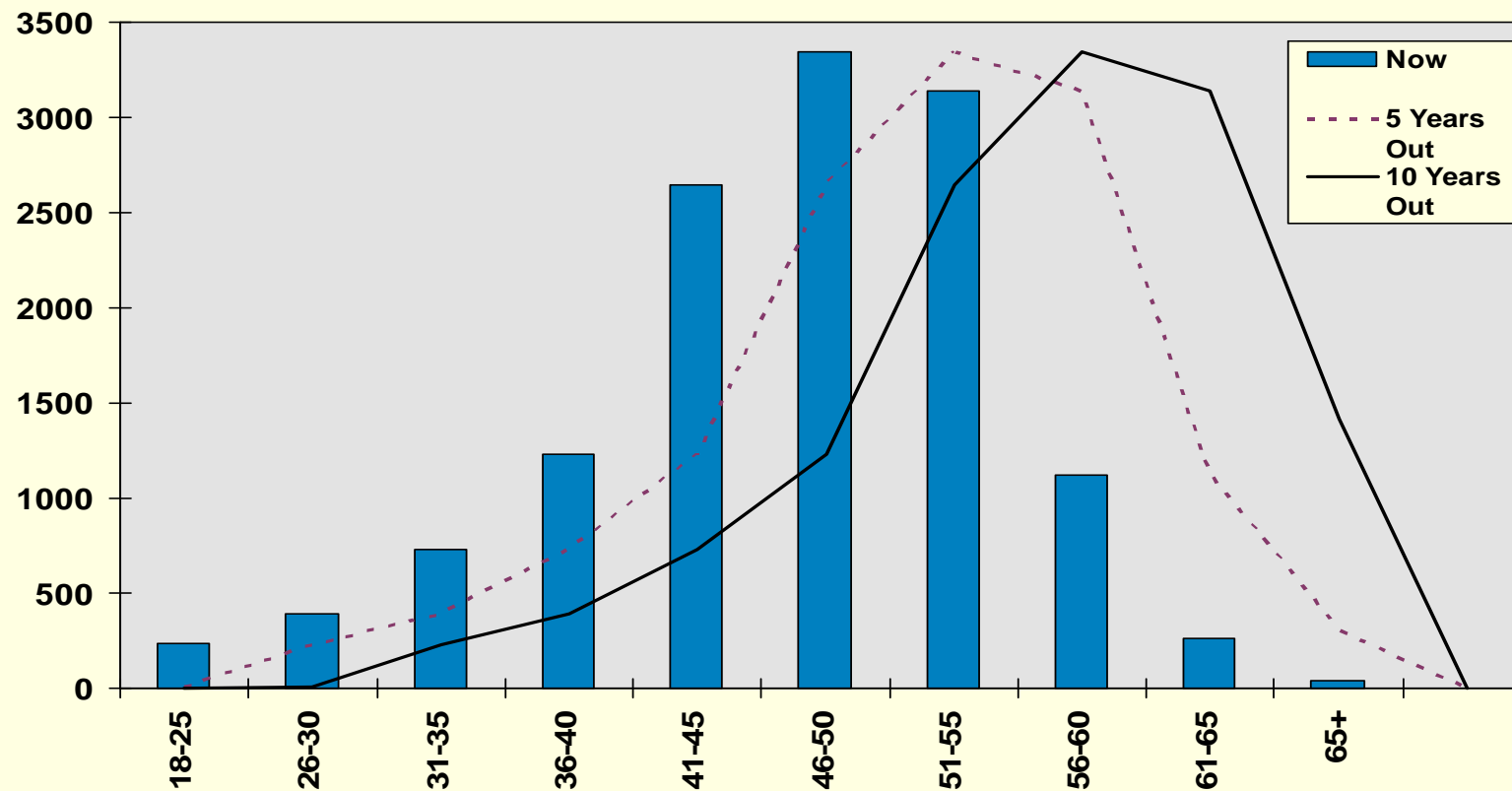
## Historical Perspective 1980 – 2006

- From 53,000 to Less Than 13,400 Employees
- Nuclear Power Group from 13,900 to approximately 3,200



# Attrition Challenge

## Employee Age Distribution in 1998 An Aging Work Force Nearing Retirement



# Attrition Challenge

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- Significant downsizing over 15+ years
- Various retirement incentives to aid downsizing
- Very limited entry level recruiting
- Average age – 48; Average retirement age - 56
- Approximately 1/3 of work force was eligible to retire within next 5 years
- *The possibility of losing “critical knowledge” was great*
- *The three step process was implemented in Nuclear Power Group in 2000 and in other groups (Fossil, Hydro, etc.) by 2003*

# Knowledge Retention

## 8 Knowledge Management Strategies

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- External Best Practice Sharing
- Internal Best Practice Sharing
- Competitive Intelligence (CI)
- Knowledge of Customers
- Innovation & Creation of New Knowledge
- Intellectual Capital and CI Protection
- KM Information Technology Tools
- **Avoidance of Knowledge Loss Through Attrition**

# Knowledge Retention

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## Process Focus

- Focusing on the critical positions where knowledge loss is the greatest threat
- Identifying and prioritizing the specific knowledge and skills at risk
- Developing concrete, actionable responses to mitigate this loss

# Knowledge Retention

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## TVA's Knowledge Retention Process - Retaining Critical Knowledge

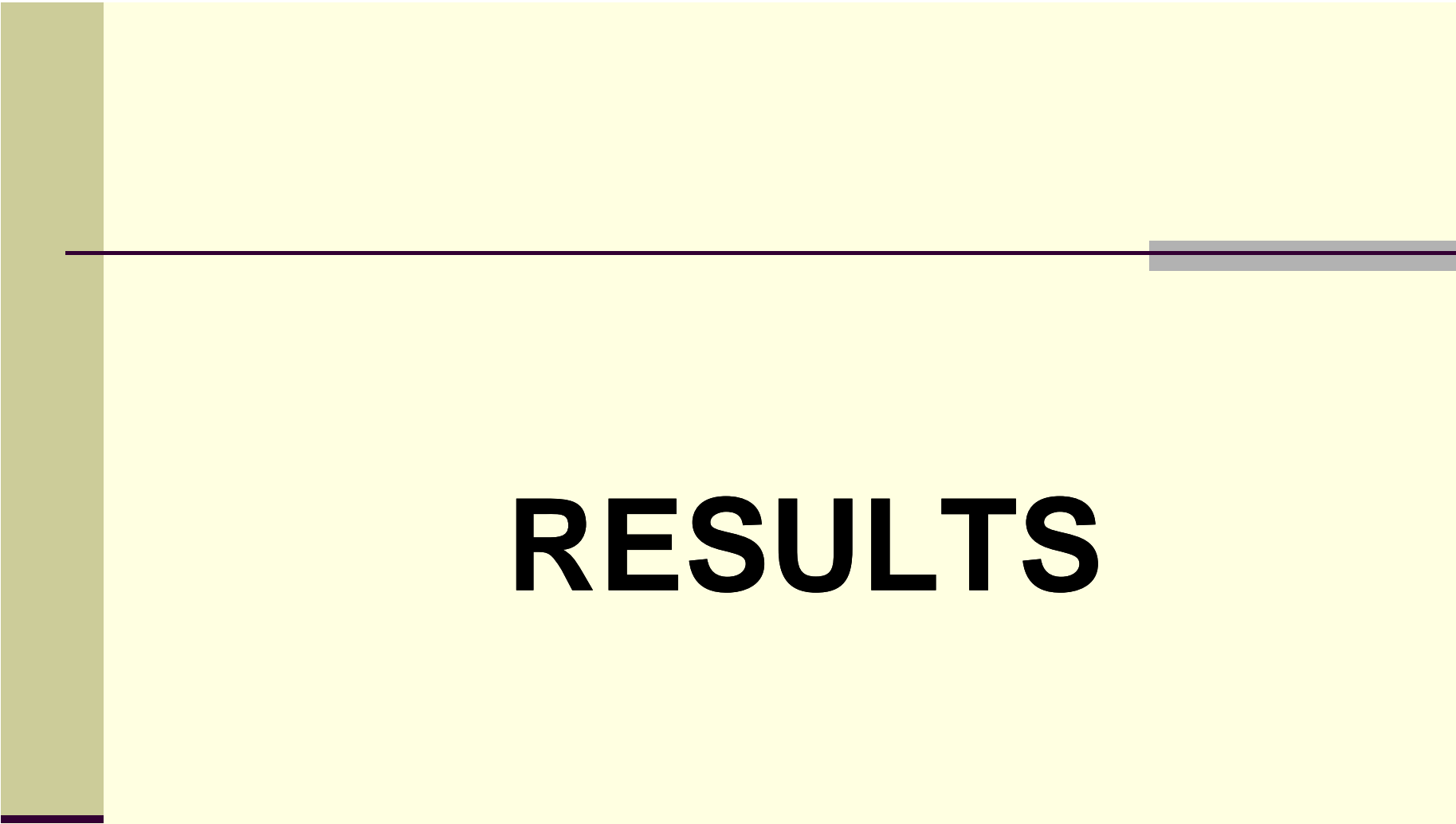
Three main sub processes/activities:

**Step 1.** Conduct a *Knowledge Loss Risk Assessment*

**Step 2.** *Determine Approach* to Capture Critical Knowledge

**Step 3.** *Monitor* and *Evaluate*





# RESULTS

## Critical Knowledge Risk – Total Risk Factor

### *2007 Status Update*

- Only 0.1% of greatest urgency (score above 20)
- 1.6% (193 positions) with scores about 15
- 0.4% (48 positions) with position risk of 5 (unique knowledge)

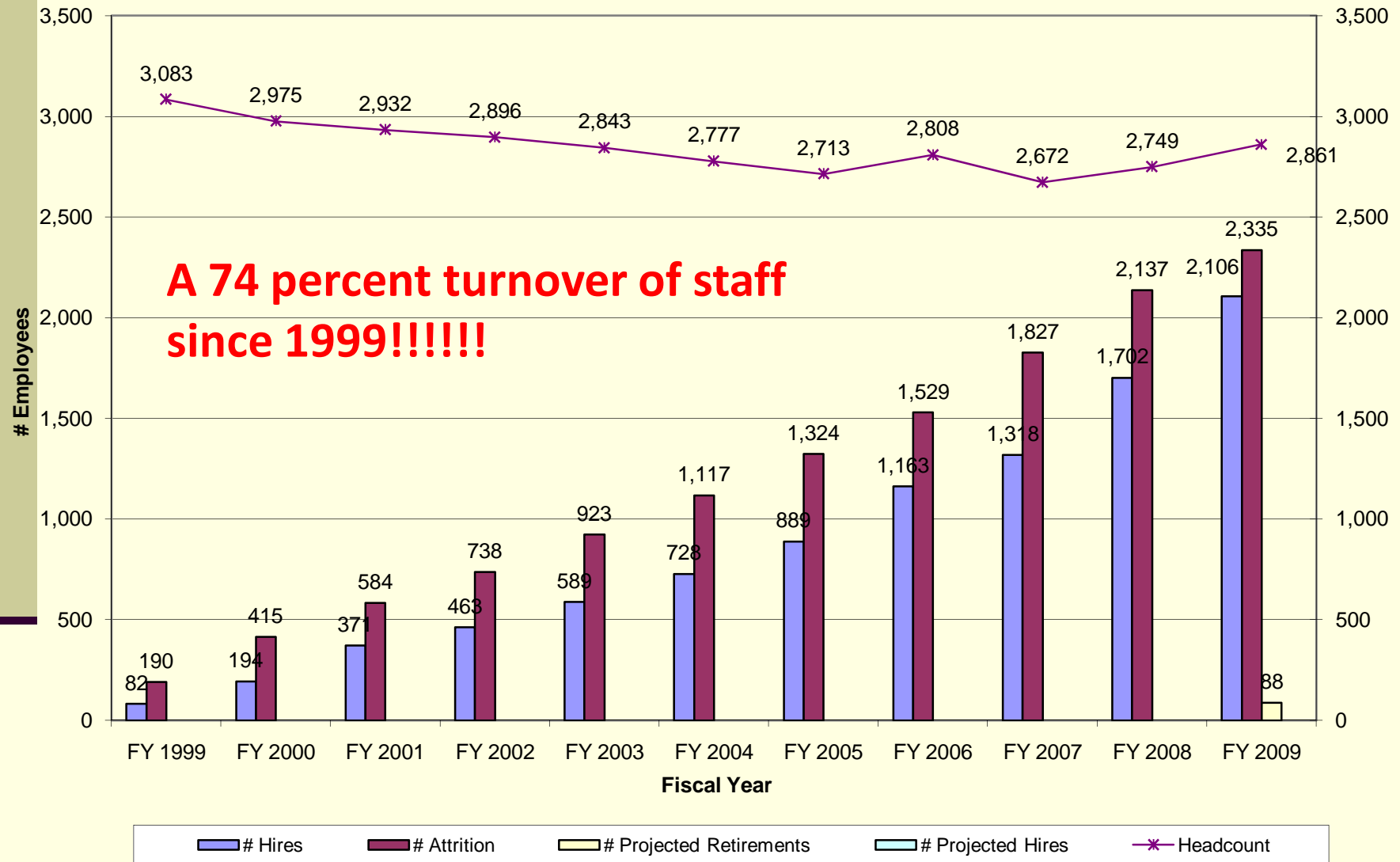
#### Position Risk Factor

		1	2	3	4	5
Attrition Risk Factor	5	29	65	141	3	1
	4	75	197	468	34	8
	3	81	210	491	41	6
	2	69	180	473	27	3
	1	1,175	2,724	5,059	226	30



# Staffing Risk

## TVA Nuclear Power Group - Cumulative Hires and Attrition





# **Lessons Learned**

# Lessons Learned

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- Risk of loss critical knowledge is greatest in specialized technical positions where problem solving strategies are needed
- Critical knowledge is not the same as good performance
- Wider range of options to mitigate knowledge loss than is typically considered
- Processes and procedures are sometimes weak – creates an over-reliance on “tribal knowledge” and individual expertise
- Pockets, or functional areas, of attrition risk may exist
- Line managers must own the solutions
- **Building and maintaining a worker pipeline is key to success**

# Questions

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