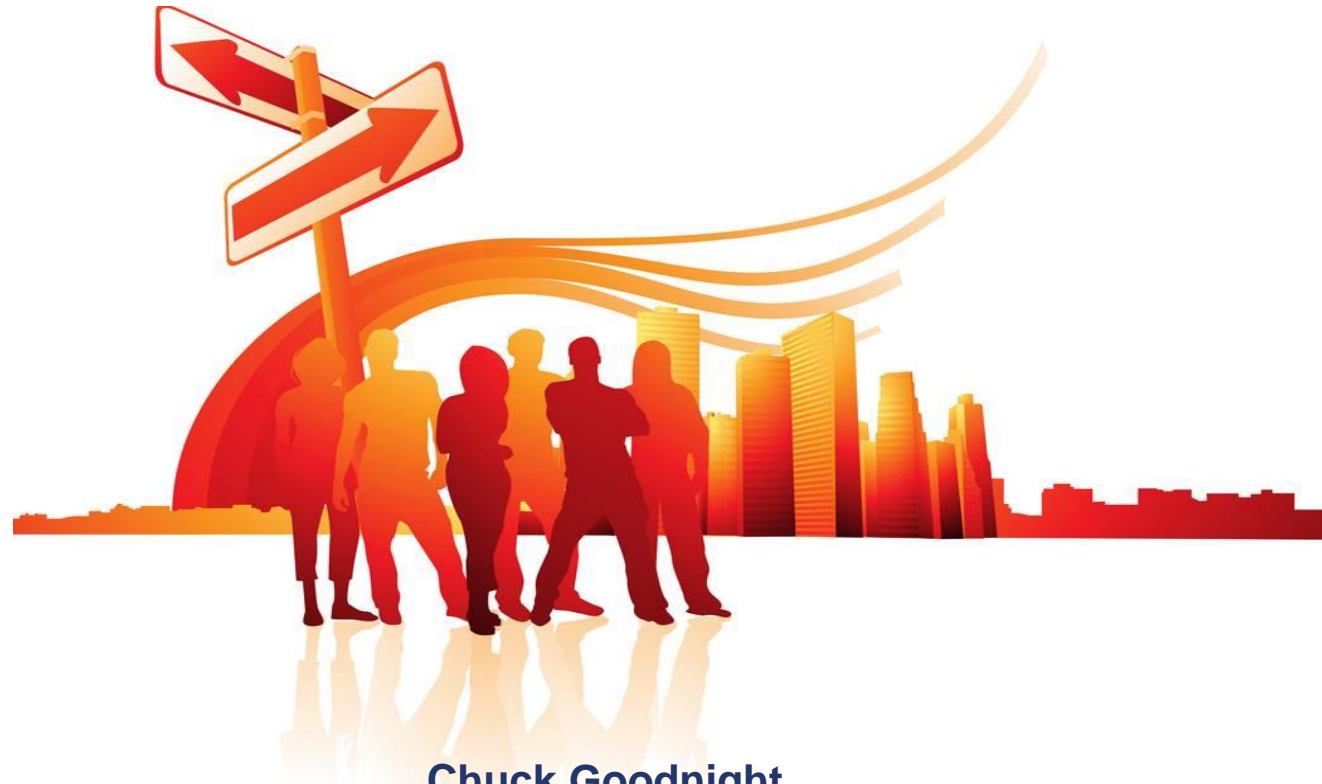


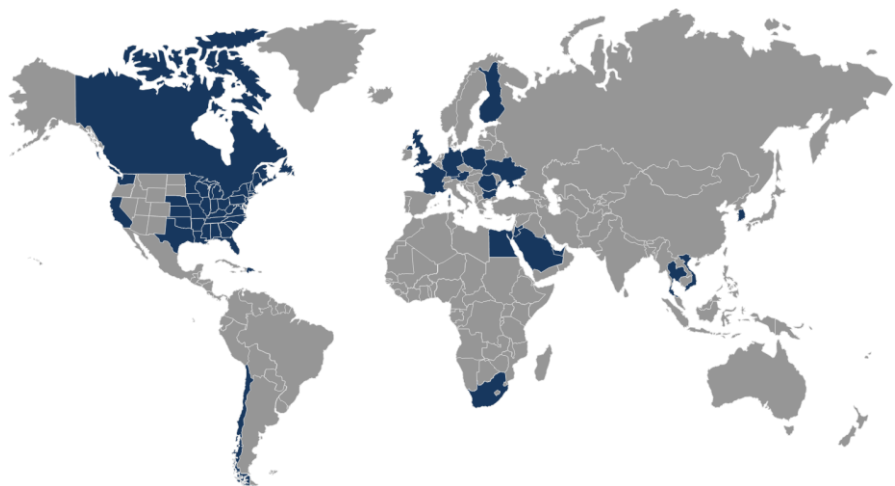
# Workforce Development Issues For Nuclear New Build

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**Chuck Goodnight**  
16 April 2019

# Goodnight Consulting Has Conducted Many Engagements For Global Nuclear Power Industry Clients



Over 140 engagements in more than 20 countries

Nearly every US nuclear operator

International nuclear operators

NSSS reactor designers

EPCs and technical firms

## Select *Non-Fleet* Clients



## Select *Fleet* Clients



## Select *Industry* Clients



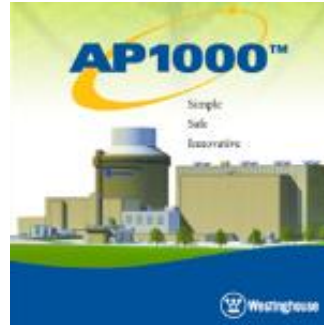
21 Consulting Projects for the IAEA focused on:

- Workforce Planning
- Human Resources Development
- Training
- Nuclear Safety Culture
- Organizational Culture
- Infrastructure Sharing

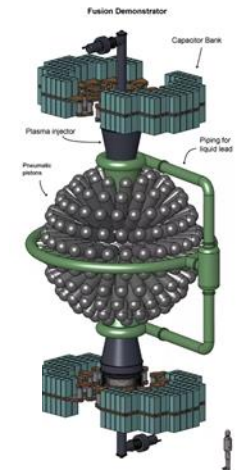
# Goodnight Consulting Has Also Developed Staffing and O&M Cost Models For Many New NPP Reactor Designs

We have developed proprietary staffing and/or O&M models for many new NPP designs:

- Areva (EPR)
- B&W (Generation mPower SMR)
- GE Hitachi (ESBWR)
- GE Hitachi (PRISM)
- GeneralFusion (Fusion Plant)
- KEPCO (APR1400)
- Rosatom (VVER-1200)
- TerraPower (TWR)
- Westinghouse (AP1000)

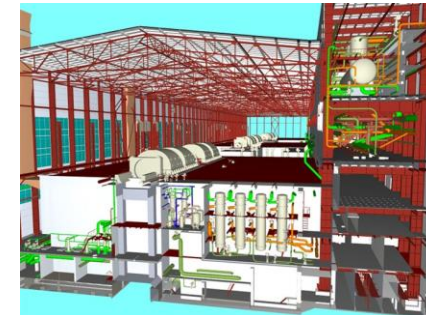
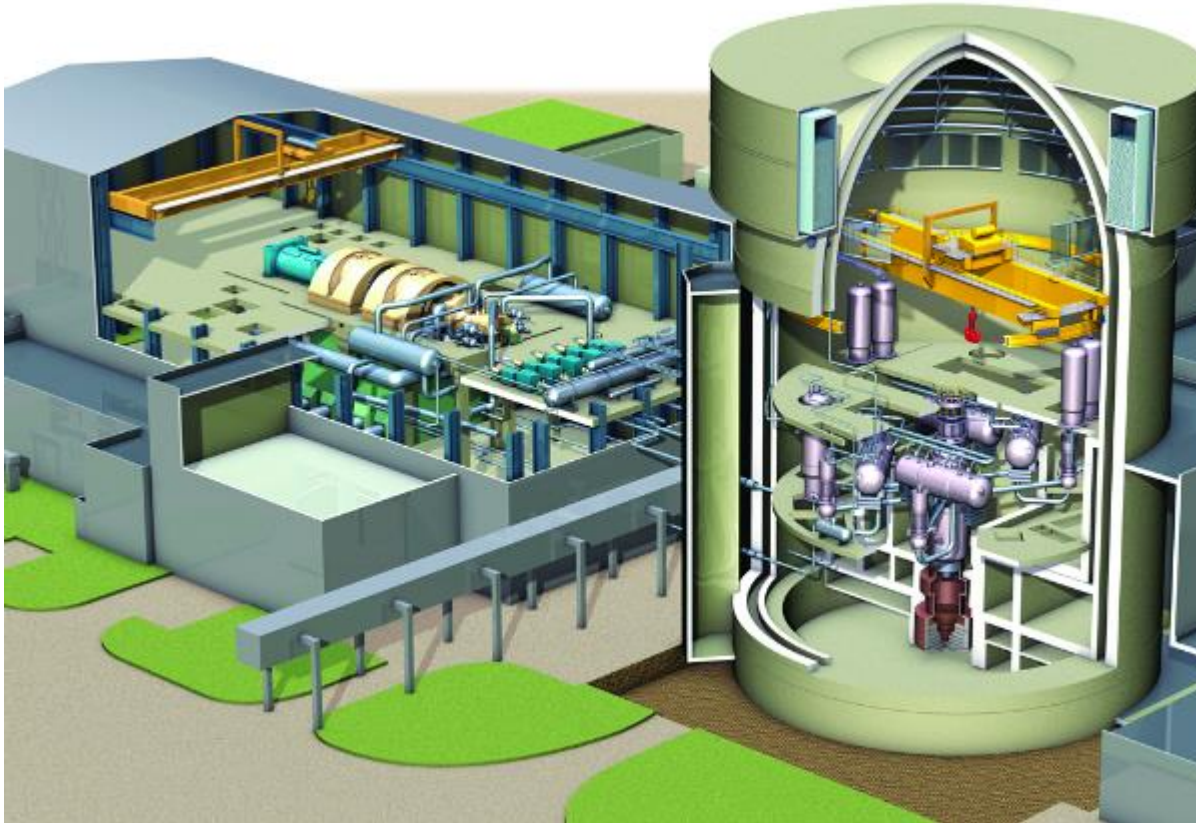


generalfusion





# Operations, Maintenance, Technical Support, Business Operations, and Regulatory Compliance For NPPs Are Very Demanding



# Regulatory Bodies Require Unique Competencies

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- Typical nuclear regulatory body organizations perform the following work functions:

*Administration*

*Information Technology*

*Nuclear Security*

*Appeals/Adjudication*

*Inspections - Construction*

*Quality Assurance*

*Budget/Finance*

*Inspections - Operational*

*Reactor Projects*

*Communications/Public Affairs*

*International Cooperation*

*Reactor Safety*

*Congressional Affairs*

*Investigations*

*Records Management*

*Contracts/Purchasing*

*Licensing*

*Research Programs*

*Employee Concerns*

*Management*

*Risk Assessment*

*Enforcement Programs*

*New Reactors*

*Rulemaking*

*General Counsel/Legal*

*Nuclear Material Safety*

*Safeguards*

*Human Resources*

*Nuclear Safeguards*

*Security*

*Incident Response*

*Nuclear Safety*

*Training*

# There Are A Wide Variety of Competencies Required By An NPP Operating Organization

- Typical nuclear operating organizations perform all of the following work functions:

*Admin/Clerical*

*Budget/Accounting*

*Chemistry*

*Communications*

*Contracts/Purchasing*

*Decontamination/Radwaste Processing*

*Design/Drafting*

*Document Control/Records Management*

*Emergency Preparedness*

*Engineering - Computer*

*Engineering - Mods*

*Engineering – Systems/Plant*

*Engineering - Procurement*

*Engineering - Reactor*

*Engineering - Technical*

*Environmental*

*Facilities*

*Fire Department*

*Human Resources*

*Information/Computer Technology*

*Legal*

*Licensing/Regulatory Affairs*

*Maintenance - Construction*

*Maintenance - Electrical*

*Maintenance - I&C*

*Maintenance - Mechanical*

*Maintenance - Support*

*Maintenance Planning*

*Management*

*Management Support*

*Nuclear Fuels*

*Operations*

*Operations Pipeline*

*Operations Support*

*Outage Planning/Scheduling*

*Project Management*

*Quality Assurance*

*Quality Control*

*Rad Pro Applied*

*Rad Pro Support*

*Safety Programs*

*Scheduling*

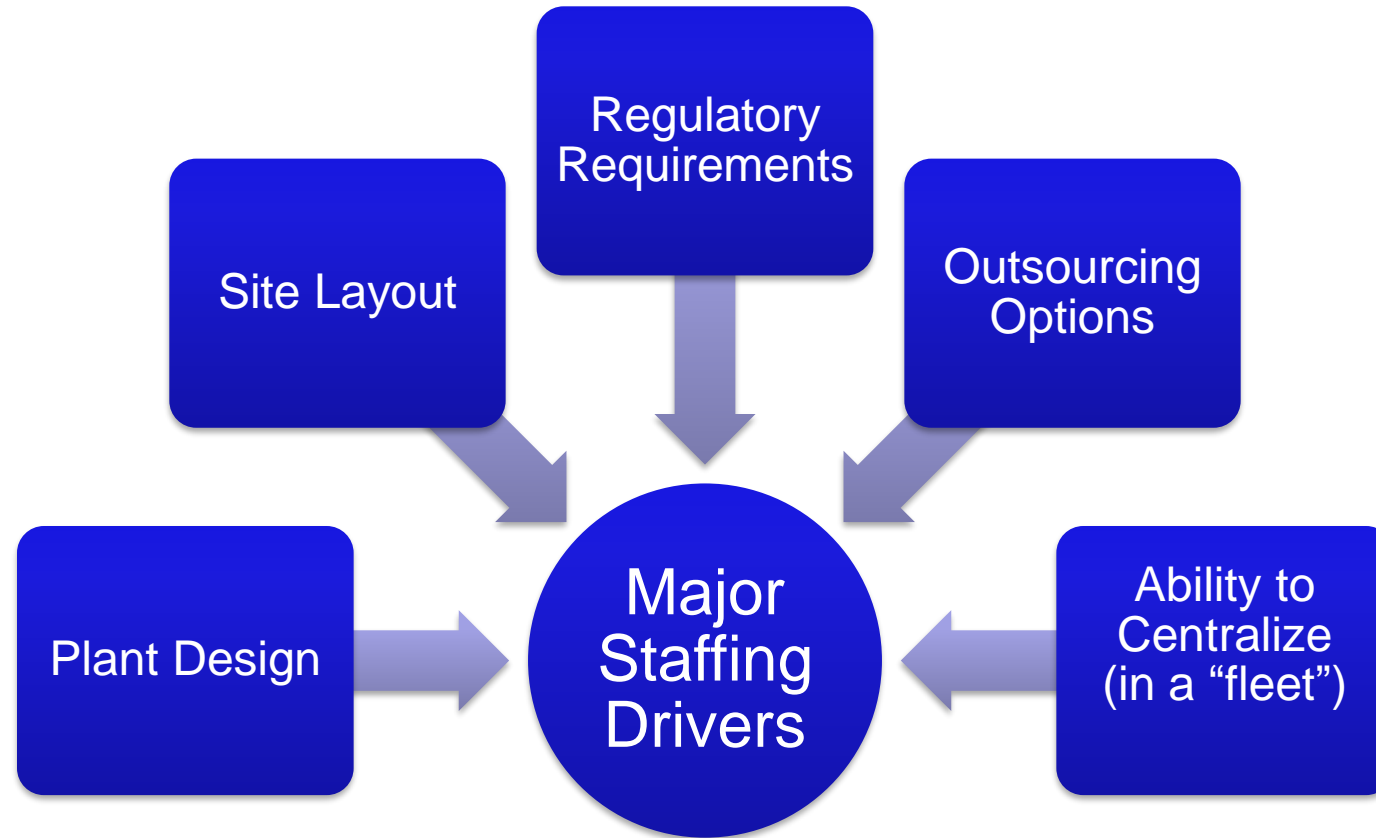
*Security Ops*

*Security Support*

*Training*

*Warehouse*

# Multiple Drivers Must Be Taken Into Consideration For Staffing Requirements At NPPs

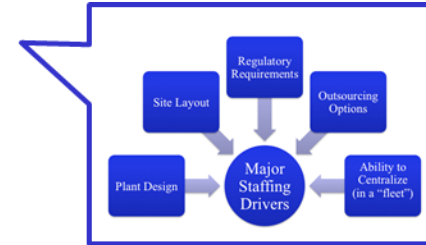


**Each staffing function may have more than one major site, plant, or organizational driver**

# The Are Many Complexities Of Staffing Requirements When Major Drivers Are Considered



Area	Function	Plant Design	Site Layout	Regulatory Requirement	Outsourcing	Centralization
Operations	Applied Radiation Protection	X		X	X	X
	ALARA/Radiological Engineering	X		X		X
	Chemistry	X		X		
	Decontamination/Radwaste Processing	X		X	X	
	Environmental		X	X	X	X
	Fire Protection	X	X	X		
	Operations	X	X	X		
	Operations Support	X	X			
	Radiation Protection Support			X	X	X
Engineering	Computer Engineering	X	X	X		X
	Design/Drafting	X	X	X	X	X
	Modifications Engineering	X	X	X	X	X
	Nuclear Fuels	X	X	X	X	X
	Plant Engineering	X	X			
	Procurement Engineering			X	X	X
	Project Management				X	X
	Reactor Engineering	X	X	X		
	Technical Engineering	X	X		X	X
	Maintenance	Facilities Maintenance		X		X
Maintenance/Construction		X	X	X	X	
Maintenance/Construction Support		X	X	X	X	
Outage Management		X	X	X		
Quality Control/Non-Destructive Examination				X	?	X
Safety/Health		X		X		X
Scheduling		X				
Regulatory	Emergency Preparedness	X	X	X		X
	Licensing	X		X		X
	Nuclear Safety Review			X		X
	Quality Assurance			X	?	X
	Security	X	X	X	X	X
Site Support	Budget/Accounting			X		X
	Communications			X		X
	Contracts				X	X
	Document Control/Records				X	X
	Human Resources					X
	Information Management				X	X
	Management			X		
	Management Support					
	Materials Management	X			X	X
	Purchasing				X	X
	Training		X	X		X
Warehouse	X	X		X	X	



**Example:**  
Modifications Engineering is impacted by all 5 drivers



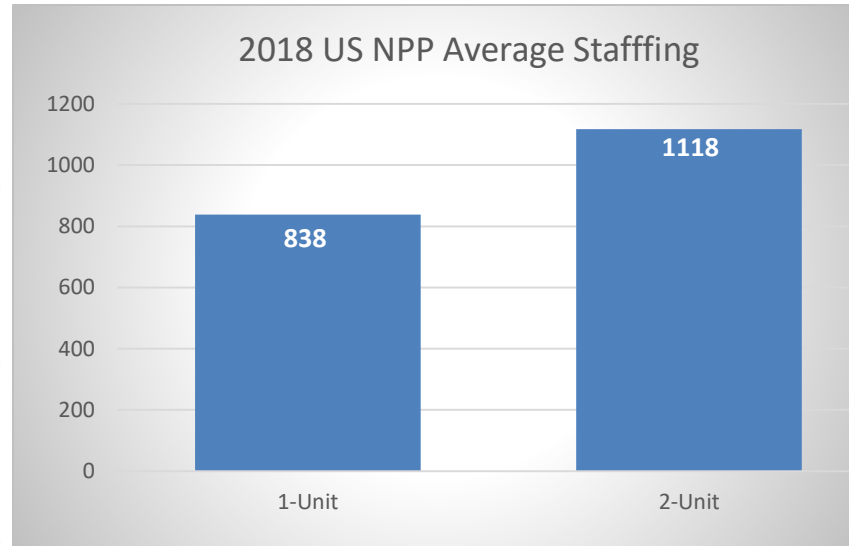
# In The US, Average 2-Unit Staffing Is ~1,100 Personnel; Average 1-Unit Staffing Is ~850 Personnel

Total staffing levels include:

Site Employees

Site baseline and long-term contractor FTEs

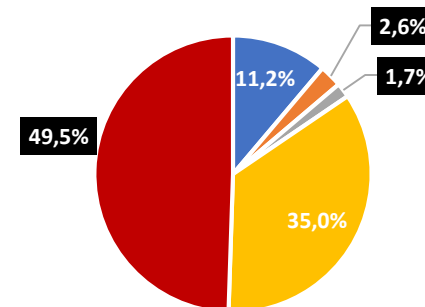
Offsite employees and contractors supporting the nuclear program



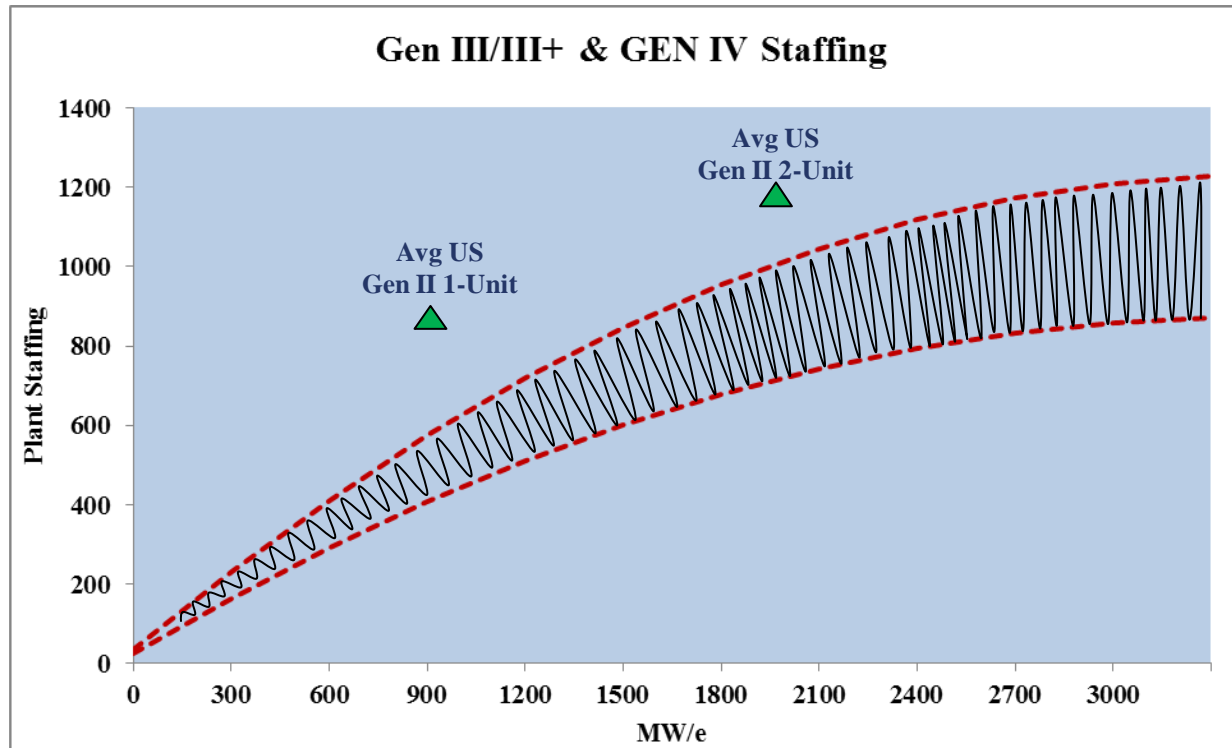
Avg US Staffing Distribution (Large 2-Unit Gen II NPP)

## For large 2-Unit NPPs:

- About half of the total staffing are technicians
- Engineers make up about 15%
- Nuclear Engineers are about 2%



# Staffing Models Show Gen III/III+ and Gen IV Reactors Will Have Fewer Personnel Than Gen II Plants



Source: Goodnight Consulting Analysis

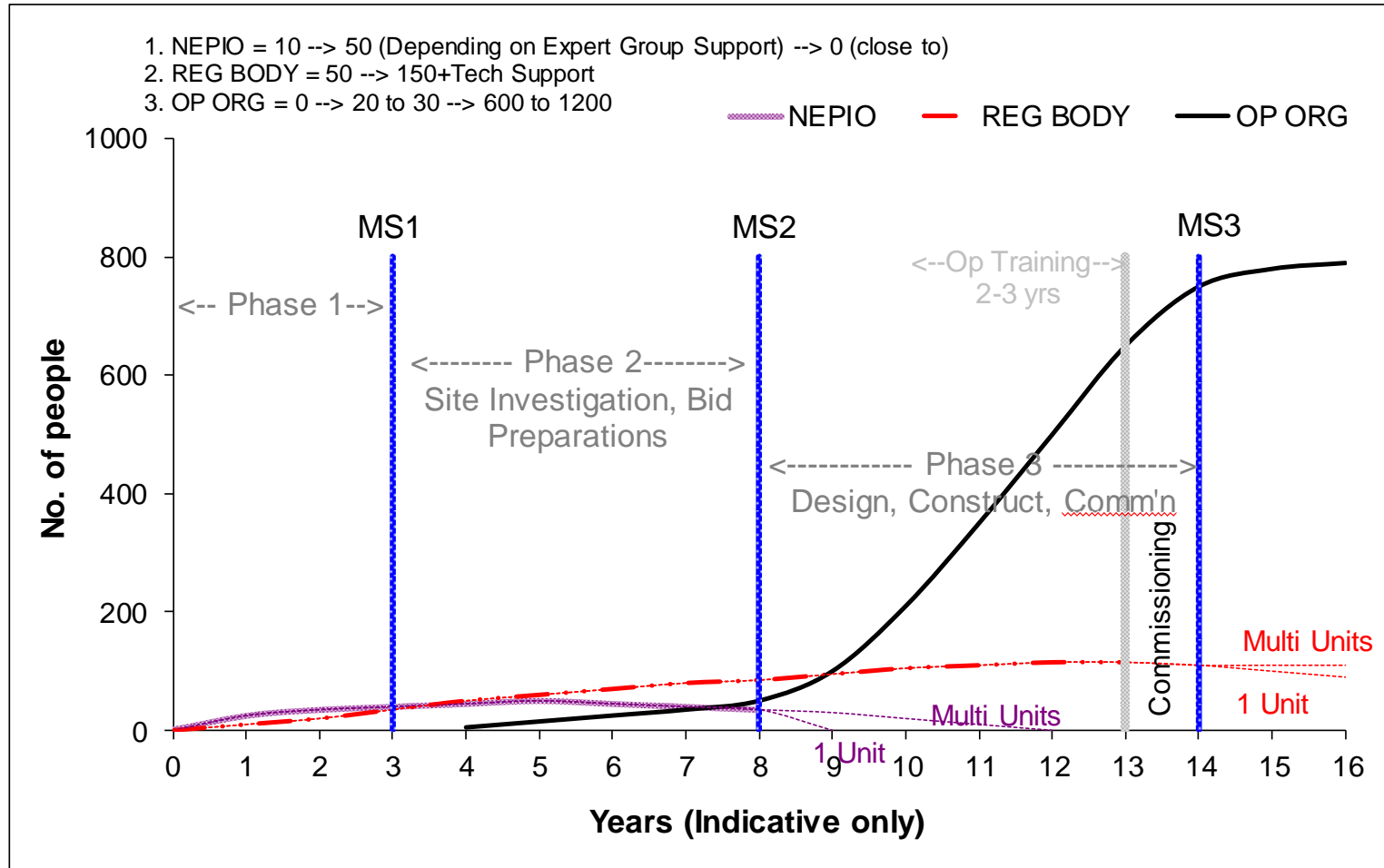
Each plant staffing model is proprietary, however the range of results can be portrayed to provide newcomers a perspective that new plant designs will require fewer personnel compared to Gen II



# Industry Experience & IAEA Guidance Shows Hundreds of Personnel & Many Years Are Required

A new nuclear power program represents a major commitment of personnel and resources

## Potential Staffing Levels & Timing Requirements

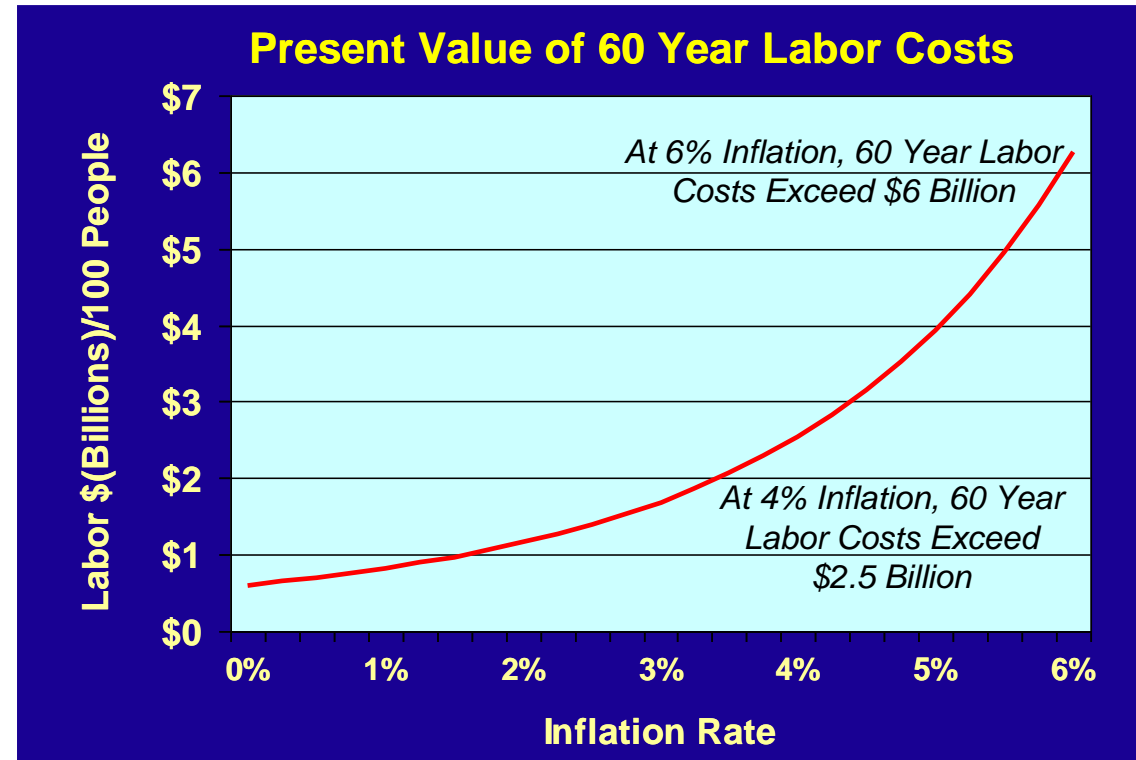


Source: IAEA Nuclear Energy Series No. NG-T-3.10, *Workforce Planning for New Nuclear Power Programmes*, 2011  
 C. Goodnight – Contributing Author

# While Often Overlooked In The Early Phases, Total Plant Staffing Is A Significant Life Cycle Cost Factor

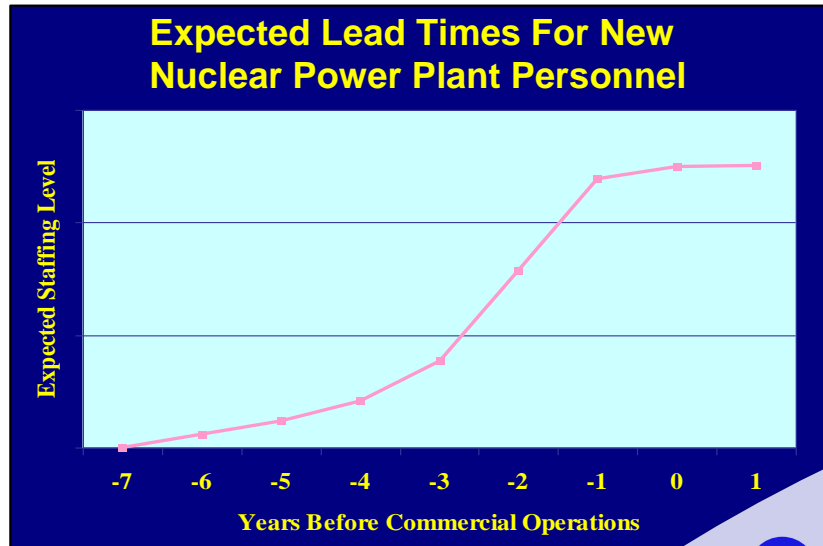
- In the USA, typical fully burdened labor costs are ~\$100,000 per person
  - Fully burdened costs include salary, bonuses, and company overheads for each employee, e.g., health care, retirement, computers, office space, etc.
- Thus, every 100 people: ~ \$10 M/year

Assuming a 60 year lifecycle for a new plant and 4% average rate of inflation, 500 personnel will cost ~ **\$12.5 Billion**





# Some Technical Functions Will Require 6-7 Year Lead-Times; Plan Accordingly



Typically engineering functions, such as system engineering, the longest lead times (~6 years); QA

Radiation Protection has the shortest lead time for a technical function (~3 years)

Non-technical functions like admin/clerical, facilities, etc. have shorter lead times

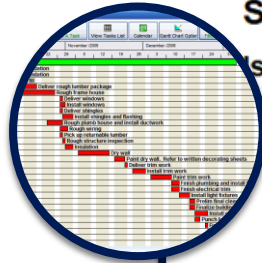


Source: IAEA Nuclear Energy Series No. NG-T-3.10, "Workforce Planning for New Nuclear Power Programmes"

# Detailed Staffing Plans Must Be Designed To Support Construction Milestones & Lead Times

## Staffing Plan: Years 1 - 10

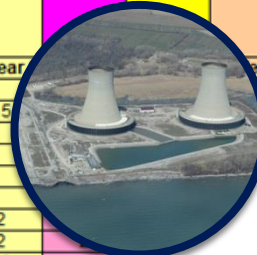
Staffing Requirements Reflect Personnel Hired During Each Year



Program and construction milestones drive the timing of staffing requirements



Each staffing function must be accounted for (>150 position types)

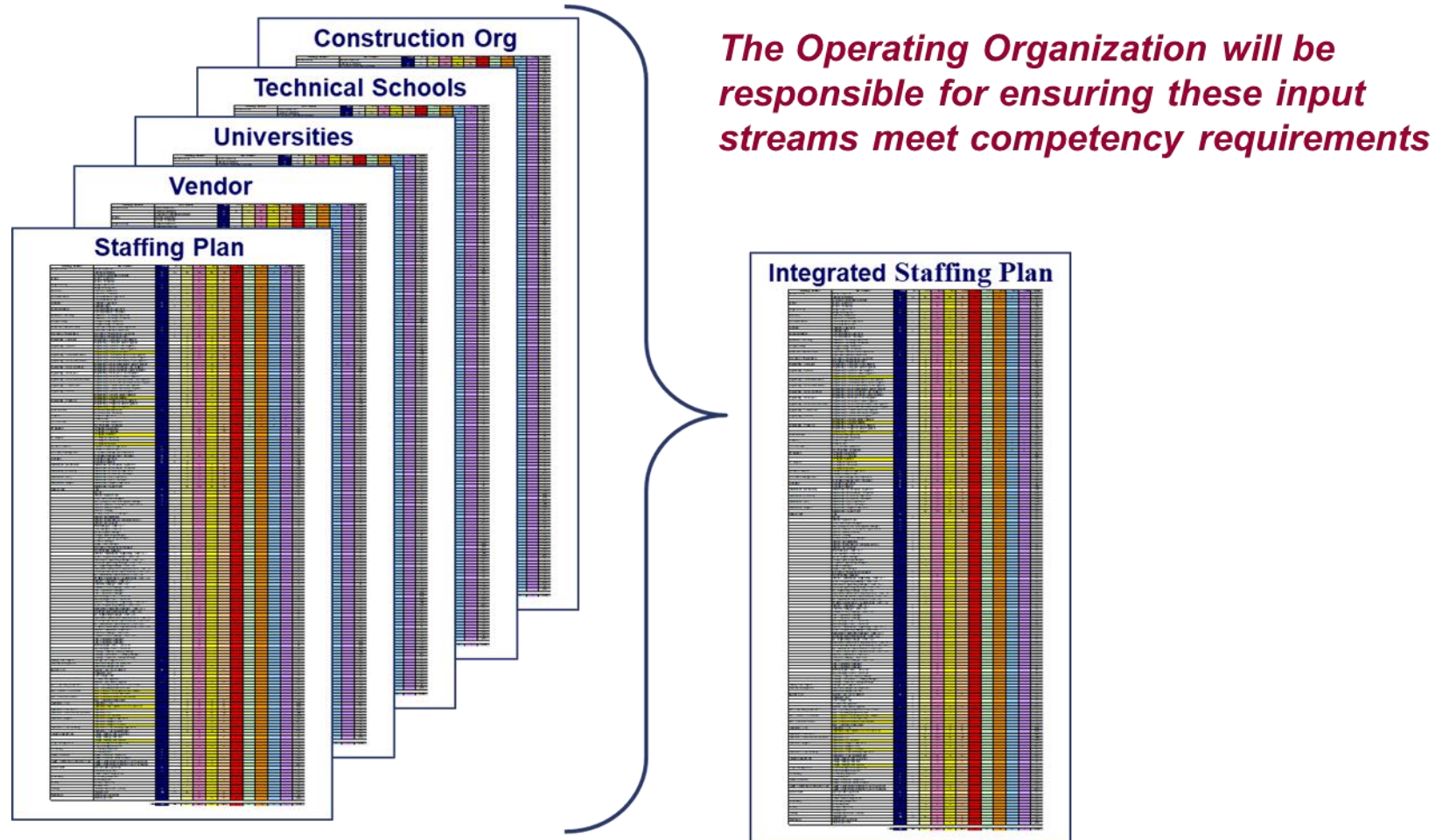


Plans for multiple units complicate requirements

Staffing Function	Job Position	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Total
1 Admin/Clerical	Admin Supervisor		1										
2	Clerical/Secretarial	1	16	15									
3	Executive/Confidential Assistant	1											
4 ALARA	ALARA Supervisor												
	ALARA Technician												
5 Acctg	Budget Supervisor	1											
	Budget/Acting Staff	4	2	2									
	Chemistry Supervisor			2									
	Chemistry Technician				16	16							64
6	Communications Supervisor		1										2
			1	1	1	1	1						8
		1											1
		3	1	1	1	1							7
						1							3
	Supervisor												21
	Technician												3
17													27
18 Design/Drafting	Design/Drafting Supervisor		1										2
	Design/Drafting Technician												12
19													1
20 Document Control/Records	Document Control/Records Supervisor						1	1					10
	Document Control/Records Staff												3
22 Emergency Preparedness	Emergency Preparedness Supervisor												3
	Emergency Preparedness Staff												21
23					4	5	4						2
24 Engineering - Computer	Engineering - Computer Lead Engineer												2
	Engineering - Computer Junior Engineer												12
25					6	6							12
26 Engineering - Systems	Engineering - Systems Lead Engineer				3	3	3	3					12
	Engineering - Systems Junior Engineer				13	13	13	13					52

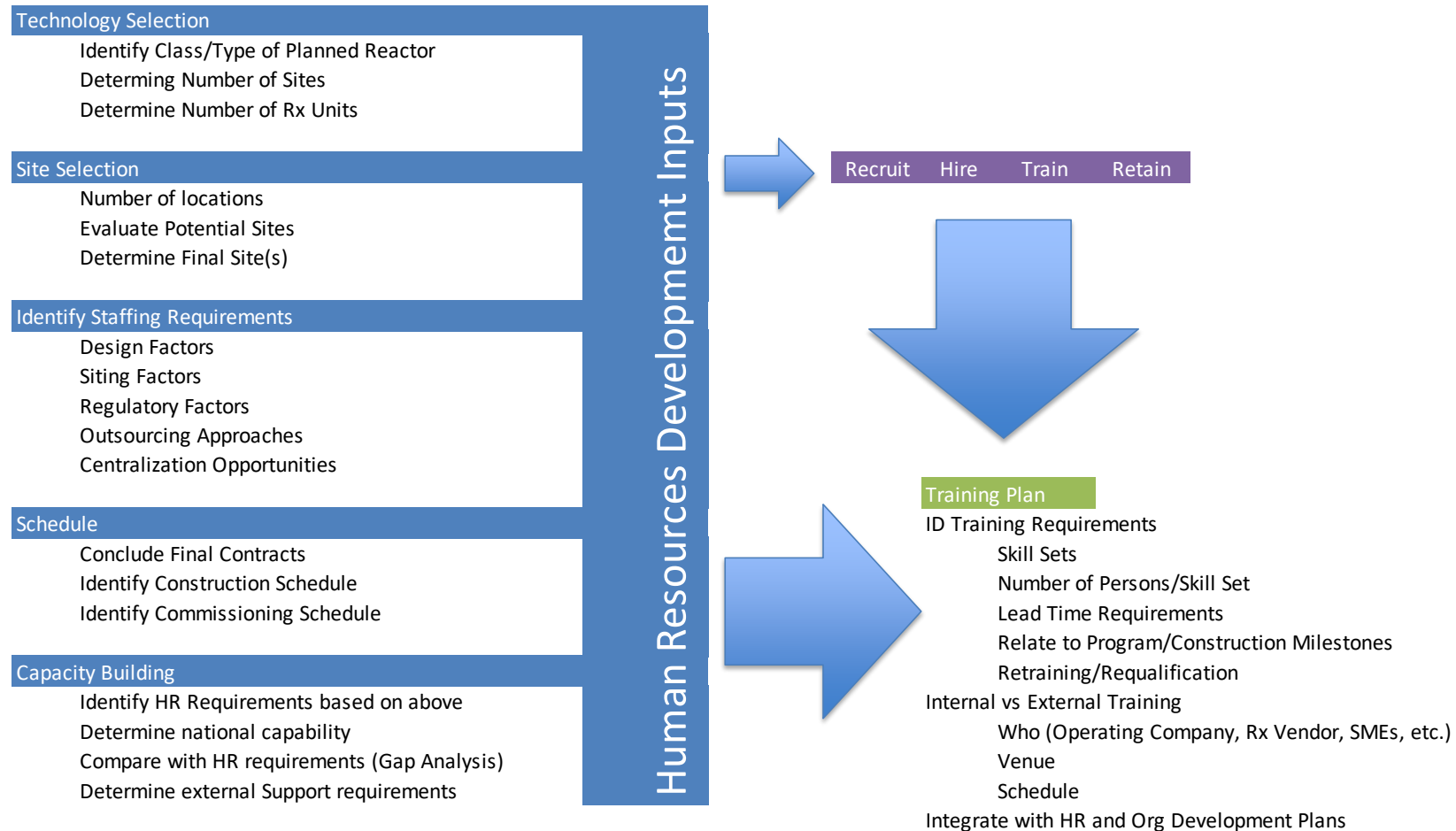
Illustrative

# Multiple Sources of Personnel Will Become Inputs to the Final Operating Organization



# Apply Competency Requirements to Create a Development Plan => Training Plan

## Human Resources Development for New Nuclear Power Programs



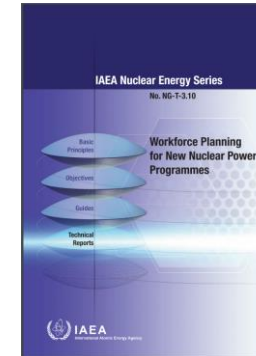


# Like an NPP, Workers Also Have A Lifecycle



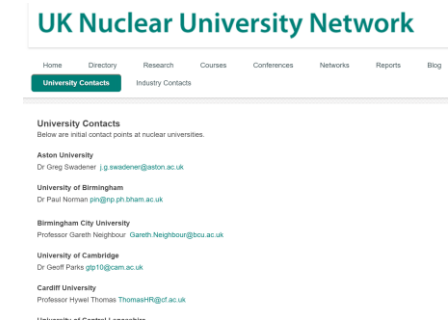
# Identifying and Achieving Competency Requirements

- Identify the necessary skills/competencies and timelines (see IAEA NG-T-3.10, Appx. III)
- Identify current competency development capabilities at the national level
- Identify existing competencies that match or are similar (i.e., Fossil power generation, Oil & Gas, etc.)
- Conduct Gap Analysis to identify options/strategies for closing the gap between future needs and current capability



# Approached For Personnel / Capacity Development: *University Level*

- Development of new university programs (ex: Establishment of Engineering programs)
- Expansion of existing university programs (Ex: Expansion of Chemical, mechanical Engineering programs to Nuclear Engineering), Khalifa University in UAE, JUST in Jordan, etc.
- Domestic cooperation of university programs (ex: Multi-university cooperation within the country)
- International Cooperation of university programs (ex: World Nuclear University)



# Options For Personnel / Capacity Development

## *Vocational And Technical Level*

- Germany example of national level certification/qualification, Ex: Master Electricians:
  - Centralization of the German system - the State regulates what happens in private companies
  - “Dual Training” – a combination of OJT and classroom time, with standardized occupational profiles (curricula), developed by the federal government in collaboration with employers, educators, and union representatives
  - Every young technician in Germany learns the same skills in the same order and on the same timetable, resulting in high-quality programs with consistent results.
- Germany example of centralized nuclear operator training:  
The Simulator Center operated by KSG in Essen. Started in 1977 with two simulators (one for PWRs and one for BWRs) the Simulator Centre today runs 8 plant-specific simulators for 10 nuclear power plants.





# Options For Personnel / Capacity Development *Vocational And Technical Level (Continued...)*

- UAE example for Institute for Applied Technology (IAT) designed to “to encourage, educate and prepare our youth to pursue careers in Science, Technology, Engineering and Mathematics-related fields”
  - IAT/Abu Dhabi Polytechnic offers Higher Diploma in Advanced Energy Engineering Technology, Applied Bachelor / Higher Diploma in Electromechanical Engineering Technology, and in other areas outside the nuclear energy field)
- Technical Support Organization support (external training experts)
  - Tecnatom (Spain), ATI (American Technical Institute/USA) ,others.....
- Sending personnel to vendor country for technical training (benefits, but also risks - Romania/CANDU example)



# Options For Personnel / Capacity Development: *International Level*

- IAEA, including:

- Nuclear safety
- Radiation protection
- Human resource management
- Sustainable energy development
- Emergency preparedness and response
- Technical cooperation



- Vendor-based training (GE, Westinghouse, Framatome, Rosatom, etc.)



- Government sponsored programs for international students

- US Department of State, Bureau of Educational & Cultural Affairs
- Private, Regional, and Local Universities



BUREAU OF EDUCATIONAL AND CULTURAL AFFAIRS  
**EXCHANGE PROGRAMS**

- World Nuclear University



# Options For Personnel / Capacity Development: Cross-Functional & Cross-Cultural

- ENEC/NAWAH Experience

- Emirati/Korean/Western (mostly US) Cooperation
- “Adopt and Adapt”
  - ❑ Organizational
  - ❑ Processes
  - ❑ Procedures
- “Nawah English”



مؤسسة الإمارات للطاقة النووية  
Emirates Nuclear Energy Corporation



شركة نواة للطاقة  
Nawah Energy Company



- Fennovoima / Rosatom / Alstom (GE Power) experience

- Different regulatory body standards
- Multi-lingual environment/translations
- Finland is an EU country = other EU country participation

FENNO  
VOIMA



ROSATOM



GE Power



- Canada/Romania CANDU experience

- Language training: Romanians learning English
- Technical training: Nuclear Island issues
- Documentation: Which language: processes descriptions, procedures, signs, communications, etc.



NUCLEARELECTRICA

# Everything About Nuclear Power Programs Is Big

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- A large number of people
  - A large variety of skill sets
  - A long time for capacity building
  - A large amount of training
  - A large amount of investment (both capital and personnel)
  - A large amount of time to get started
  - A very long life cycle
  - A big process for decommissioning
- 
- .....therefore, you **MUST** be a knowledgeable customer

# Conclusions

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- Begin with the end in mind, and then work the schedule in reverse
- Technicians (not engineers) are the largest part of the operating organization
- Labor costs will be significant, and they must be planned for separately from capital investments
- Organizational development & migration will also be challenging and planned for carefully
- New nuclear is a 100 year program = 3 to 4 generations of workers, so workforce plans must be constantly reviewed/updated



# Thank You For Your Attention

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