

Status and Developments of Human Resource Requirements in the Nuclear Industry

BNS Evening Lecture

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*European **H**uman Resource **O**bservatory
in the **N**uclear Energy Sector*

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Introduction

Background

EHRO-N provides bottom up information about HR-developments from surveys with nuclear stakeholders

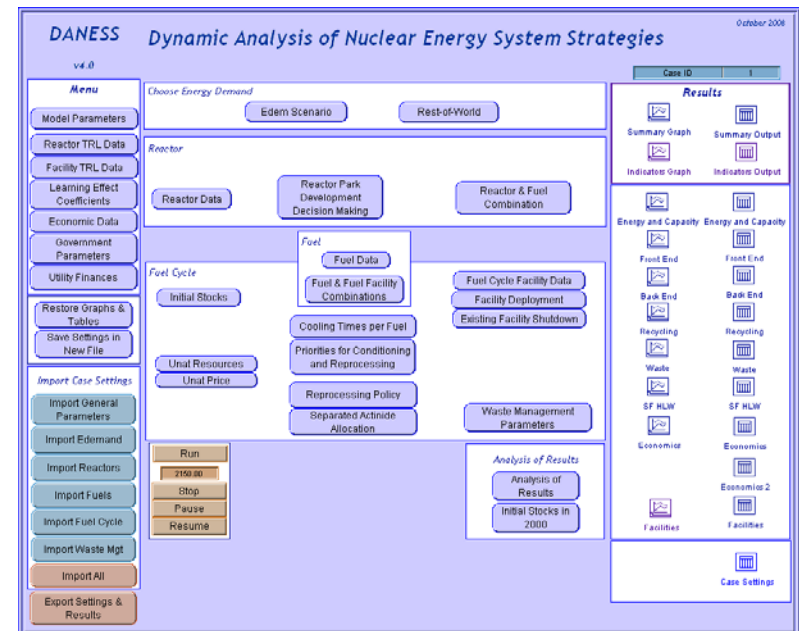
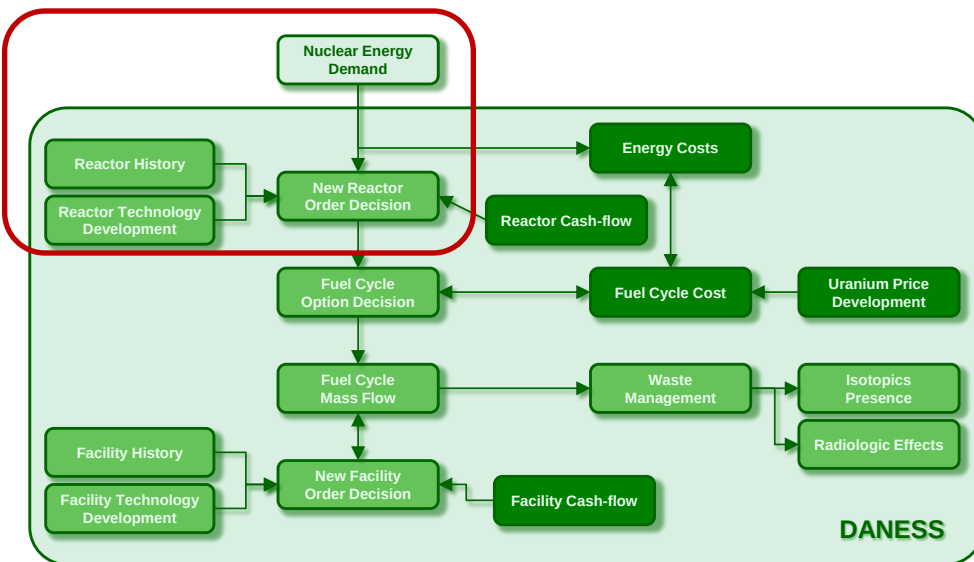
Complementary a top-down modeling approach is followed providing information about HR development for construction and operation of NPPs in EU28 + E&I countries

DANESS Analysis Tool

Dynamic Analysis of Nuclear Energy System Strategies (v4.0)

Developed at ANL

Integrated Dynamic Nuclear Process Model

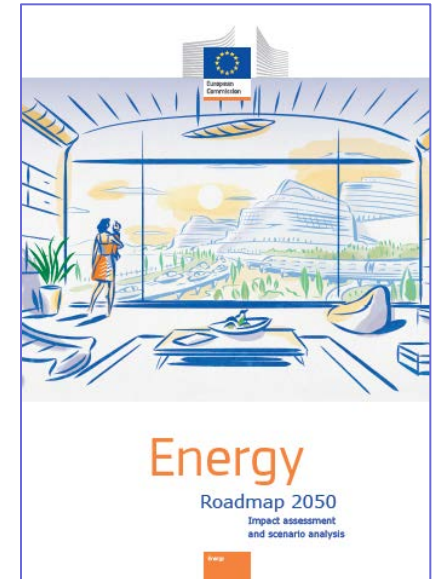
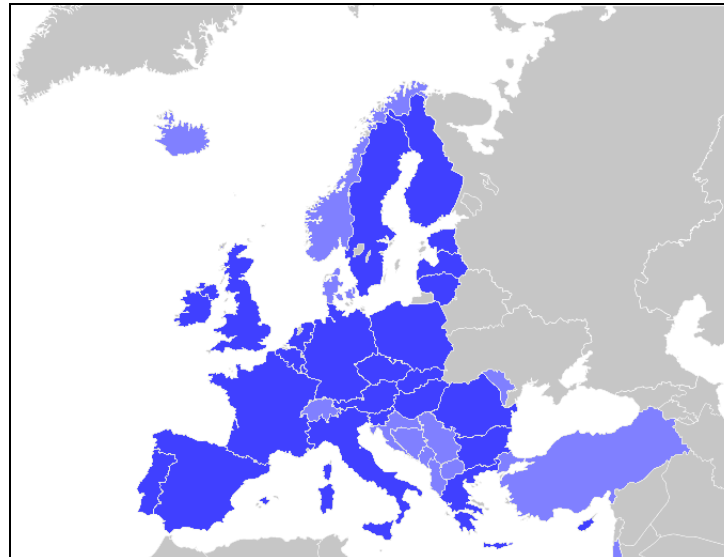


Nuclear Energy Demand Scenarios

EC Energy Roadmap 2050

EU27 '20% Nuclear Electricity' Scenario (5)

- Nuclear Energy Production
- EU27 Countries
- Extrapolation for EU28 + E&I Countries

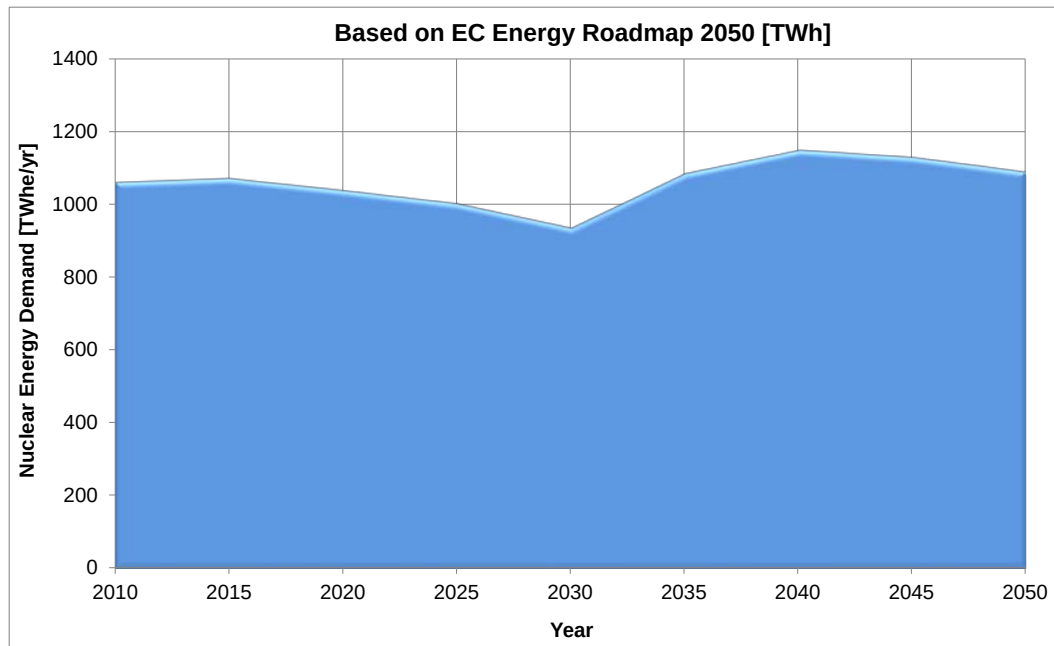


Nuclear Energy Demand Scenarios

EC Energy Roadmap 2050

Nuclear Energy Generation

- **'20 % nuclear electricity' scenario + extrapolation**



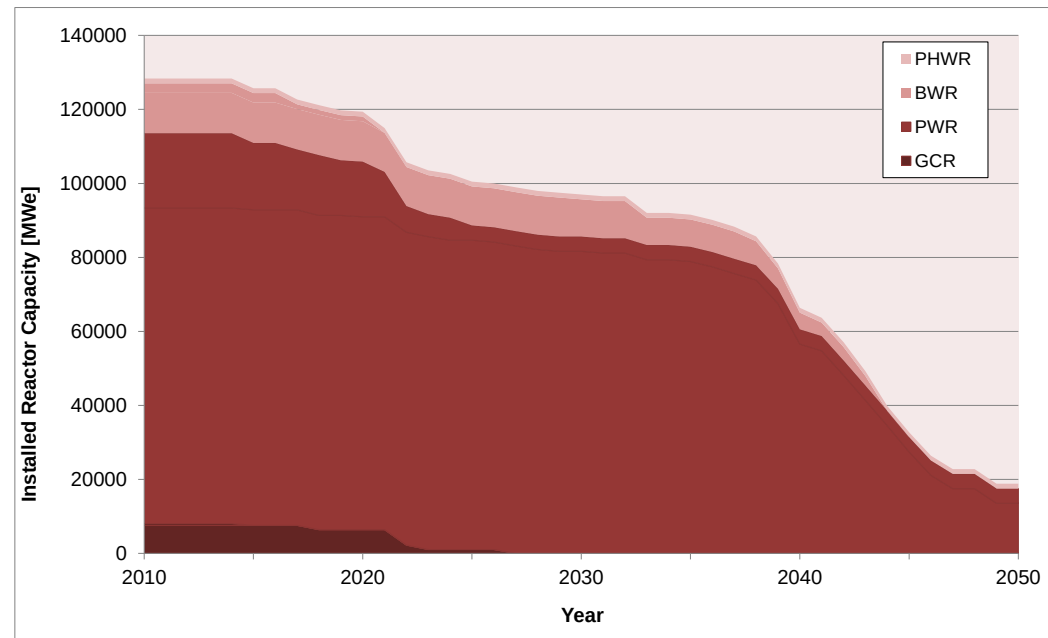
Reactor Park

Current reactor park

- **Existing reactors according WNA Website (Jan. 2014)**
- **Reactors under construction**
 - Olkiluoto 3 (Finland)
 - Flamanville 3 (France)
 - Mochovce 3&4 (Slovakia)

Shutdown profile

- **Based on WNA Website (Jan. 2014)**
- **60 year lifetime for Olkiluoto and Flamanville**
- **40 year lifetime for Mochovce**

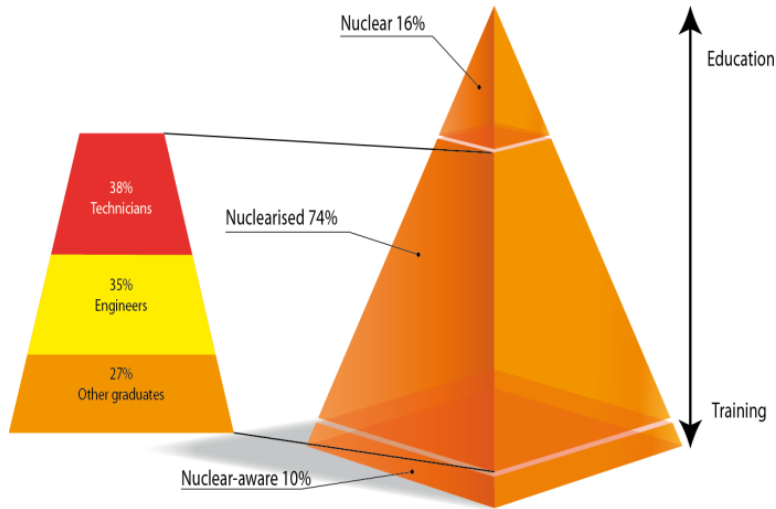


New Reactors

New Reactors



	Power [MWe]	Efficiency [%]	Load Factor [%]	Lifetime [years]
Gen III LWR	1400	36	80	60



Workforce Model Operations

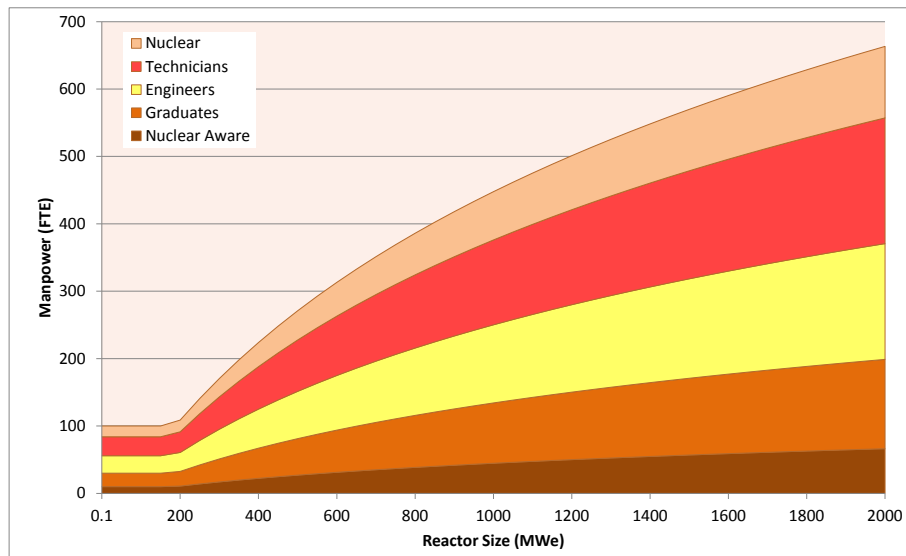
*Manpower requirements for
operations based on*

Johnson (1982)

NIA (2006)

Thuohy (2009)

Mazour (2010)



manpower model required for operations

- **Model (Roelofs et al., 2011):**

$$fte = \max[a \cdot \ln(P+b) + c; 100]$$

P = reactor size

$a = 400$

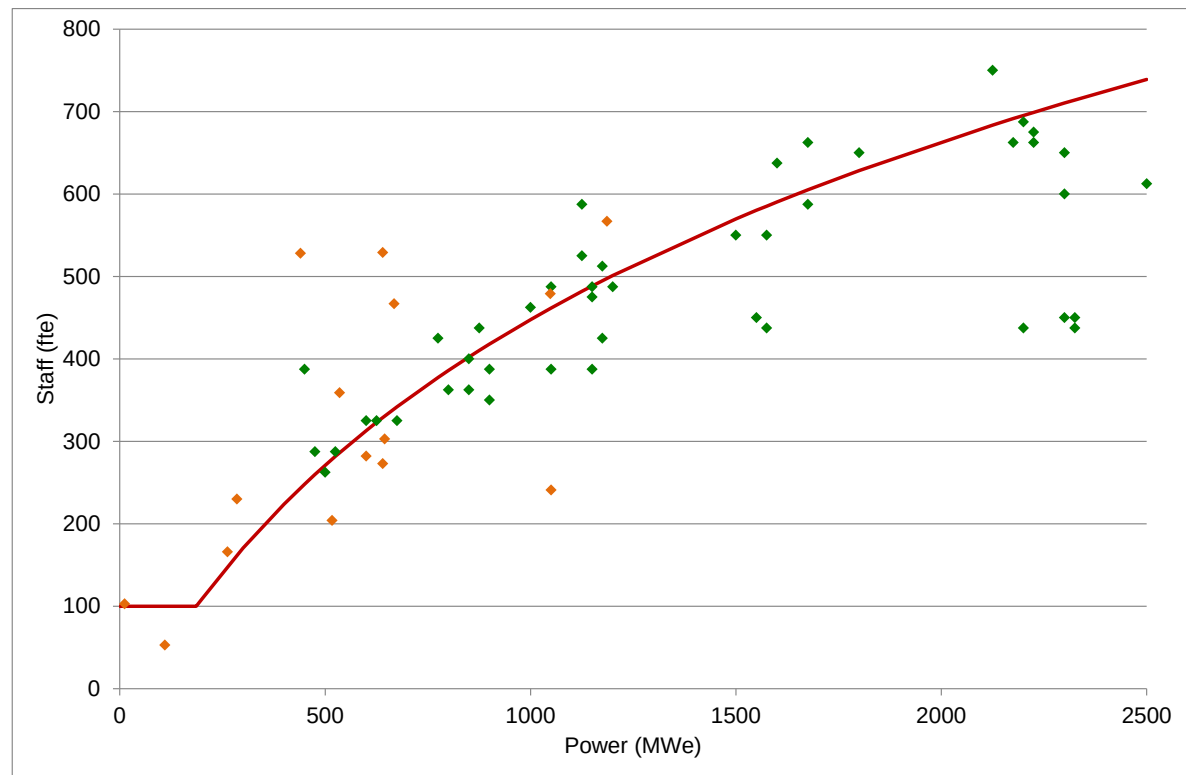
$b = 400$

$c = -2450$

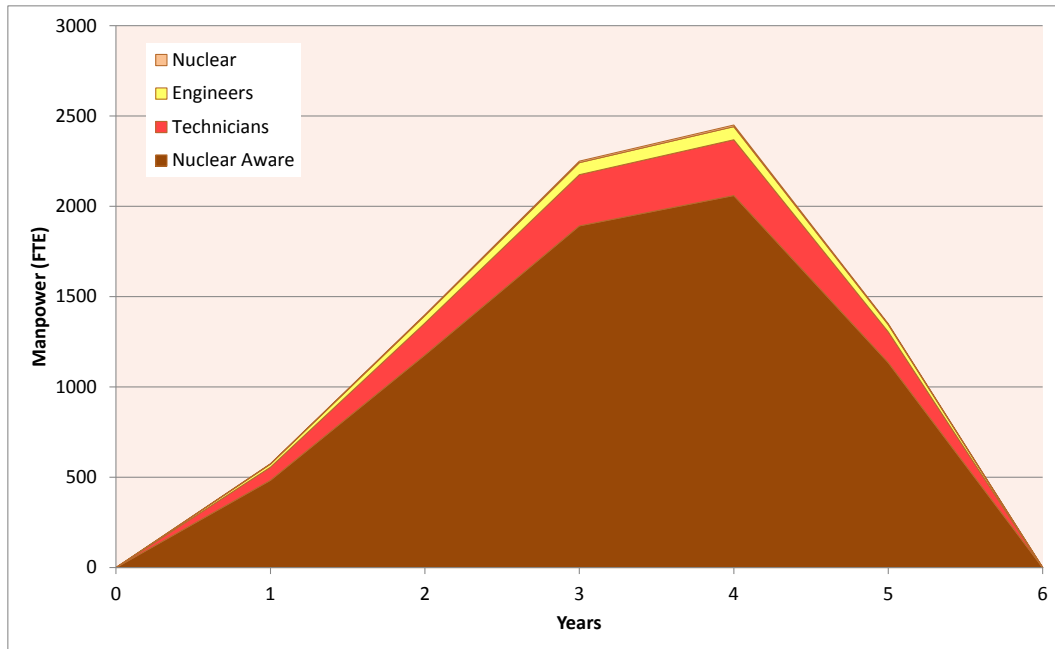
In Comparison: Workforce Model for Operations

Data taken from:

- EPRI (2005) ◆
- IAEA Tecdoc 1193 ◆

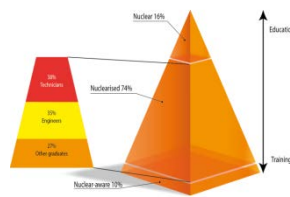


Workforce Model Construction



*Manpower requirements for construction based on IAEA
Typically 6 years of construction*

manpower model required for construction

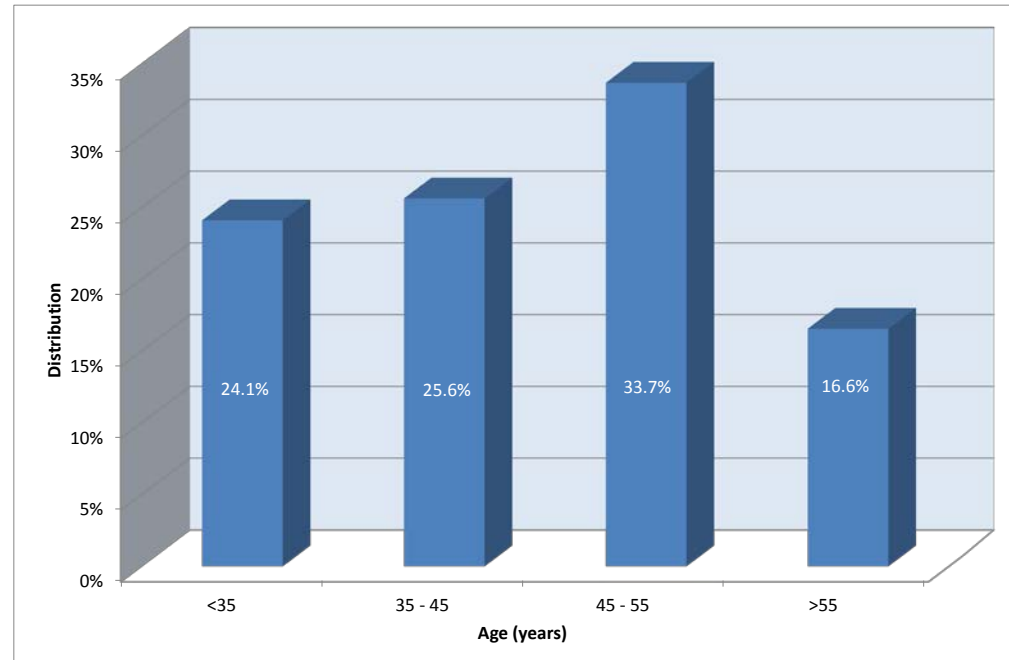


Retirement Profiles

Data from EHRO-N Survey

- **Age profile ('nuclear' experts)**

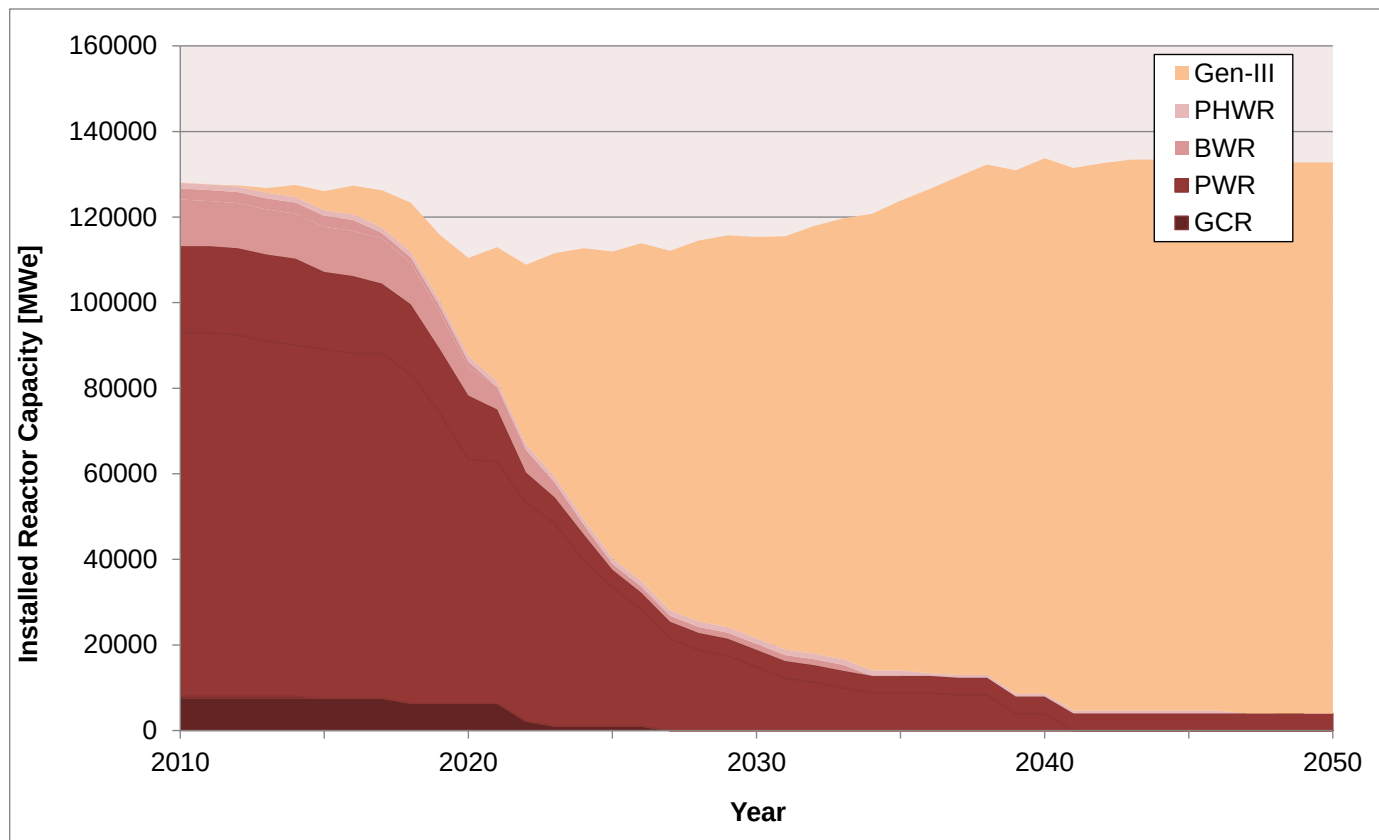
<35	24.1%
35-45	25.6%
45-55	33.7%
>55	16.6%
- **Assume similar age profile for 'nuclearized' and 'nuclear aware' workforce**
- **Assume average retirement age of 65**



Reference Scenario

Reference Scenario

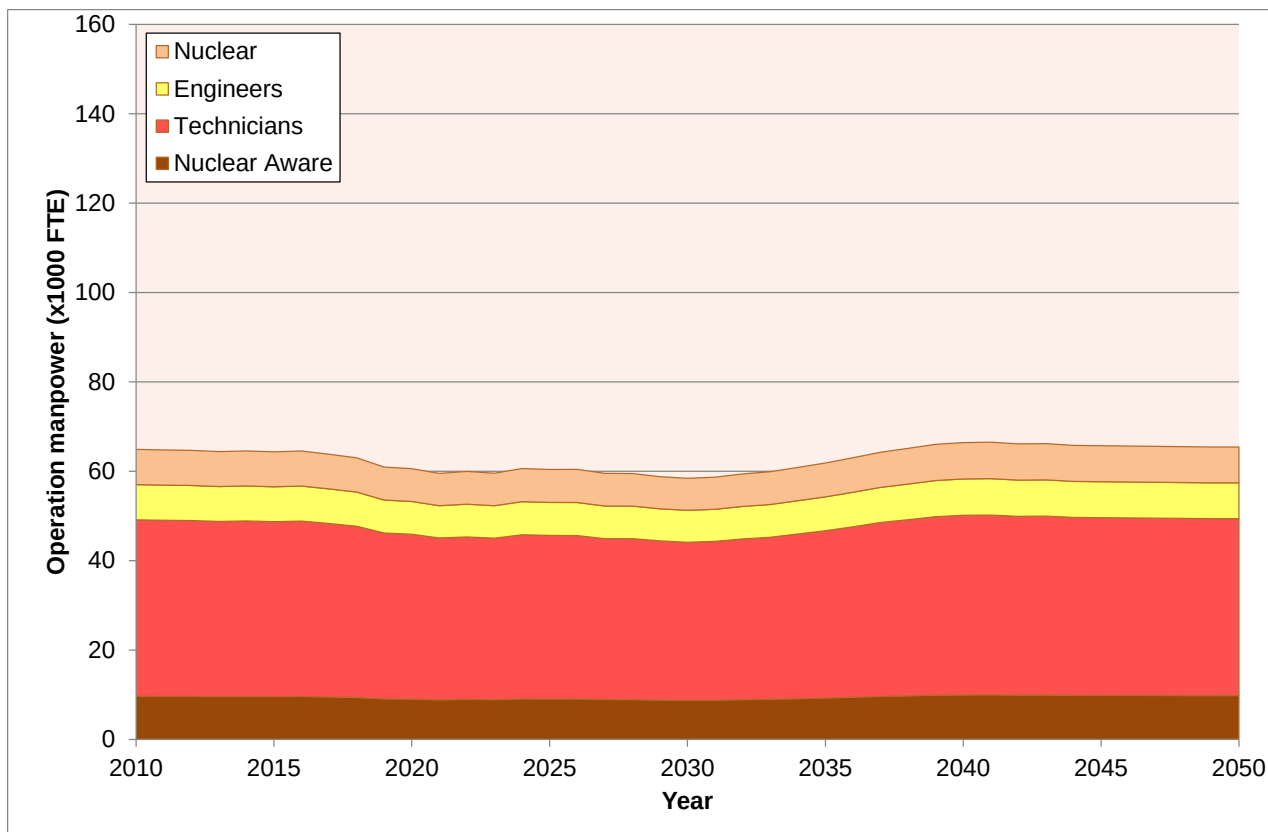
Reactor Park Development



~130 new reactors

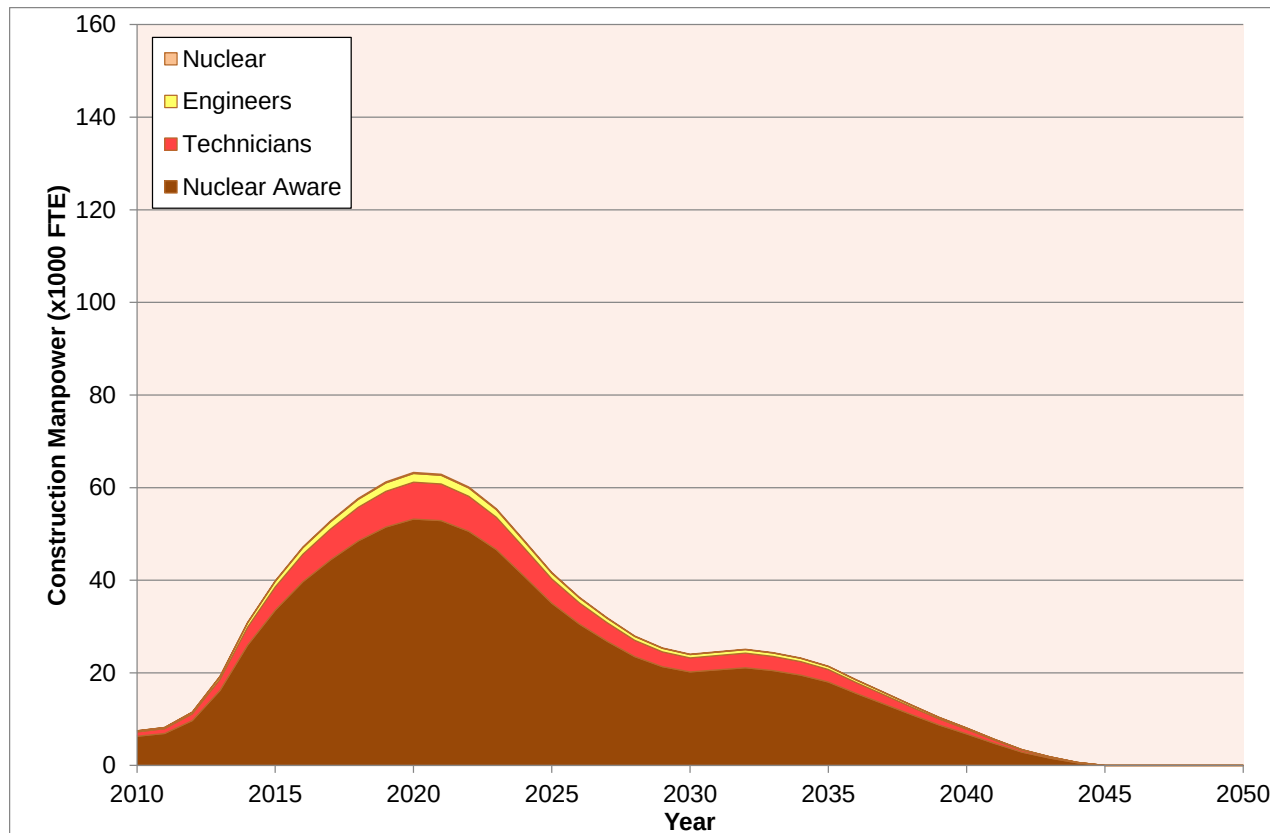
Reference Scenario

Manpower Operations



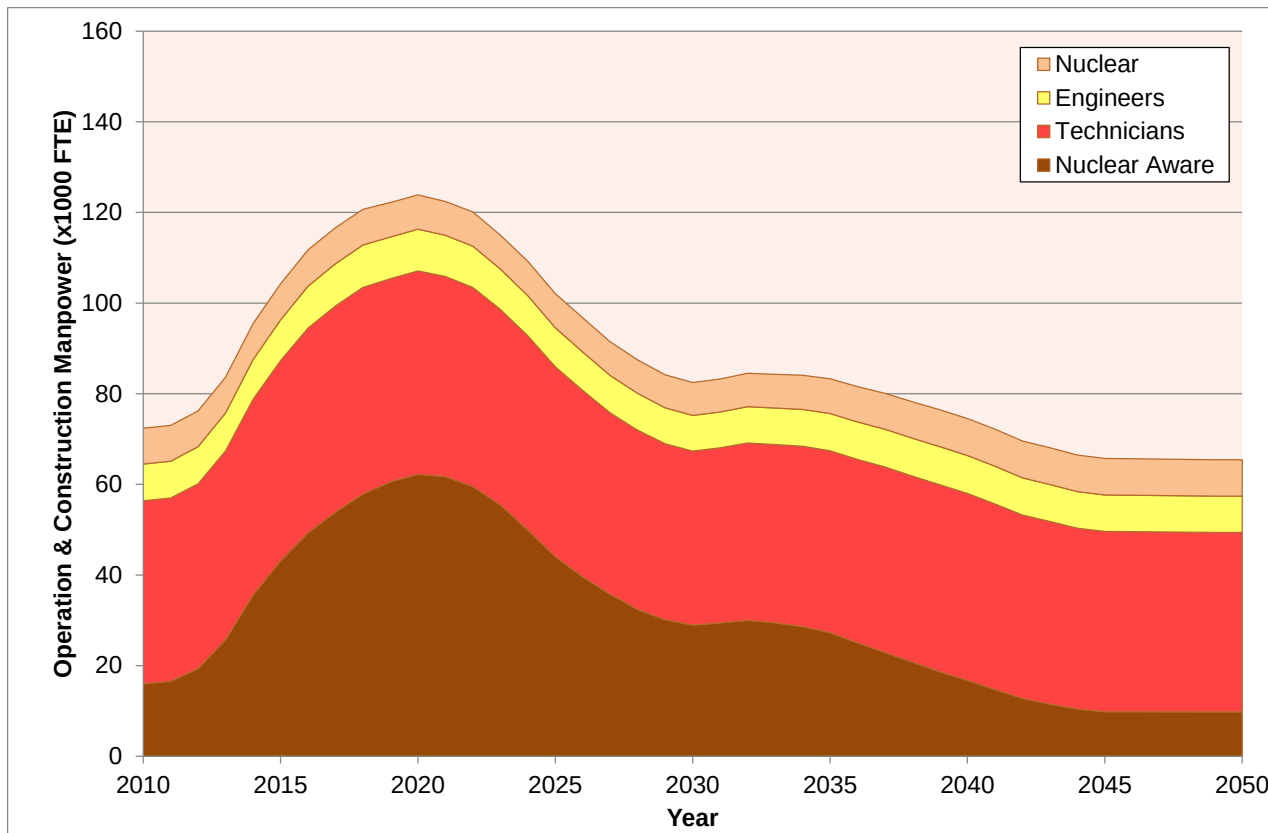
Reference Scenario

Manpower Construction



Reference Scenario

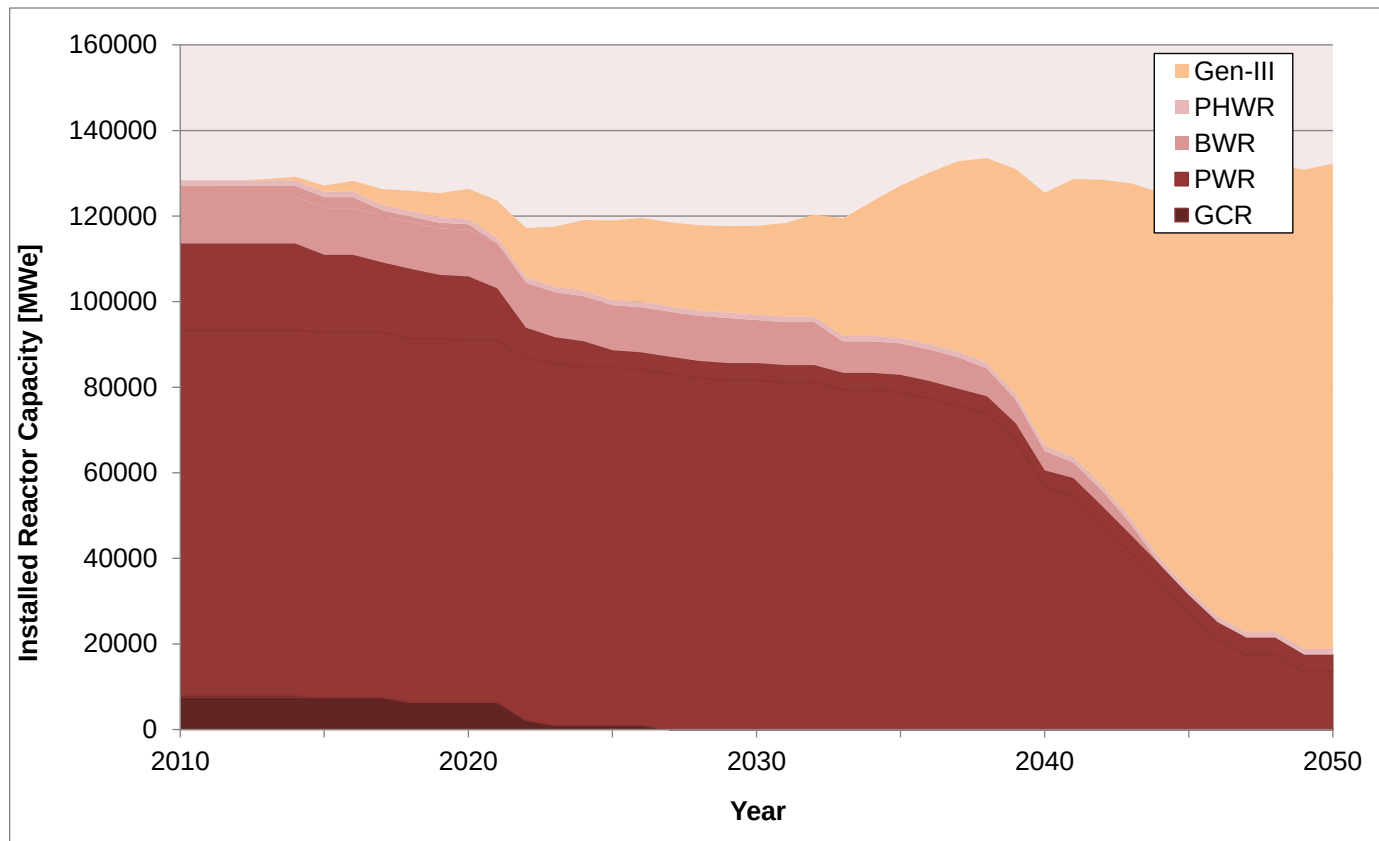
Manpower Operations & Construction



Long Term Operation

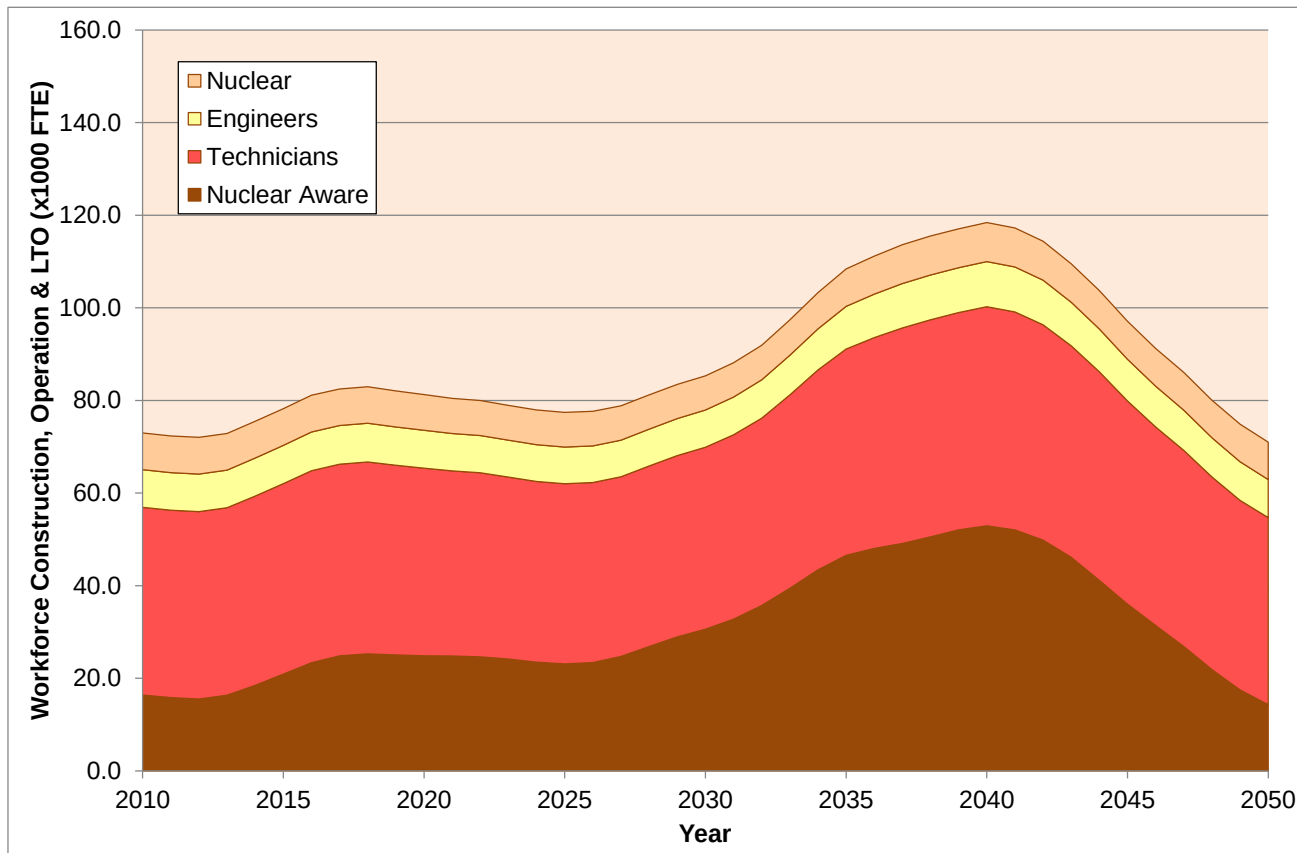
Long Term Operation

Reactor Park Development



Long Term Operation

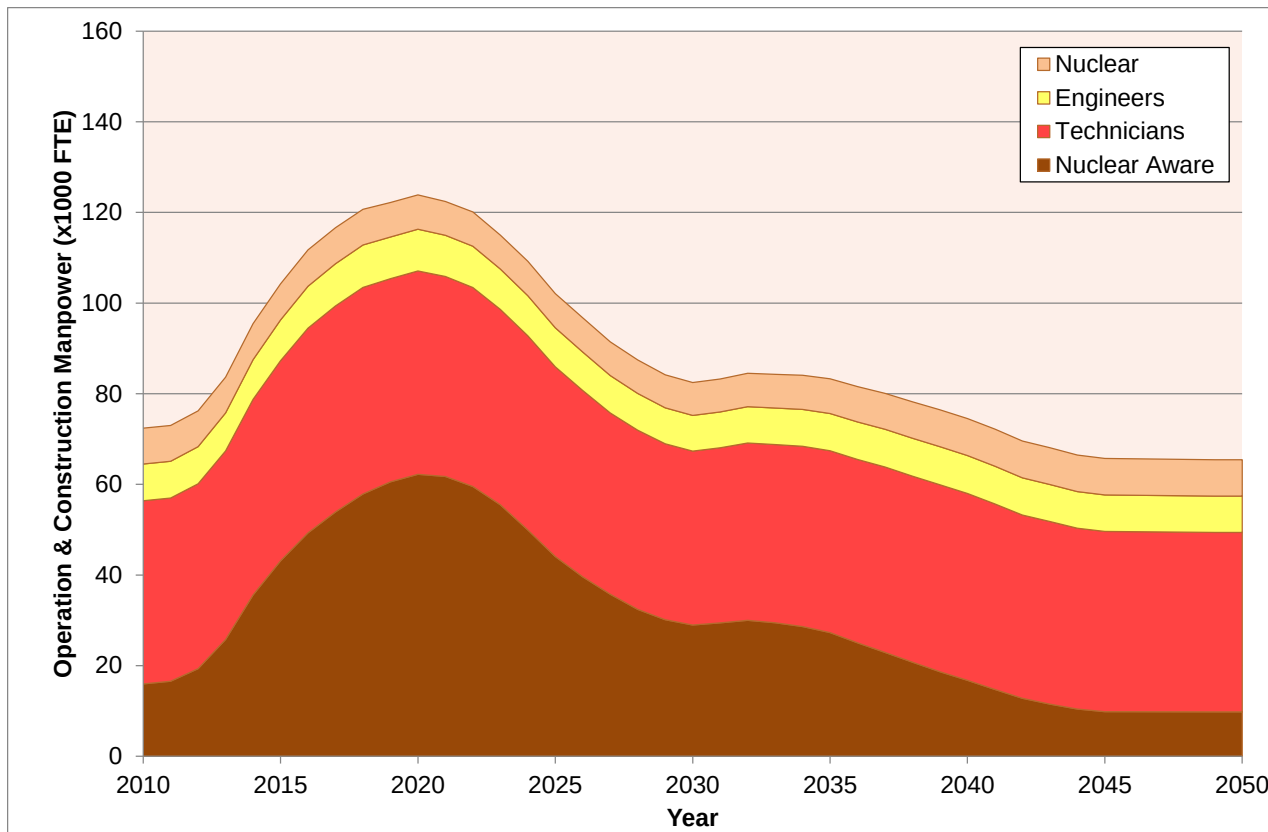
Manpower Operations, Construction & LTO



Retirements

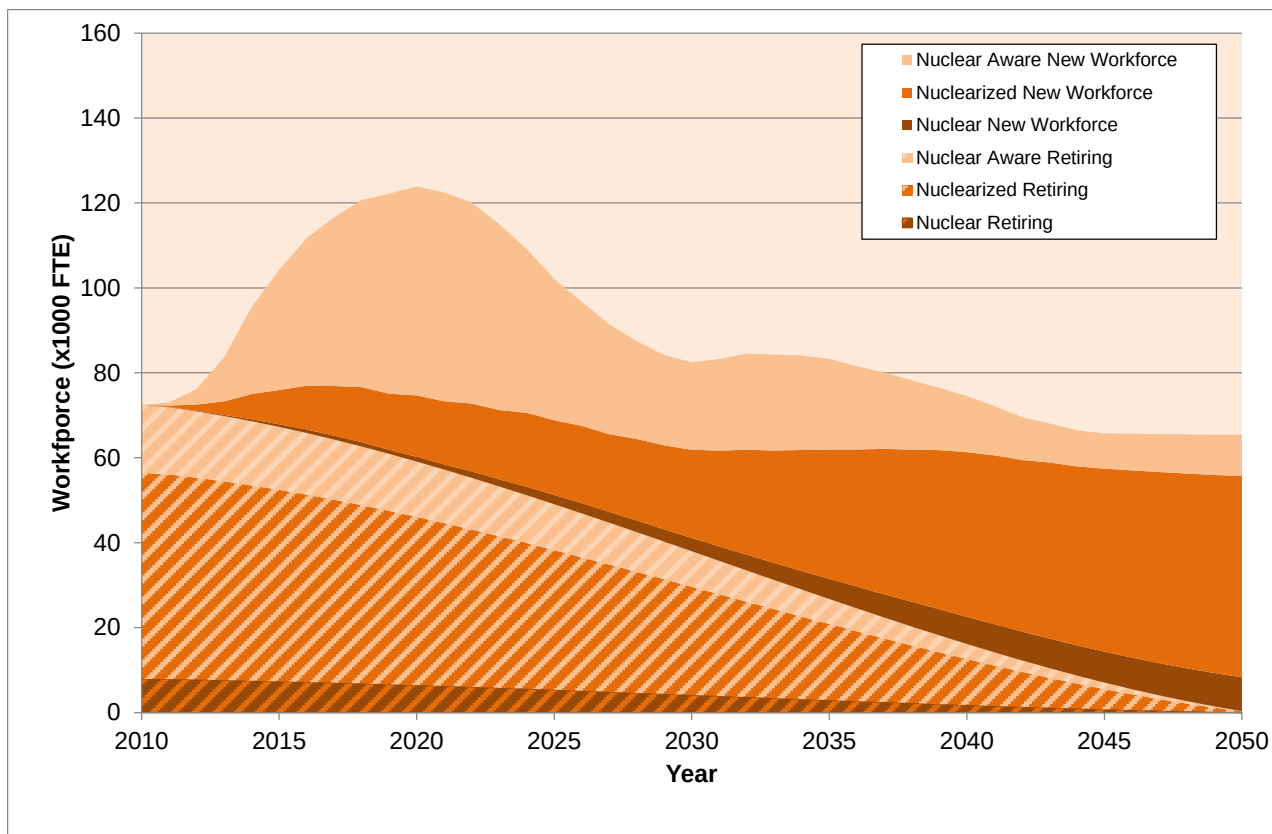
Retirements

Reference Scenario: Operations & Construction



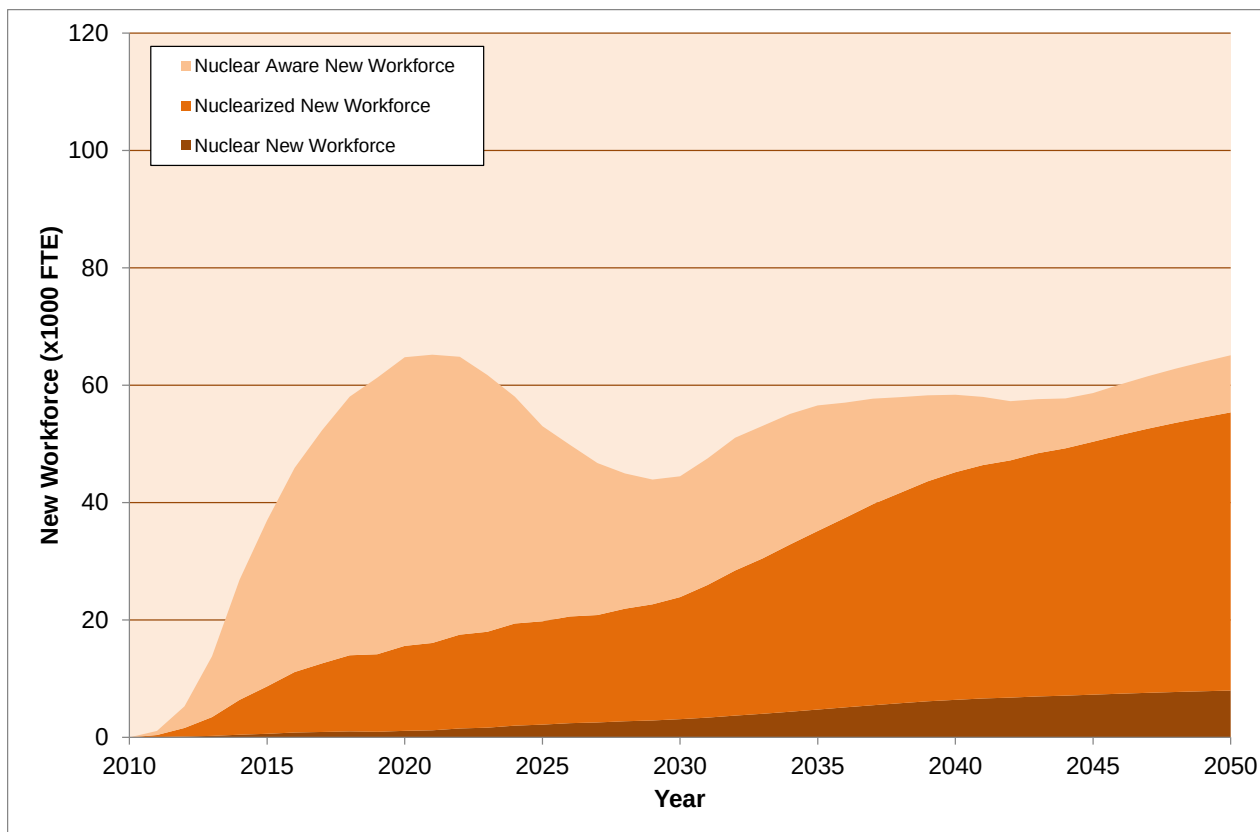
Retirements

Reference Scenario: Retirements vs. New Workforce



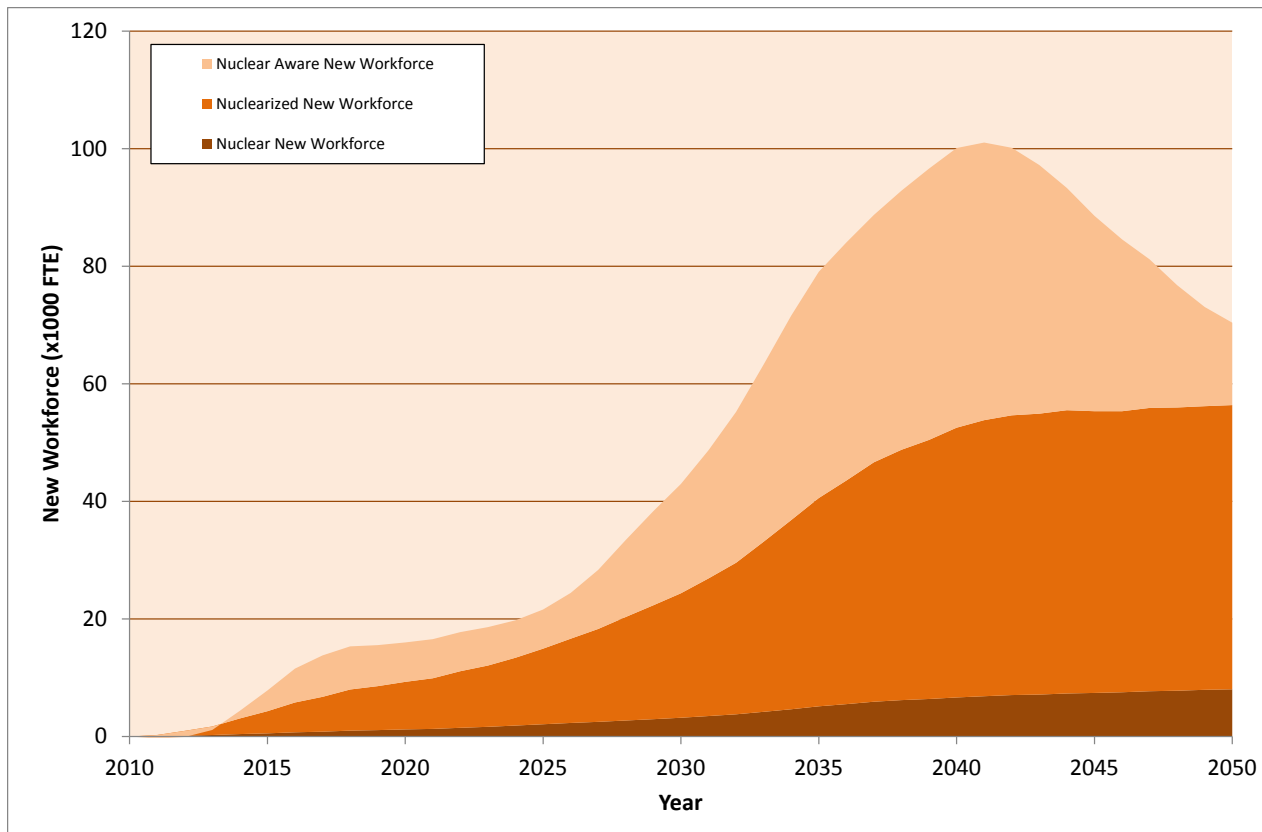
Retirements

Reference Scenario: New Workforce



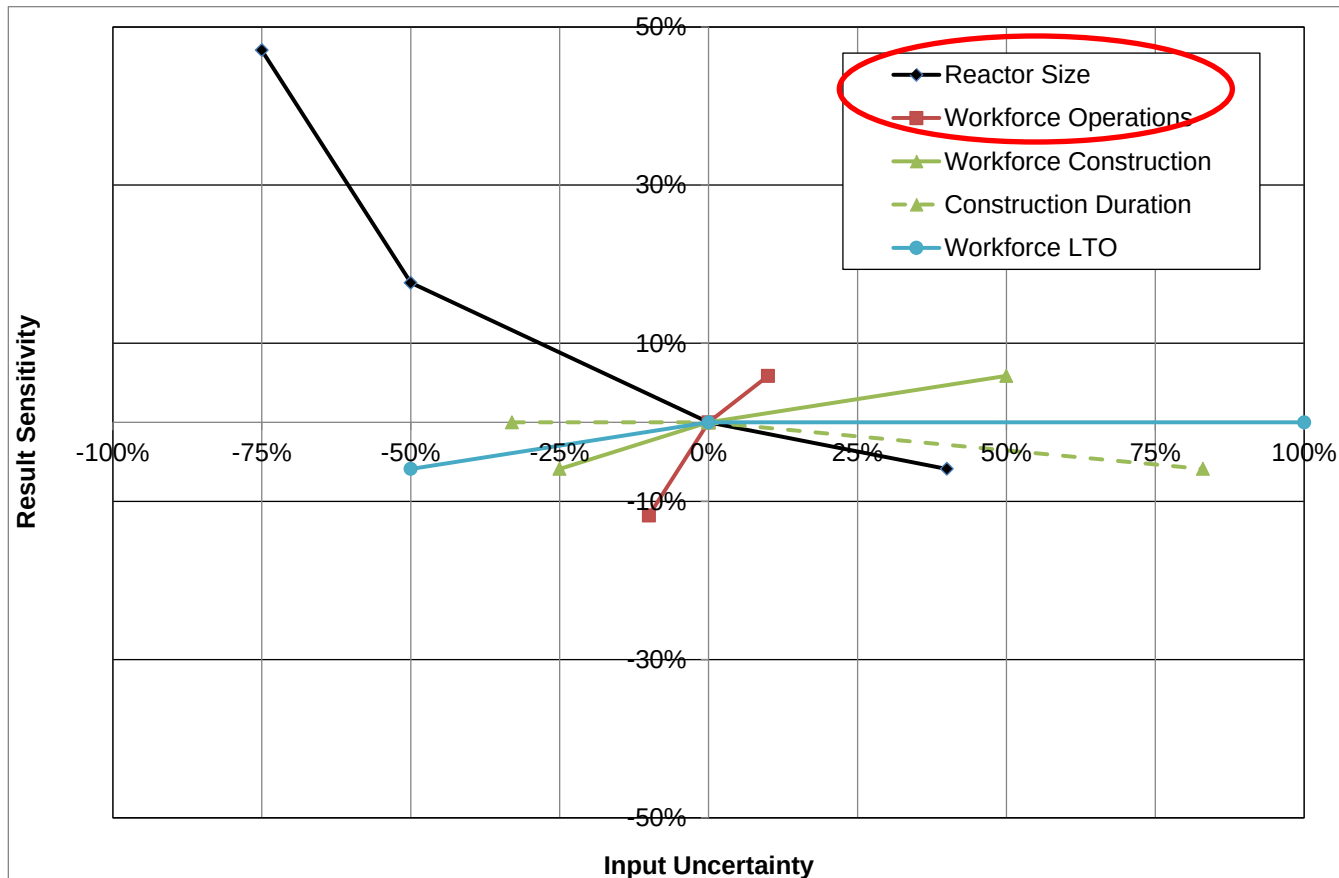
Retirements

Long Term Operation: New Workforce

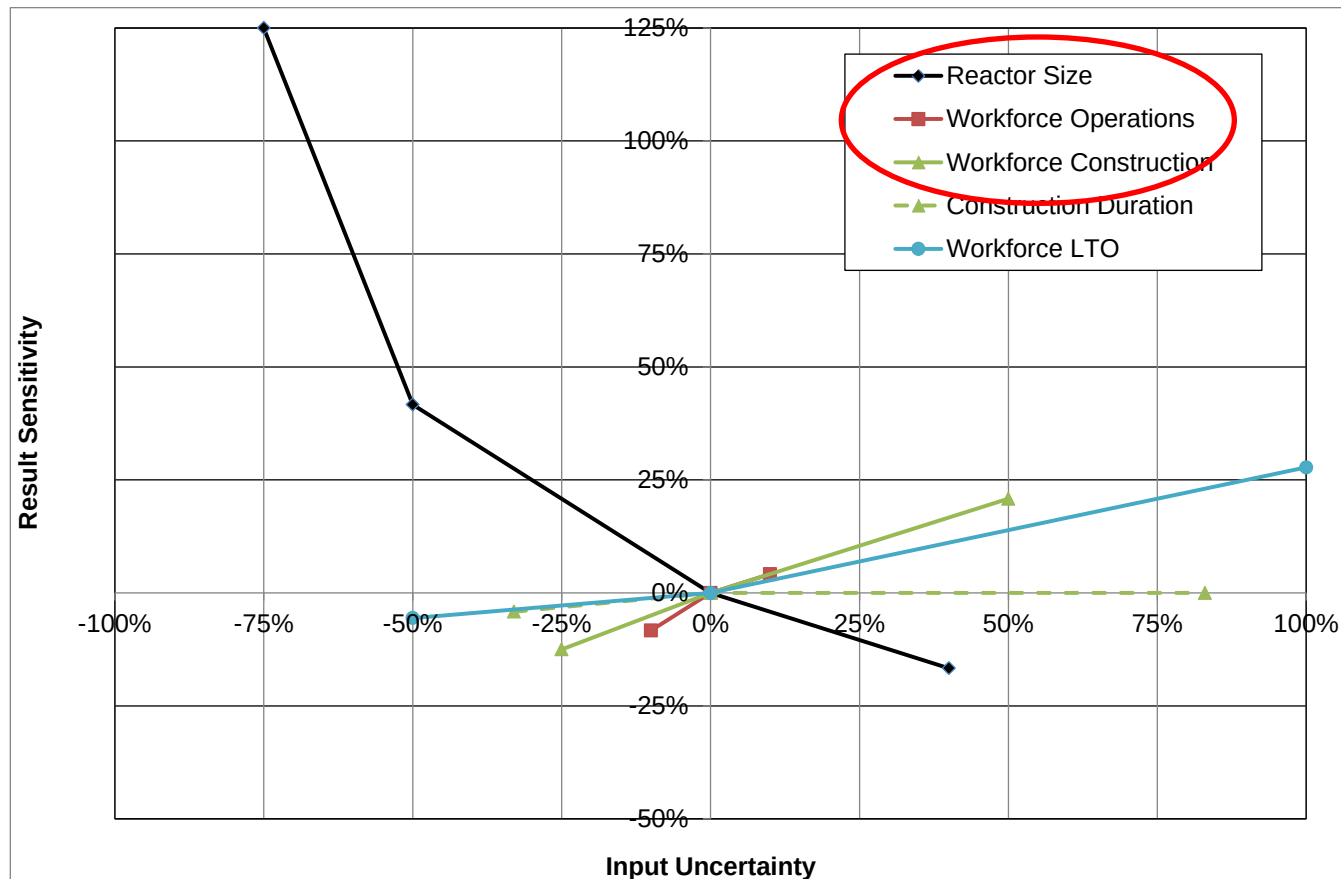


Sensitivity Analysis

Sensitivity (Near Term, ~2020)

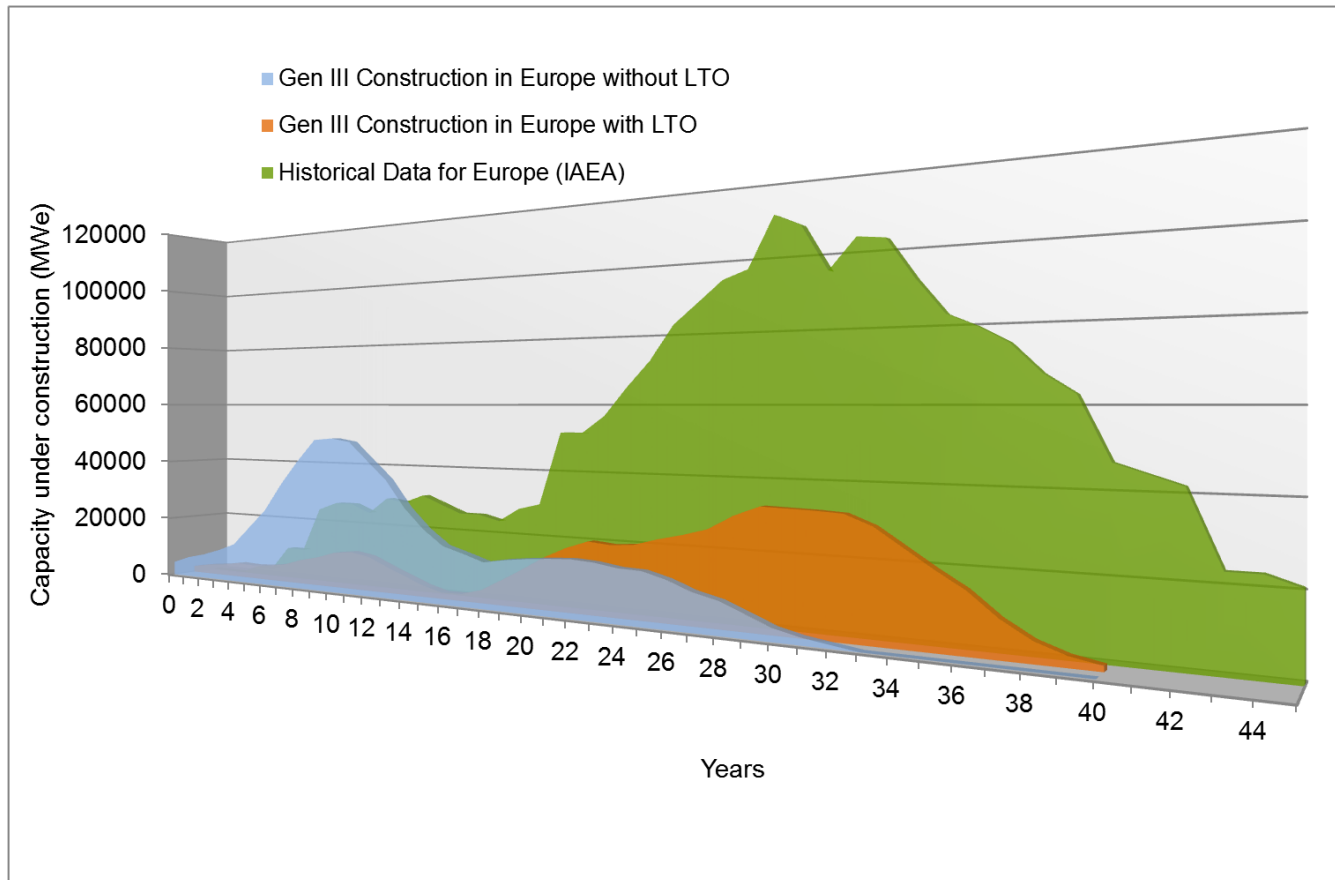


Sensitivity (Long Term, ~2040)



Historical Comparison

Historical Comparison



Conclusions

Reference Scenario

- **Number of new reactors: ± 100 depending on nuclear energy demand scenario (in 2010: 140 reactors with an average power of ~ 900 MWe).**
- **Workforce operations ~ 60000**
- **Workforce construction ~ 30000 (55000 peak)**

Long Term Operation

- **Shift of large efforts from 2020-2030 to 2040-2050**
- **Workforce LTO negligible compared to total workforce for operation and construction (even if no permanent staff is assumed for such activities)**

Retirements

- **Long term operation delays peak demand for new workforce from near future to around 2040**

Conclusions

Sensitivity Analysis

- **Results are largely sensitive to uncertainties in:**
 - Reactor size
 - Workforce for operations (uncertainties are known well and limited to $\pm 10\%$)
 - Workforce for construction (long term)
 - Not shown:* Retirements (near term)

Historical Comparison

- **Construction peak to be expected in first half of 21st century <50 GWe (compared to >100 GWe in early 80s)**
- **Peak in the early 80s was higher (However, skills requirements might have been more relaxed)**
- **LTO relaxes the number of new reactors being installed at the same time compared to historical values and to the reference scenario**

The End

*More
information:*

<http://ehron.jrc.ec.europa.eu/>

