International Atomic Energy Agency

# Status and Performance of the Operating Nuclear Power Plants

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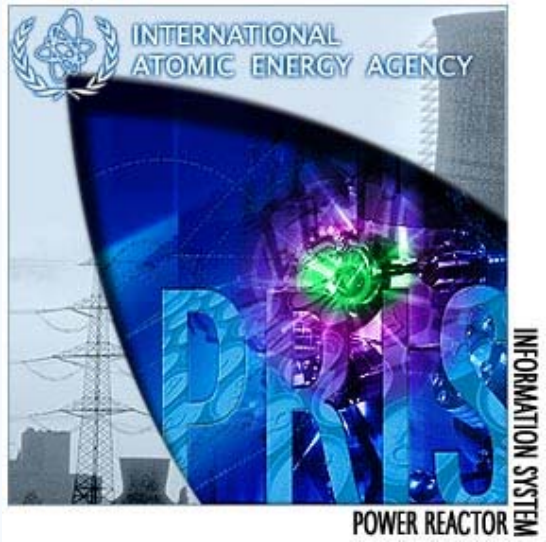
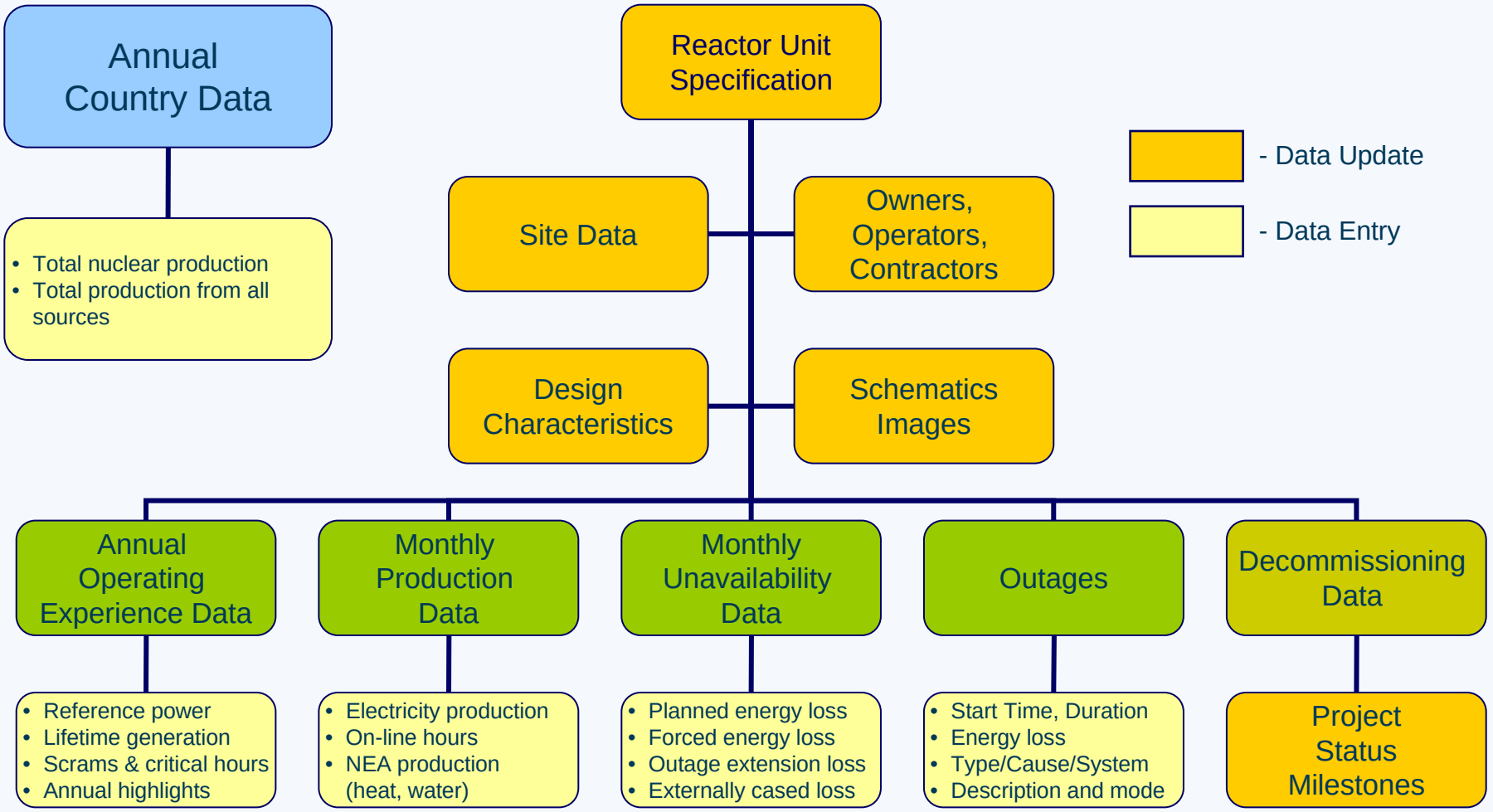
Technical Cooperation Workshop on
Nuclear Power Plant Technology Assessment
Vienna, November 17-20, 2008

# What is PRIS?

- Reference database of authoritative information about NPPs
- PRIS covers:
  - Basic and design information on nuclear power reactors
  - Performance data
  - Decommissioning data
- PRIS consists of:
  - Database and supporting SW
  - Documents, instructions and guidelines
  - Reports, publications



# PRIS data structure

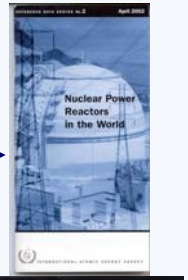


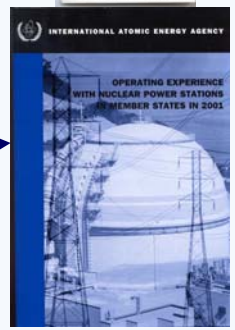
# PRIS Outputs

Local Installation

IAEA PRIS

Publications




**NPR in the World**

since 1981

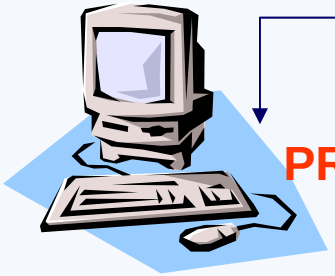
**Operating Experience with NPP**

since 1971


**PRIS on CD**

On-line Access

WEB Applications

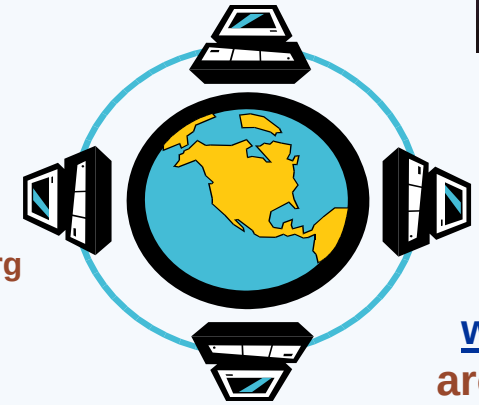


**PRIS-PC**

**WEDAS**

Data Entry

**prisweb.iaea.org**



**Homepage**

one of the ten top IAEA gateways

**www.iaea.org/dbpage**

**around 180 visitors /day**

**Statistics**

Data Reporting

**prisweb.iaea.org/Statistics**

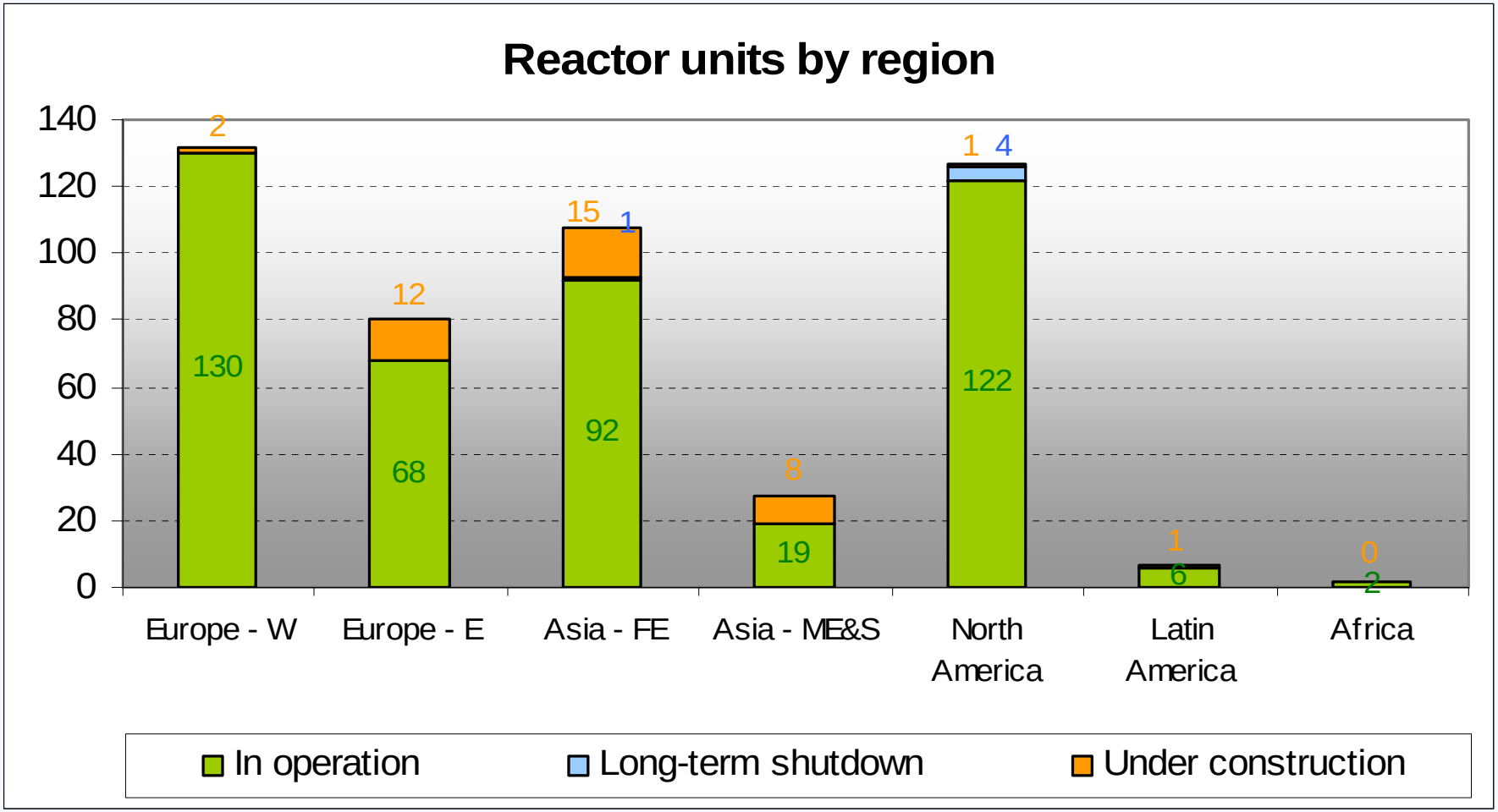
# What can be get from PRIS?

- Overview of power reactors
- Well defined and internationally accepted indicators
- Industrial standards – average, median, quartiles
- Goals and threshold for plant indicators
- Trends
- International cooperation and sharing of good practices

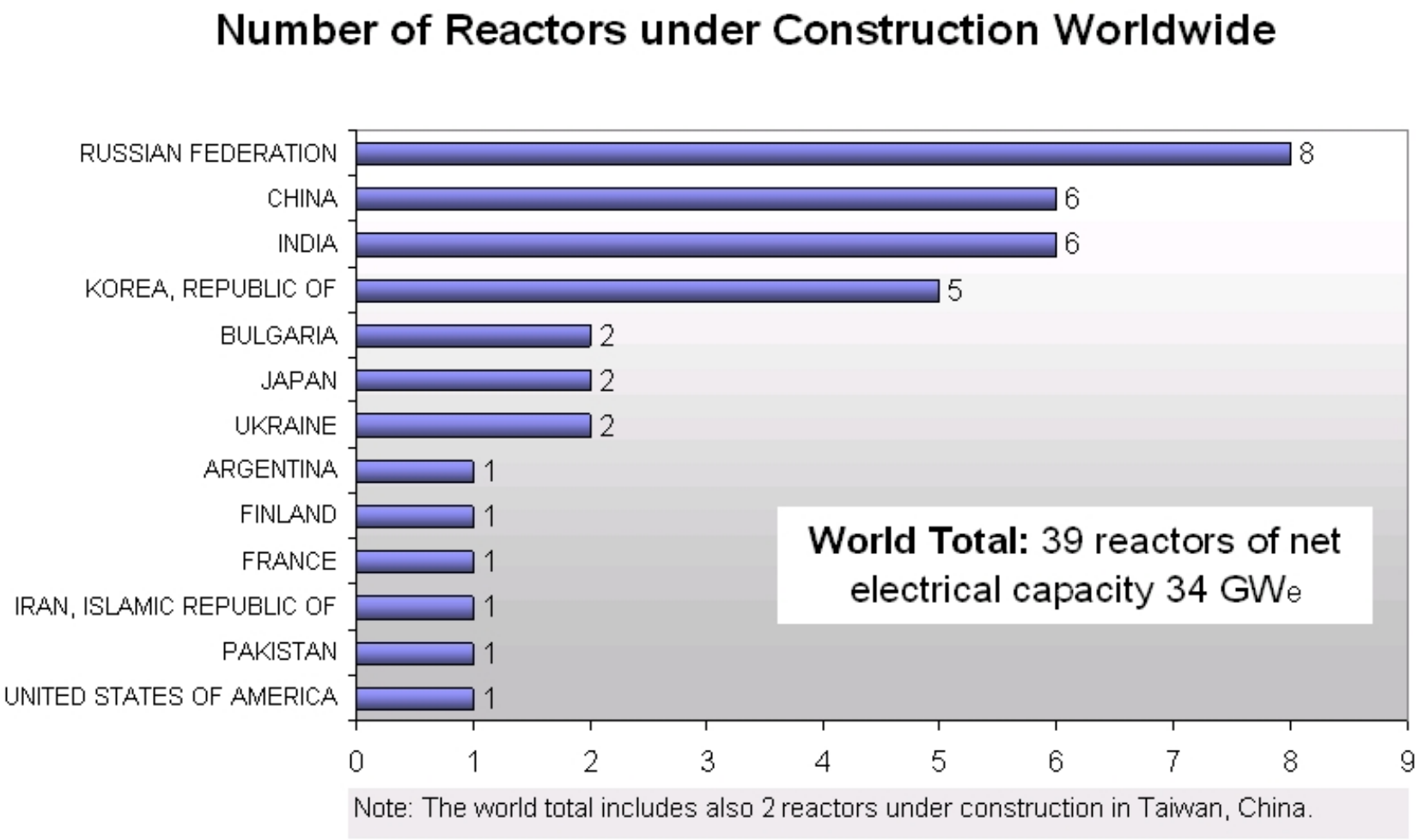
# Current Status of Nuclear Industry

- **439 reactors in operation**
  - *Installed capacity 372 $GW_e$*
- **5 reactors in long-term shutdown**
  - *Installed capacity 3 $GW_e$*
- **39 reactors under construction**
  - *Installed capacity 34 $GW_e$*

# Reactors in regions



# Latest status: construction



# Nuclear Industry development

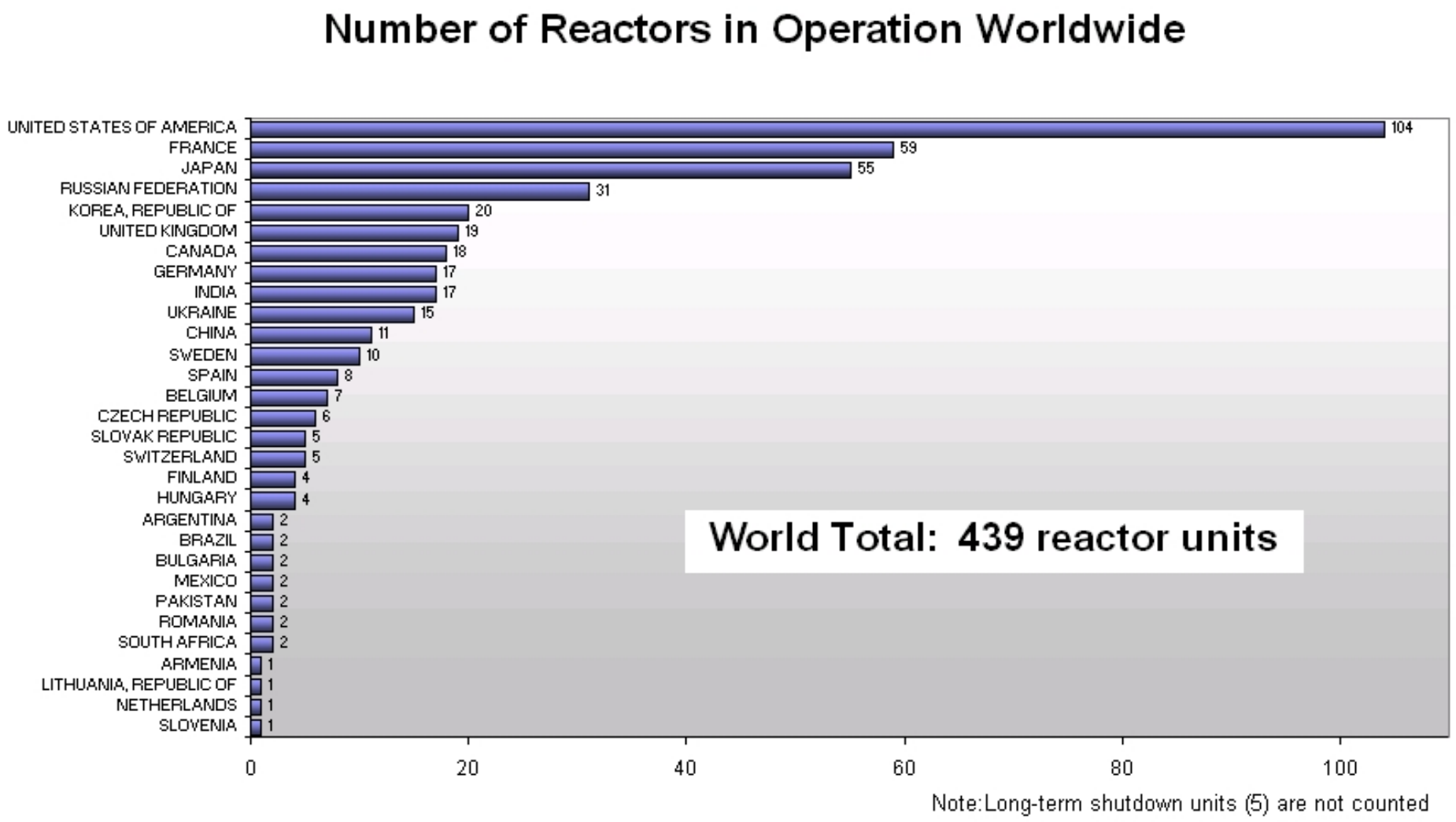
Current expansion, as well as near-term and long-term growth prospects, are centred in Asia:

- 23 of 39 reactors under construction worldwide
- 23 of the last 30 reactors connected to the grid
- ambitious near-term programs:
  - China: 32-40 $GW_e$ by 2020 (now 8.6 $GW_e$)
  - India: 25 $GW_e$ by 2022 (now 3.5 $GW_e$)
  - S. Korea: 26.6 $GW_e$ by 2017 (now 17.5 $GW_e$)
  - Pakistan: 8.5 $GW_e$ by 2030 (now 0.43 $GW_e$)

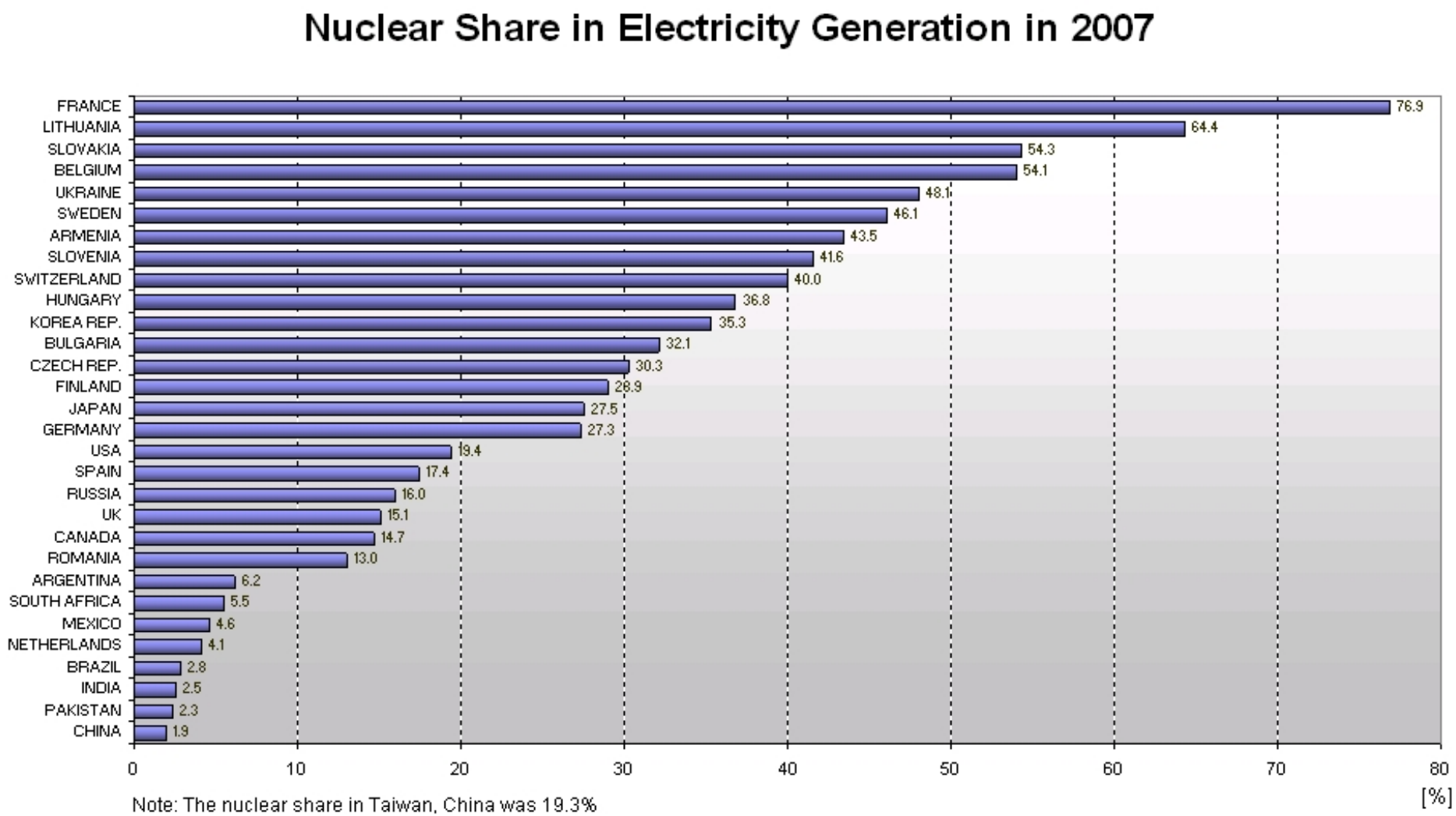
Russia : 44 $GW_e$ in 2030 (now 22 $GW_e$)

Ukraina: 26 $GW_e$ by 2030 (now 13.1 $GW_e$)

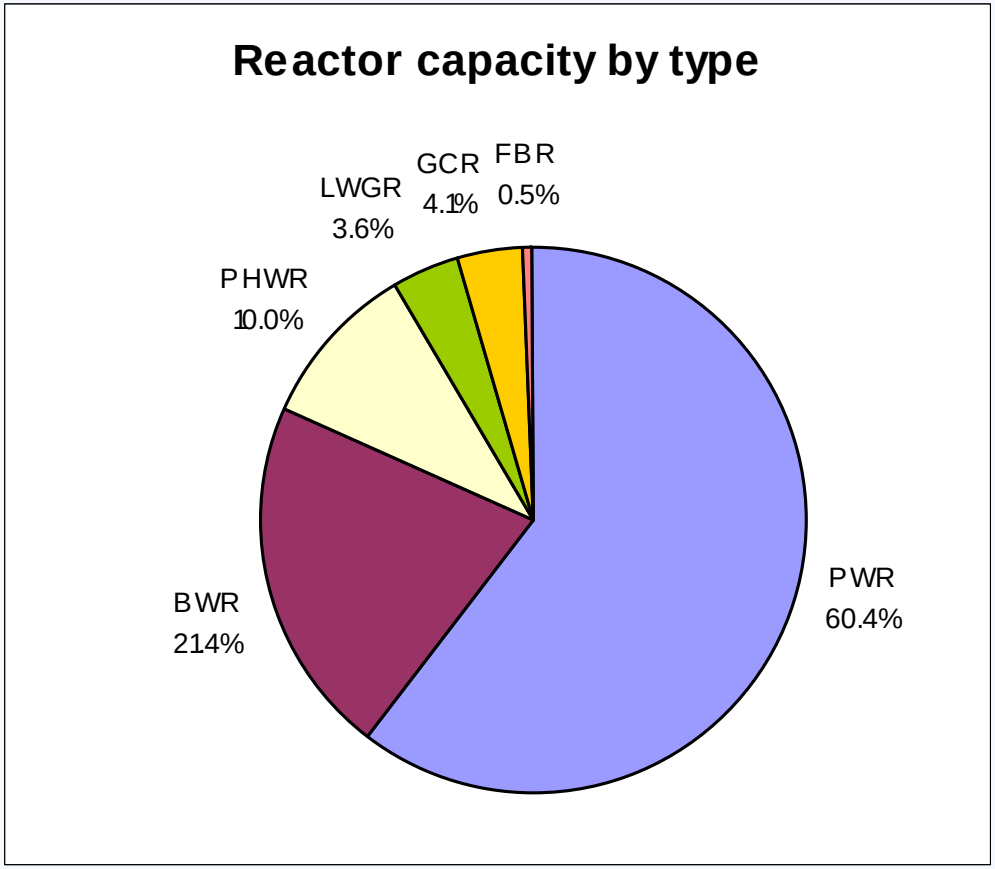
# Operational reactors

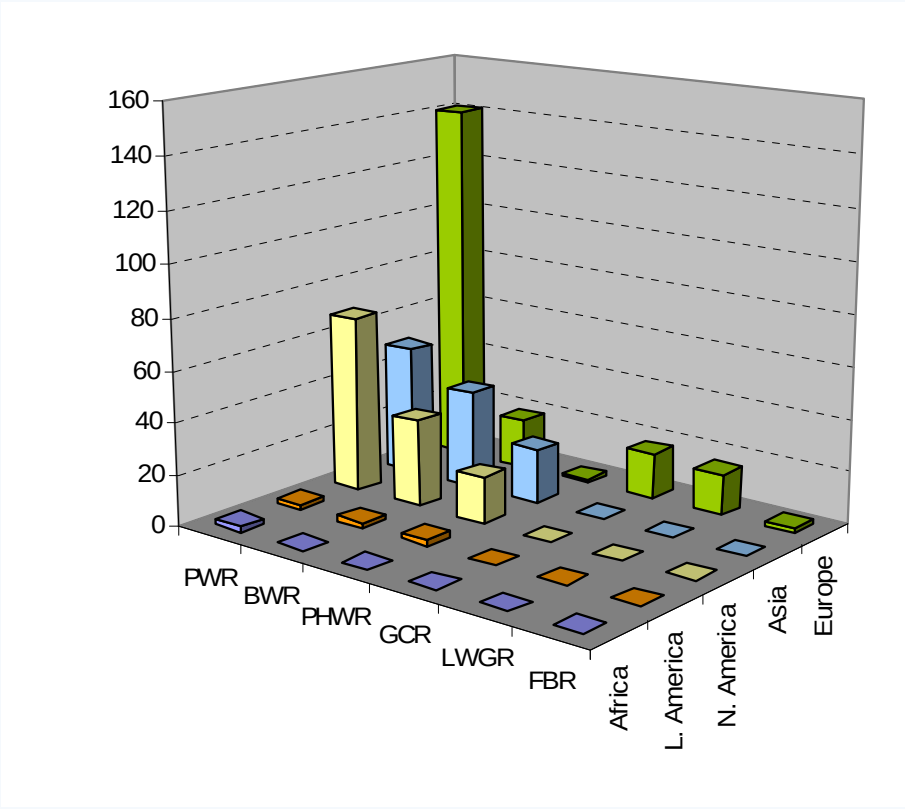


# Nuclear share

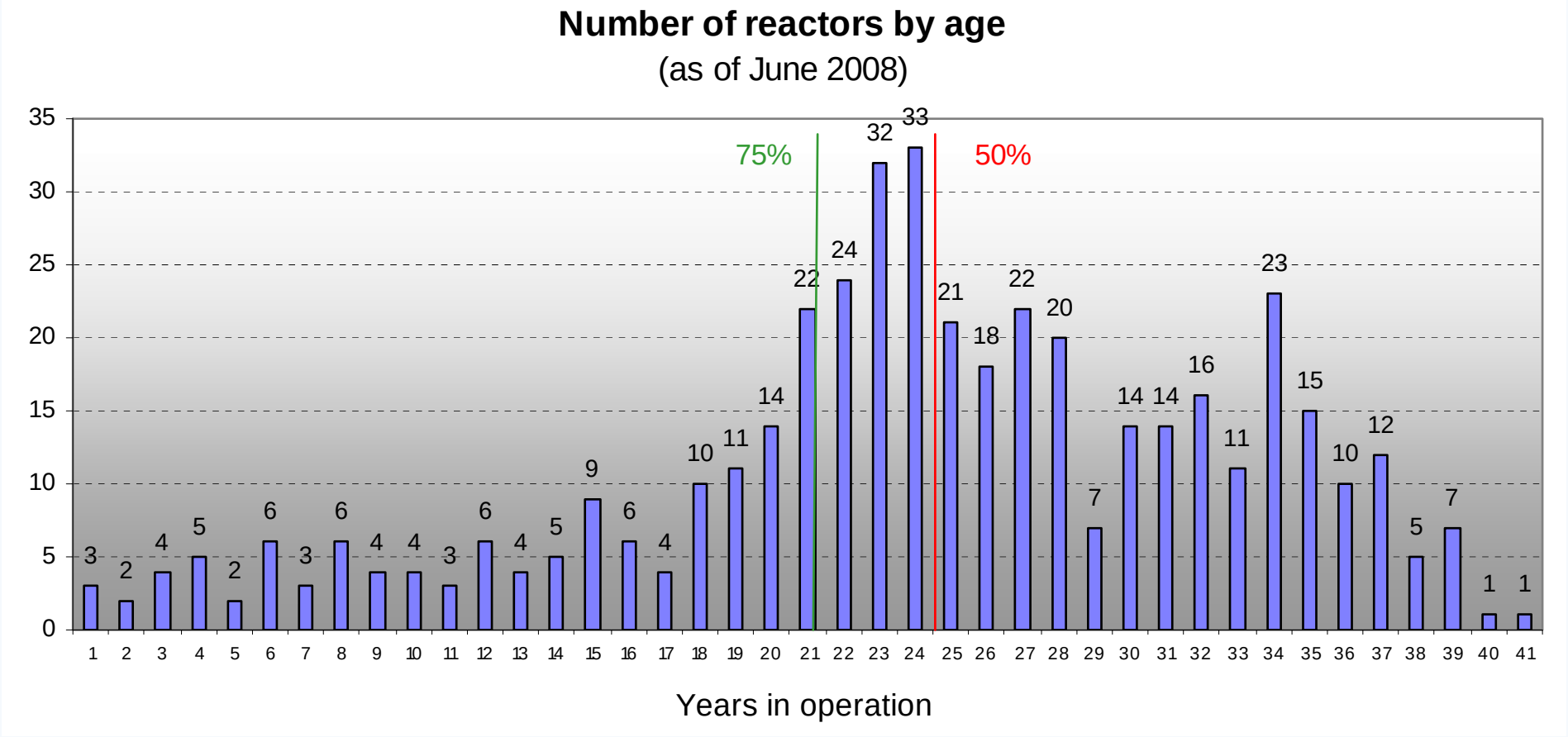


# Nuclear reactor types

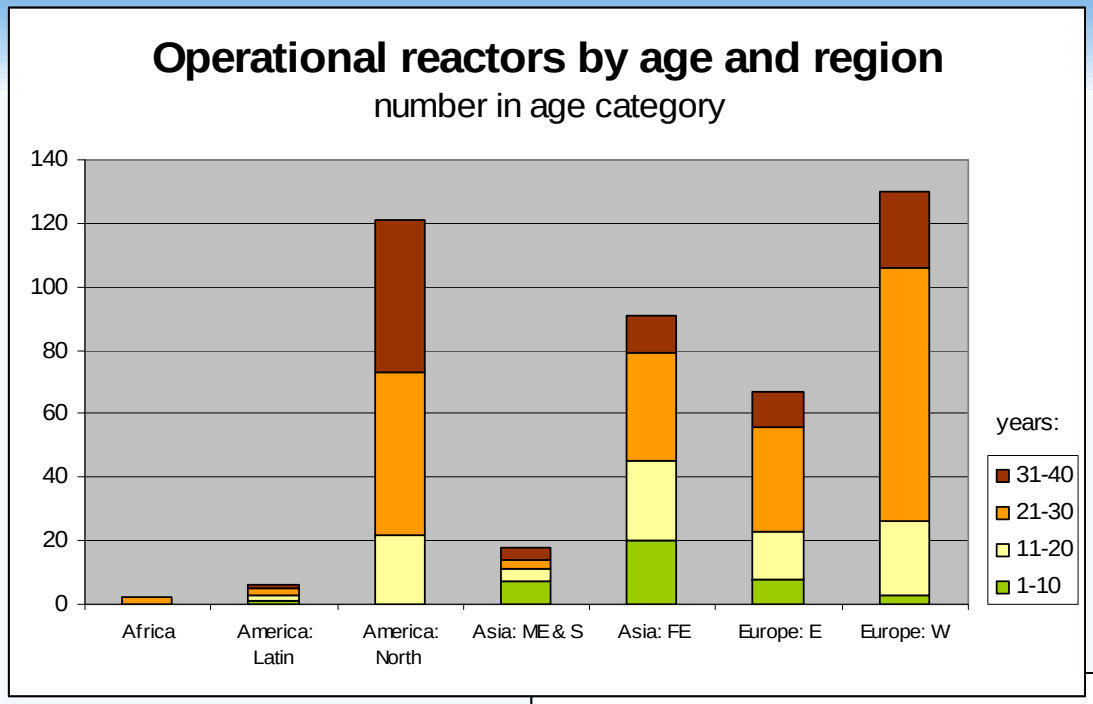


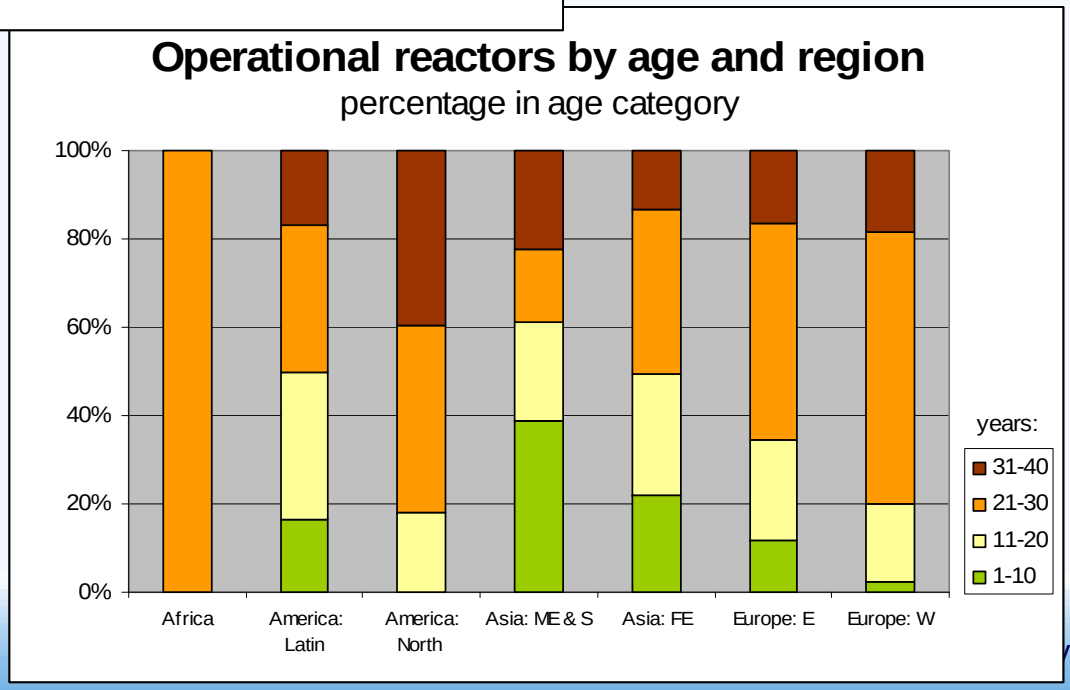



# Nuclear reactor vintage

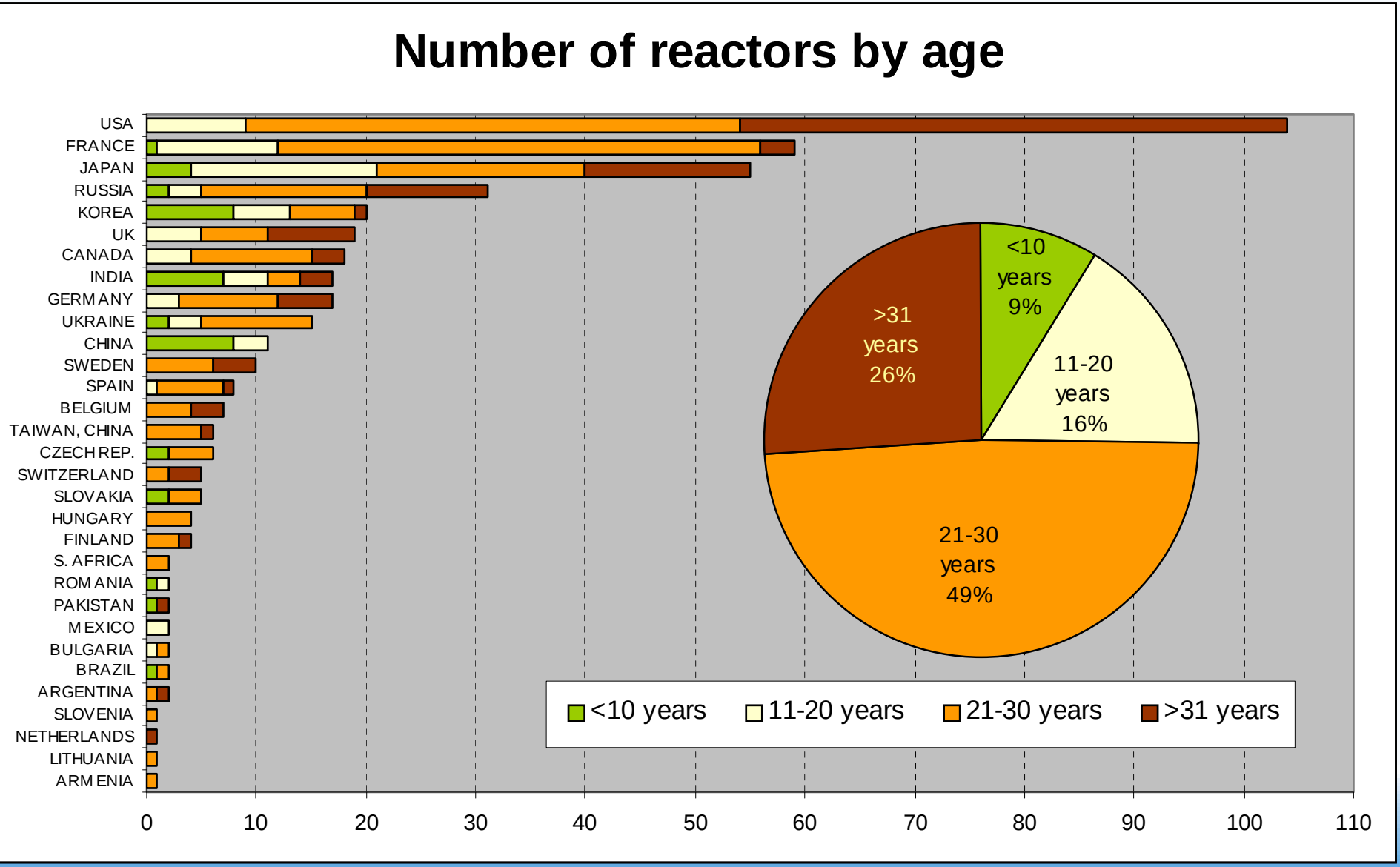


# Distribution by Age



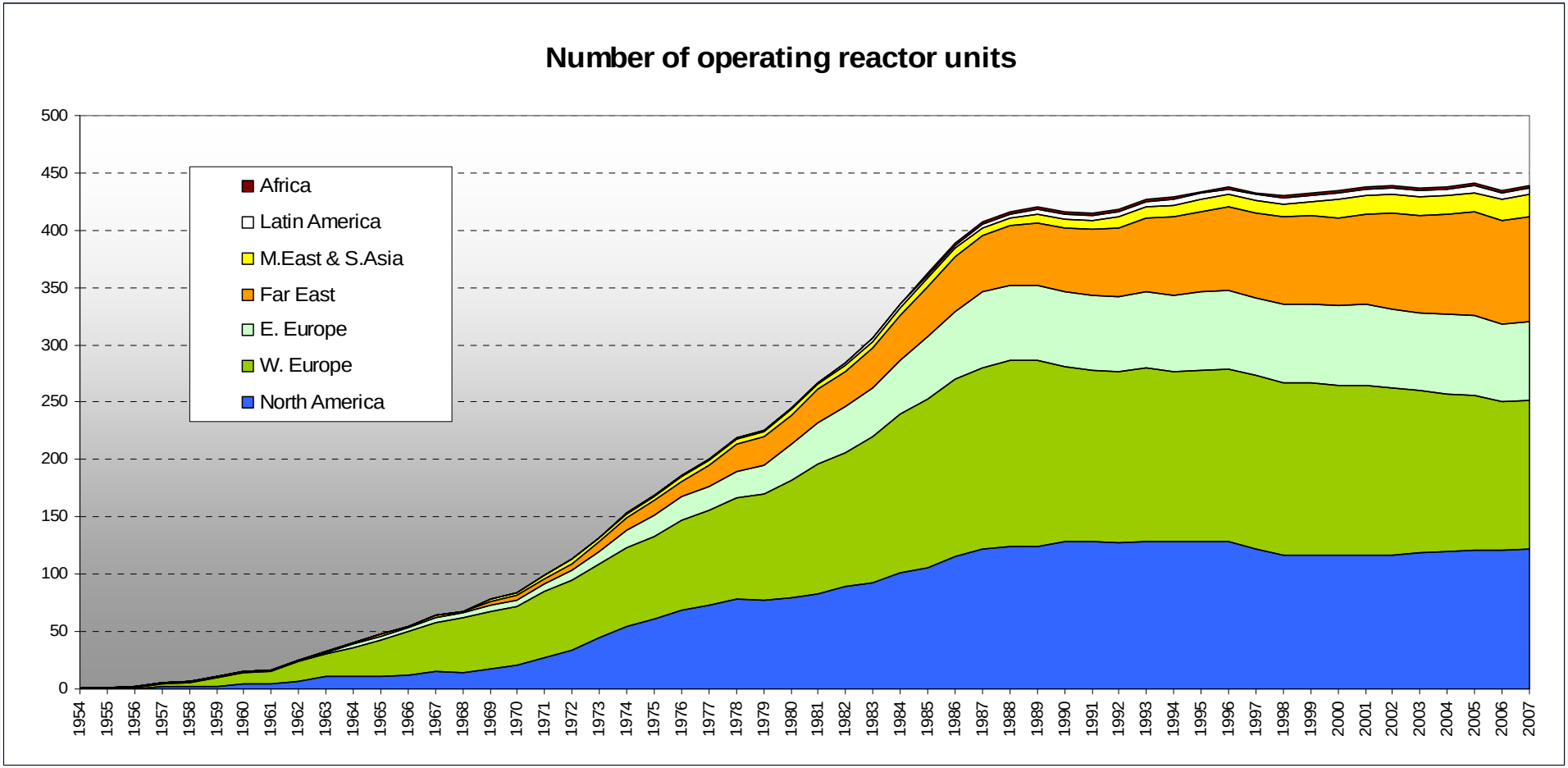
# Nuclear reactors by country



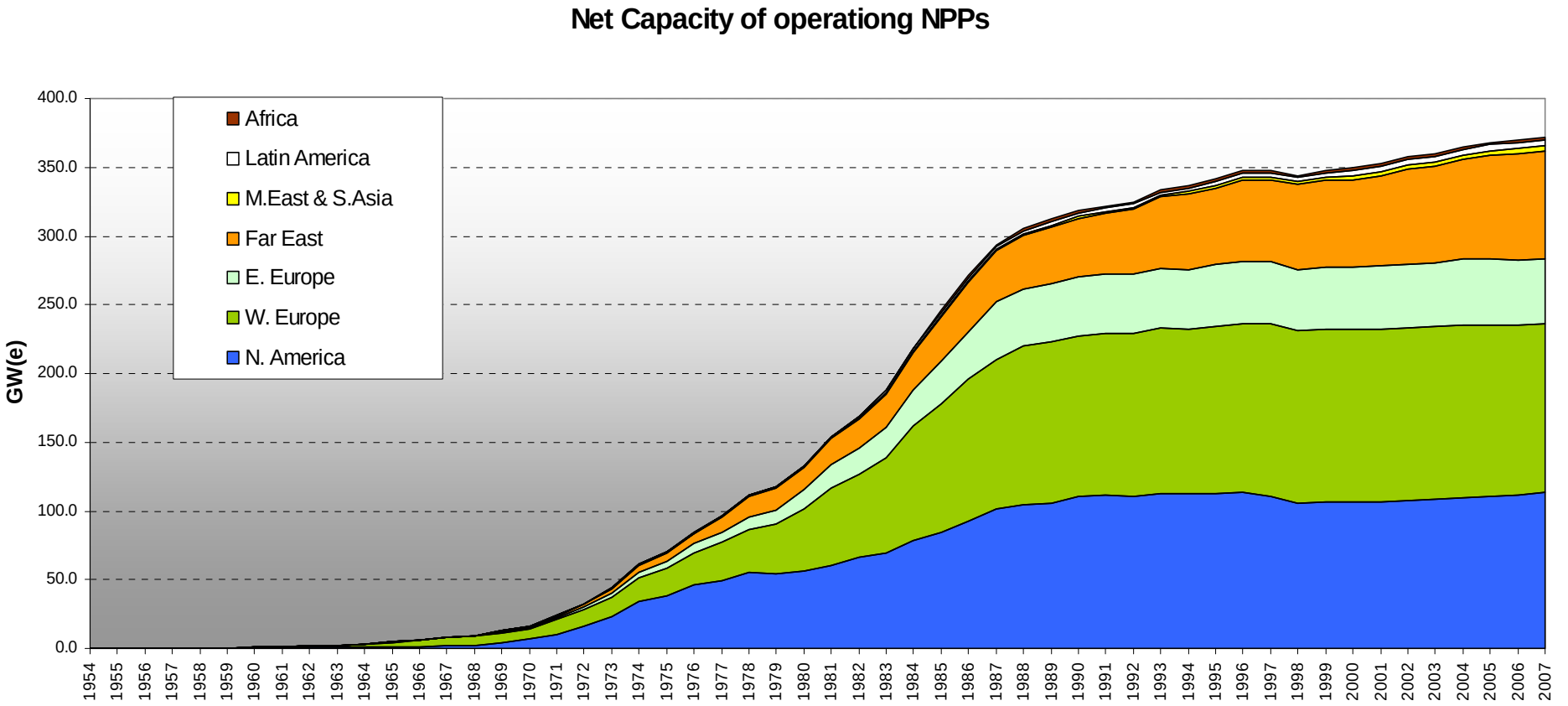
# License Renewal

- The original 40-year term for reactor licenses
- The Nuclear Regulatory Commission (NRC) issues licenses for commercial power reactors to operate for up to 40 years and allows these licenses to be renewed for additional periods of 20 years.
- License has been renewed for 38 US reactors
- 18 applications currently under review

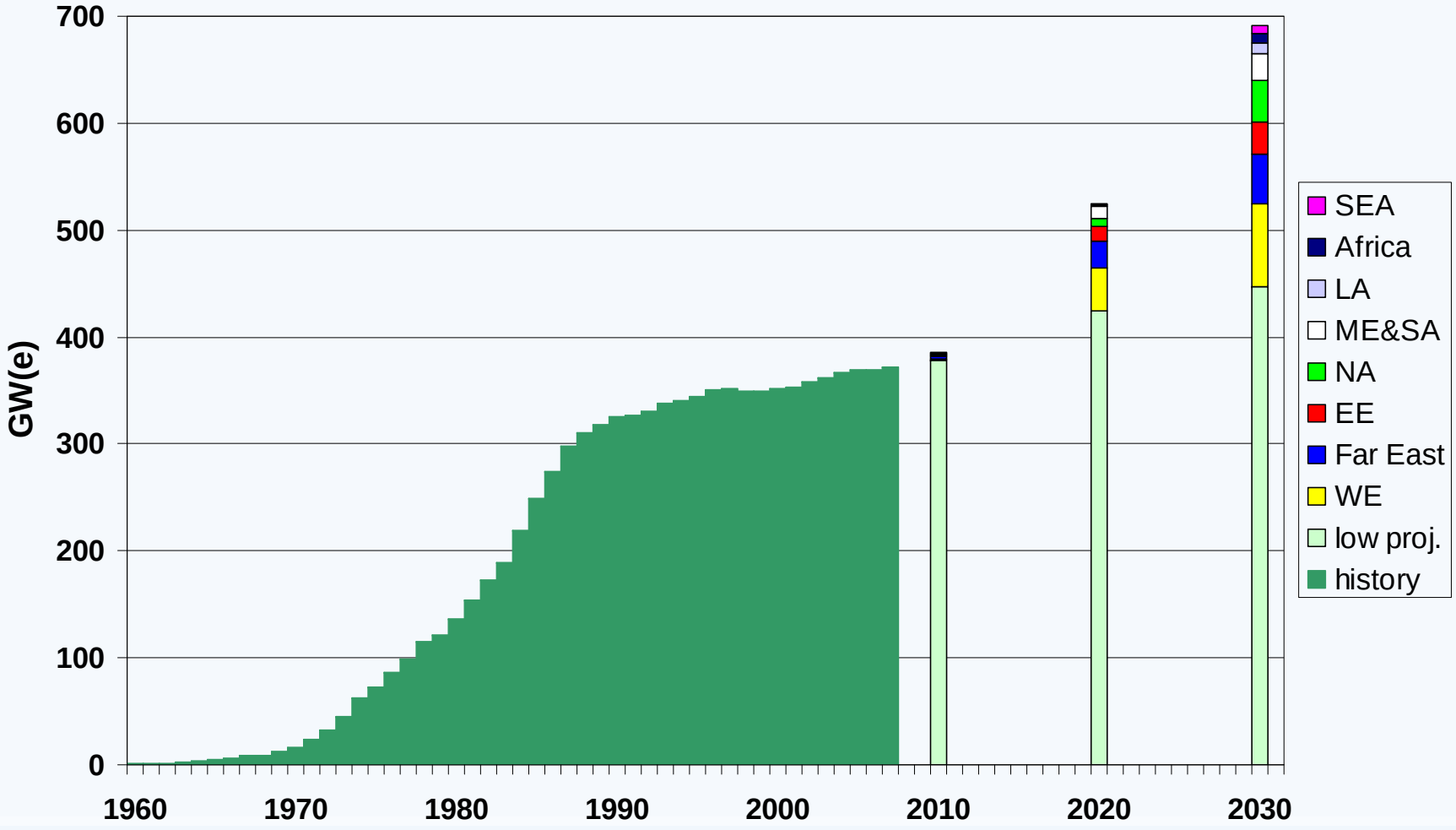
# Development in regions



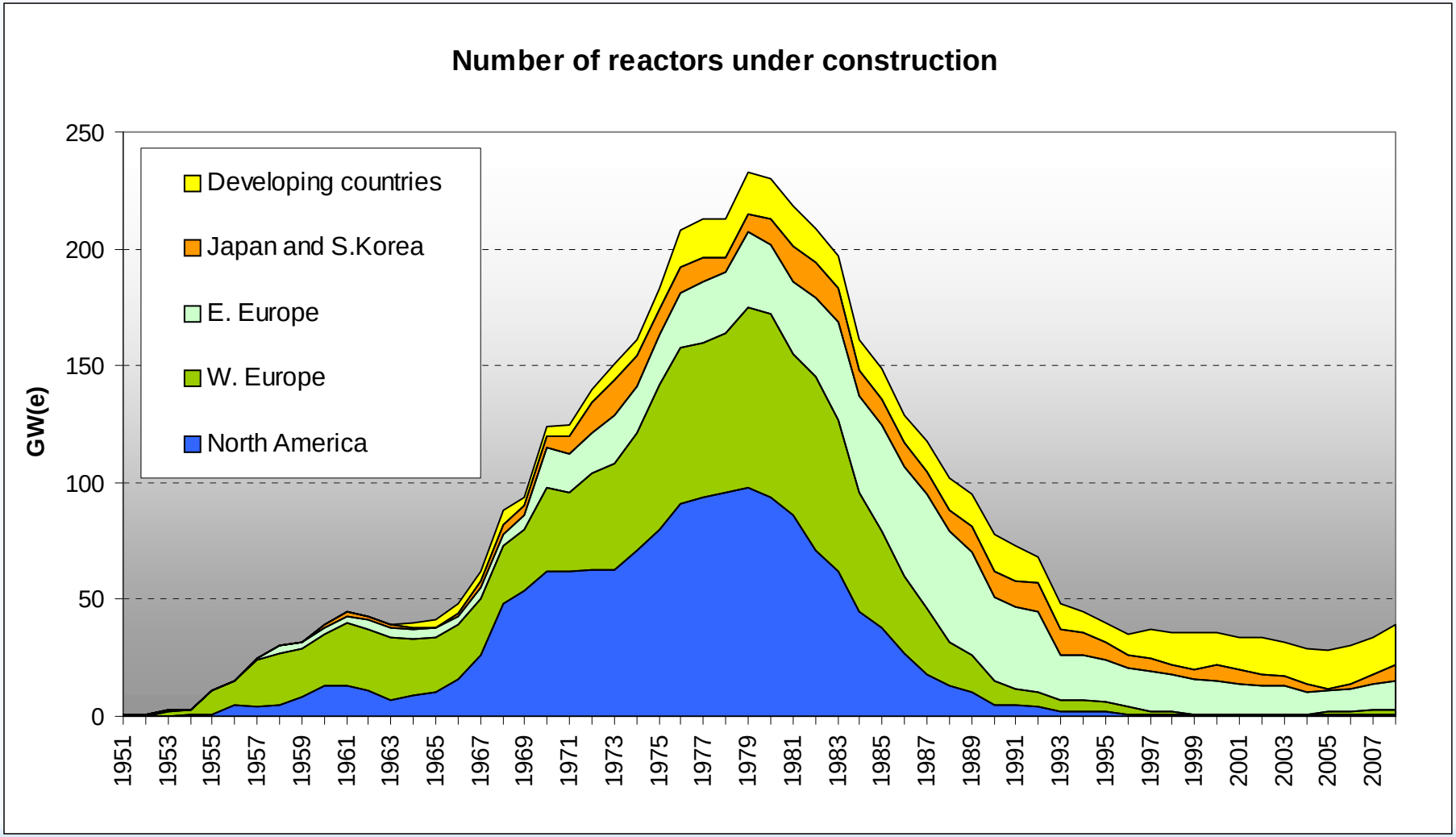
# Net Capacity by Region



# Nuclear Energy Projection



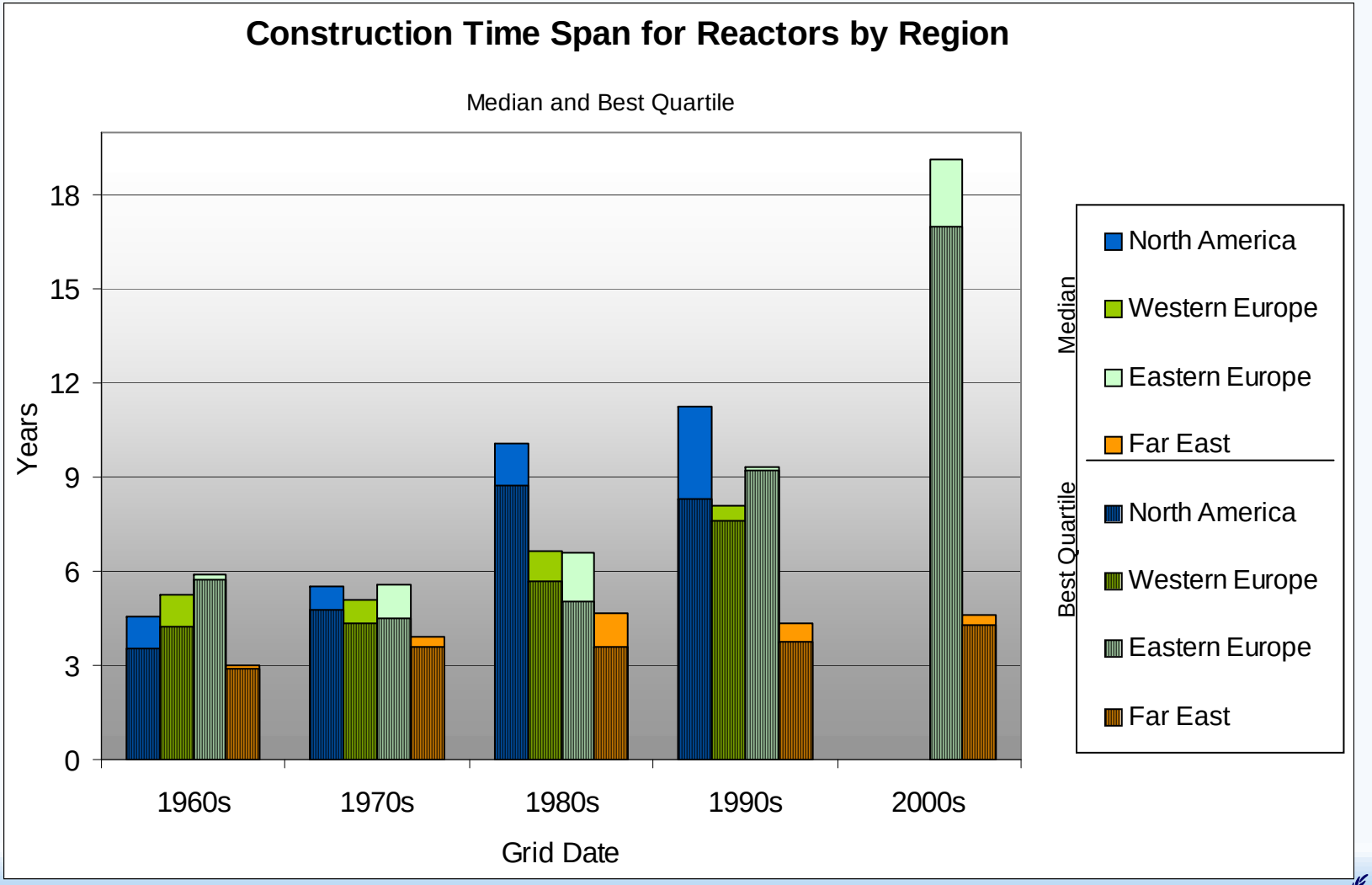
# History of NPP construction



# NPP construction time span

- Median of construction period: 6 years
- Best quarter: less then 5 years
- Best achievements: 3 yeas
- Regional and reactor type variance
- Delayed projects
  - economic reasons
  - suspended construction after 1986
  - new requirements

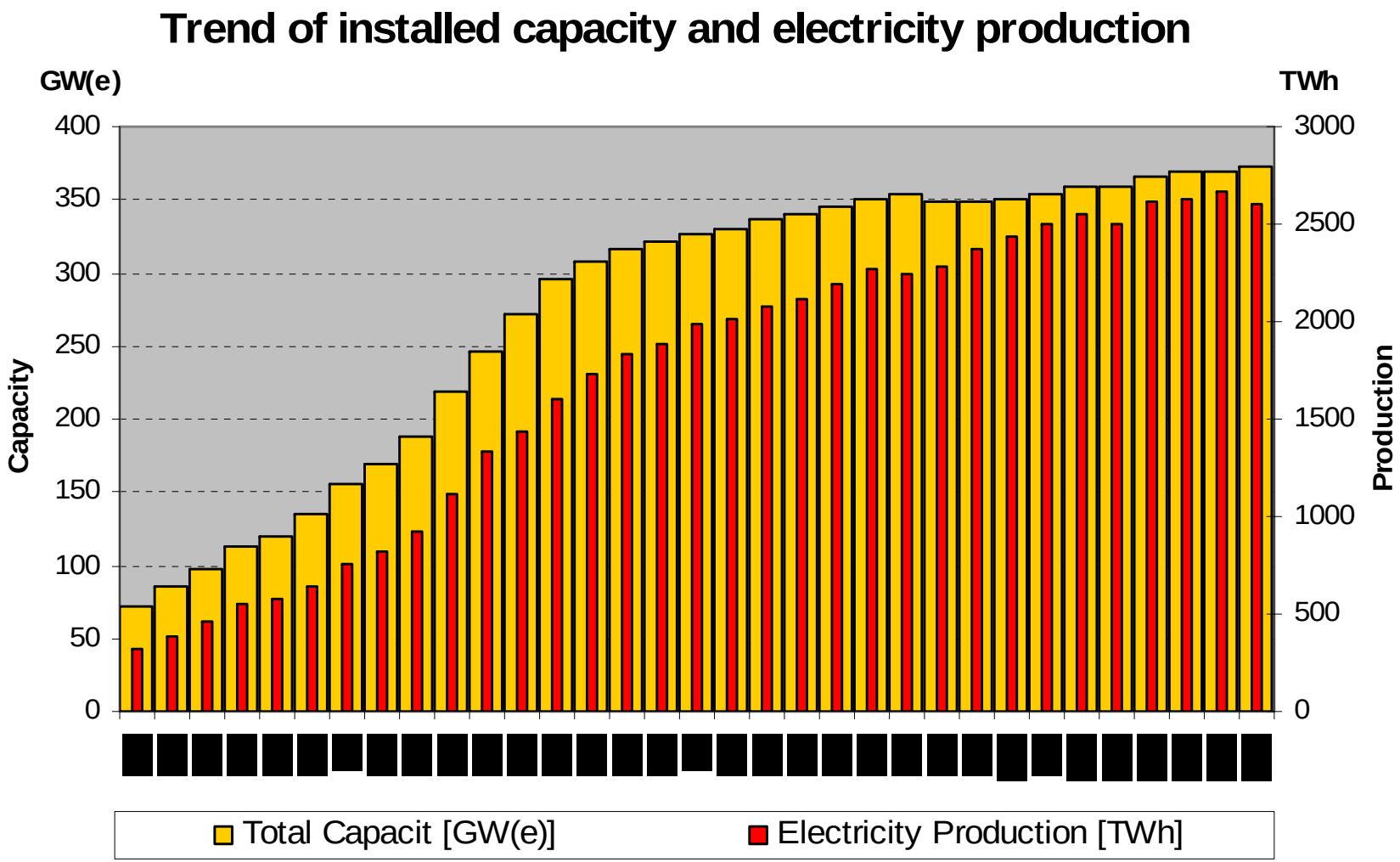
# Construction time span



# Shortest and longest constructions

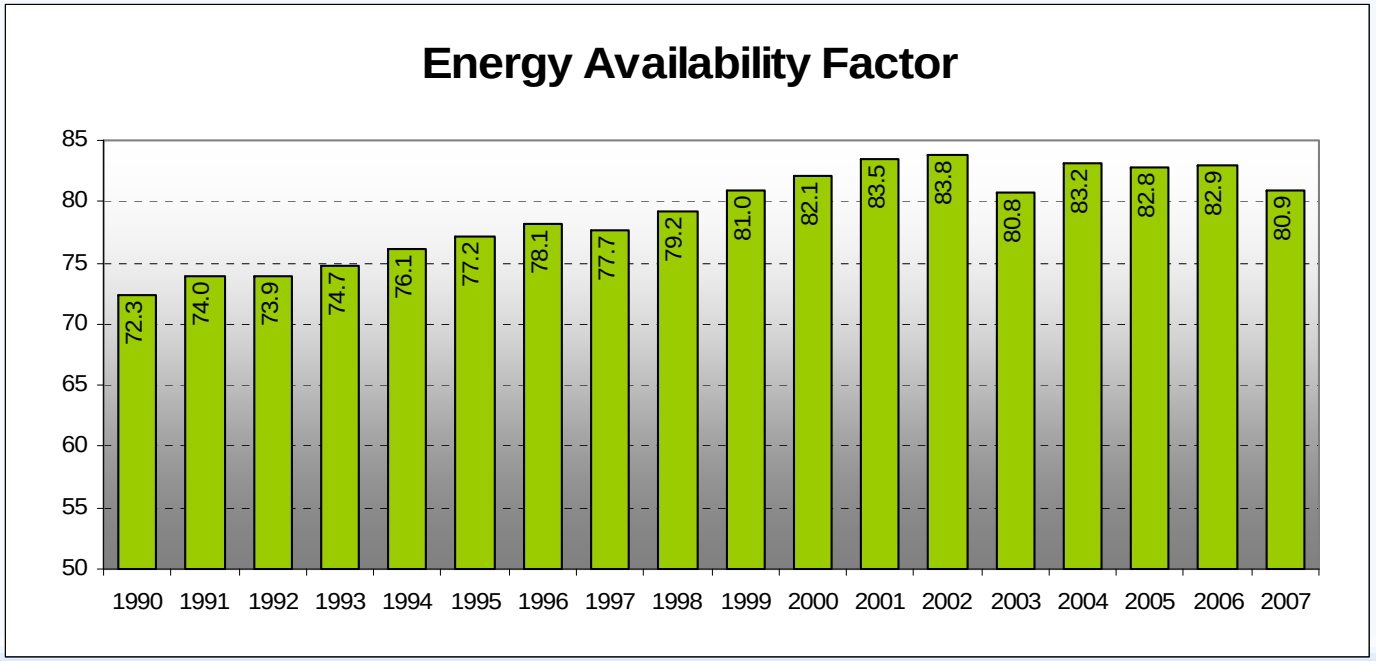
| Iso Code | Station | Type | Model | Net Elec Capacity | Operator | Reactor Supplier | Turbine Supplier | Construction Date | Grid Date | Duration in years |
|---|---|---|---|---|---|---|---|---|---|---|
| JP | TSURUGA-1 | BWR | BWR | 340 | JAPCO | GE | GE/T | 24-Nov-66 | 16-Nov-69 | 3.0 |
| JP | HAMAOKA-1 | BWR | BWR4 | 515 | CHUBU | TOSHIBA | HITACHI | 10-Jun-71 | 13-Aug-74 | 3.2 |
| JP | KASHIWAZAKI KARIWA-6 | BWR | ABWR | 1315 | TEPCO | TOSHIBA | GE | 03-Nov-92 | 29-Jan-96 | 3.2 |
| JP | HAMAOKA-4 | BWR | BWR5 | 1092 | CHUBU | TOSHIBA | HITACHI | 13-Oct-89 | 27-Jan-93 | 3.3 |
| US | POINT BEACH-1 | PWR | W (2-loop) | 512 | WEP | WH | WH | 19-Jul-67 | 06-Nov-70 | 3.3 |
| | | | | | | | | | | |
| RU | VOLGODONSK-1 | PWR | WWER V-320 | 950 | REA | FAEA | | 01-Sep-81 | 30-Mar-01 | 19.6 |
| GB | DUNGENESS-B2 | GCR | AGR | 545 | BE | APC | PARSONS | 01-Oct-65 | 29-Dec-85 | 20.2 |
| US | WATTS BAR-1 | PWR | W (4-loop) | 1121 | TVA | WH | WH | 23-Jan-73 | 06-Feb-96 | 23.0 |
| RO | CERNAVODA-2 | PHWR | CANDU 600 | 655 | SNN | AECL | G.E. | 01-Jul-83 | 07-Aug-07 | 24.1 |
| BR | ANGRA-2 | PWR | | 1275 | ELETRONU | KWU | KWU | 01-Jan-76 | 21-Jul-00 | 24.6 |

# Nuclear energy production



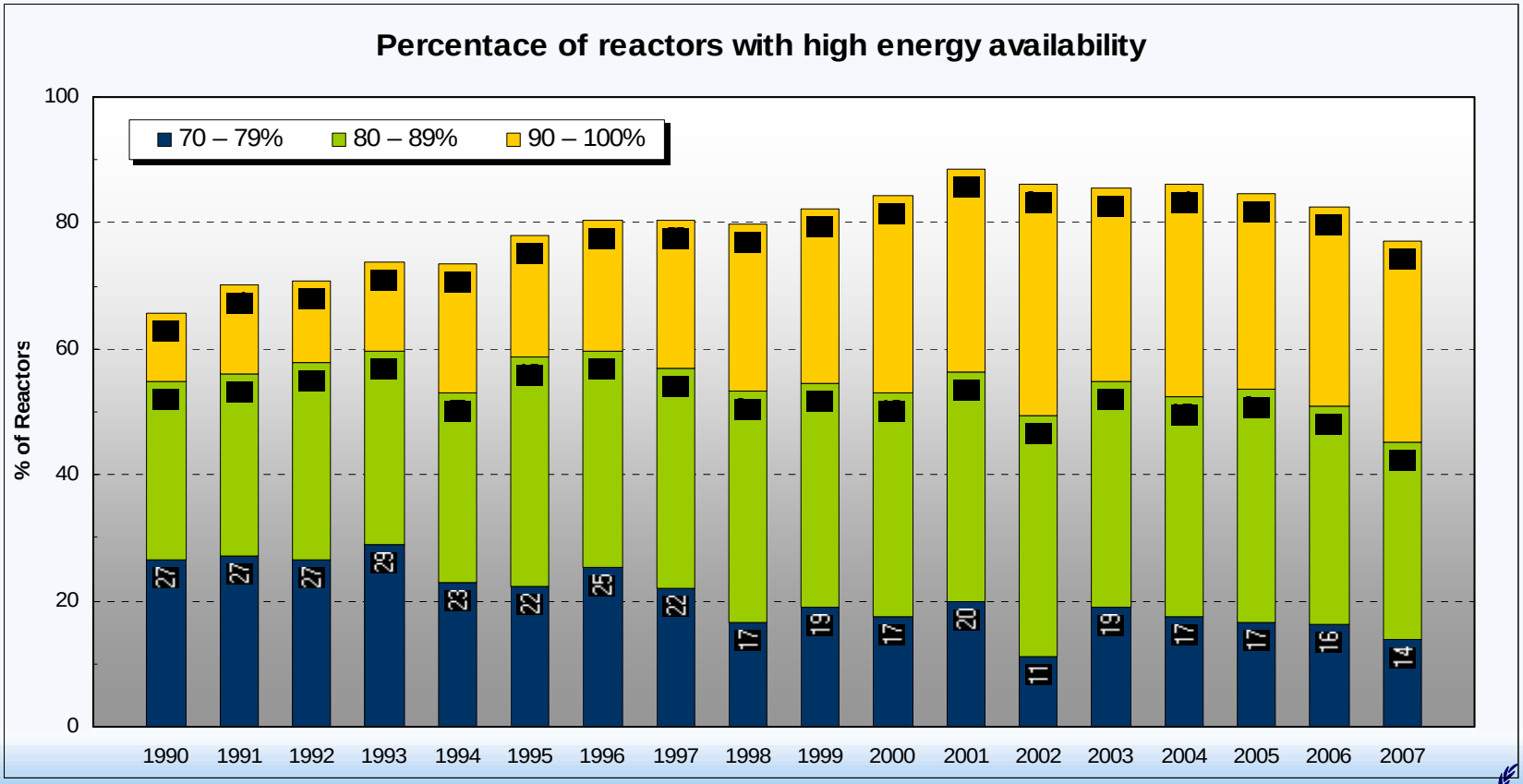
# Installed Capacity Utilization

- Continuous increase during last 20 years has halted in last years
- In 2007 the Energy Availability Factor (EAF) was 81% in average. Half of nuclear reactors operated with EAF above 85%.
- In 1990s an average annul increment was 1% - equivalent to construction of 4 new units every year



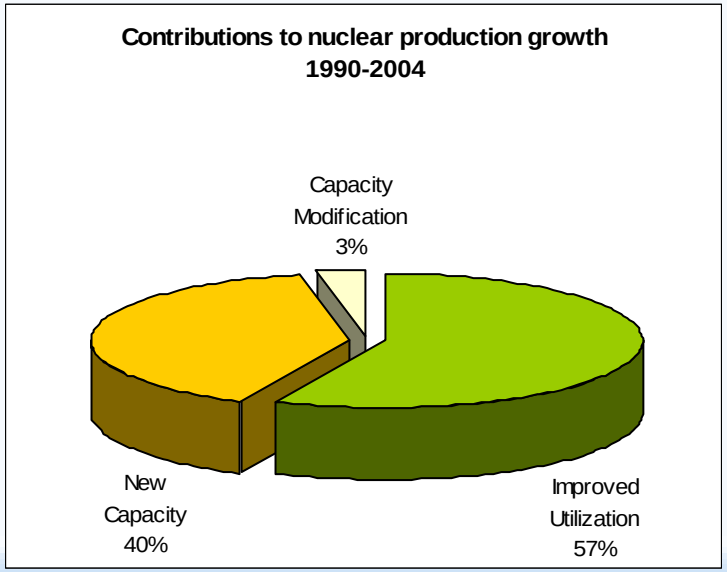
# EAF Distribution

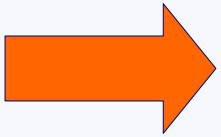
Increasing percentage of reactor units with EAF above 70%. In the category 90-100% the percentage has risen from 10.7% in 1990 up to 37% in 2002. In 2007 32% of reactor units were operated with EAF above 90%.

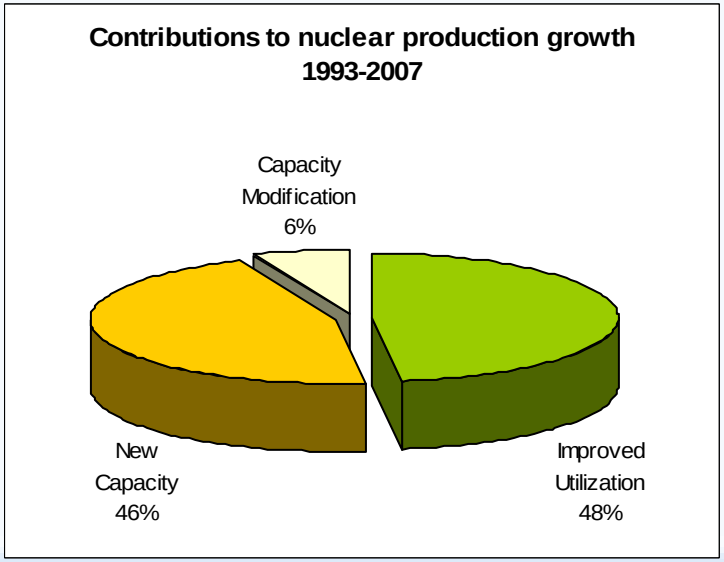


# Production growth factors

- From 1990 through 2007, global nuclear electricity production increased from 1901 to 2608 TWh (+37%), installed capacity increased from 320.5 to 372,2 GWe (+16%) and plant availability from 72.3% to 80.9%.
- In 1990s the production growth was driven by improved NPP utilisation.
- Declining trend of plant availability in last 5 years results in drop of its contribution to production growth from 57% in period 1990-2004 to 50% in period 1990-2004, respectively to 30% in period 1990-2004



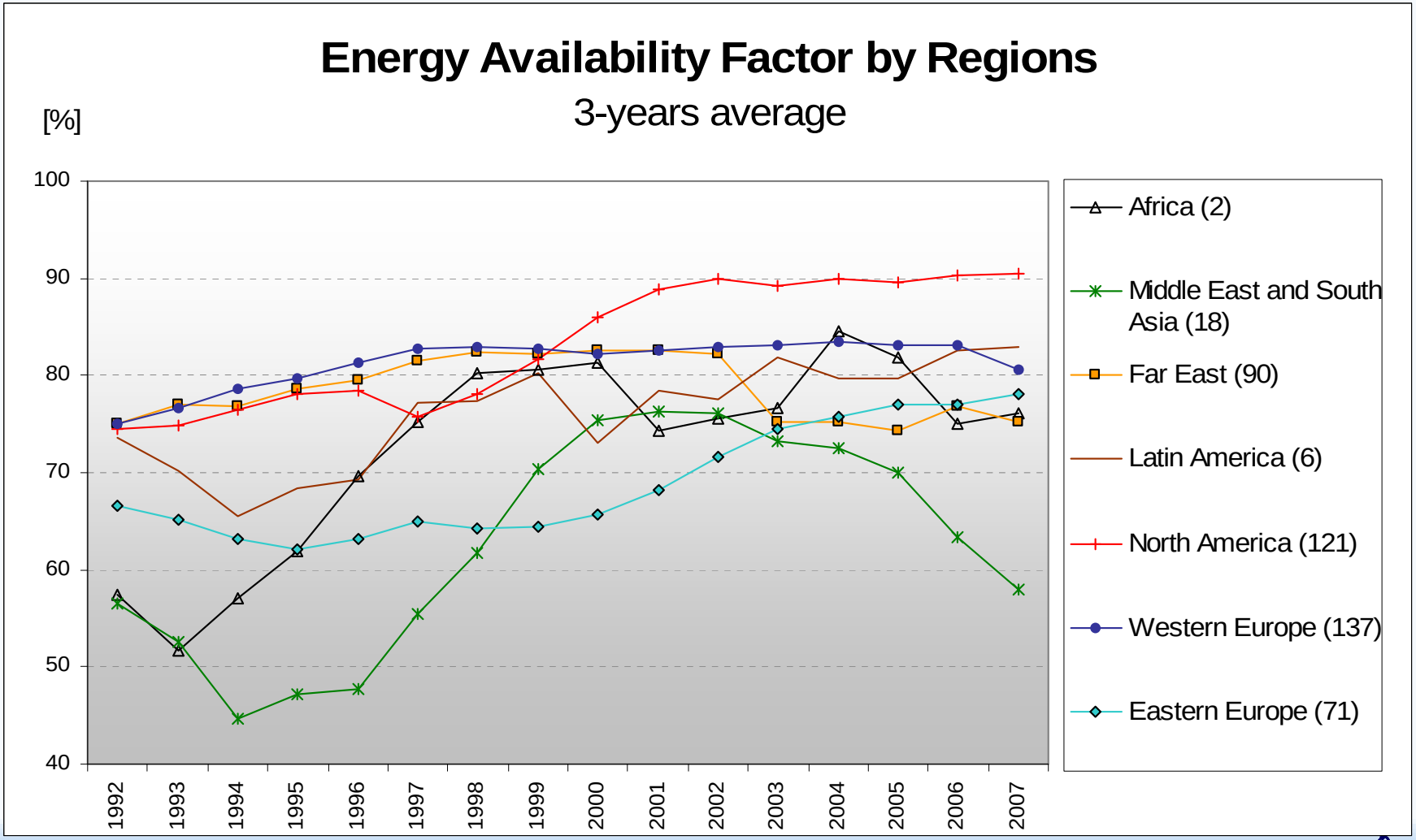





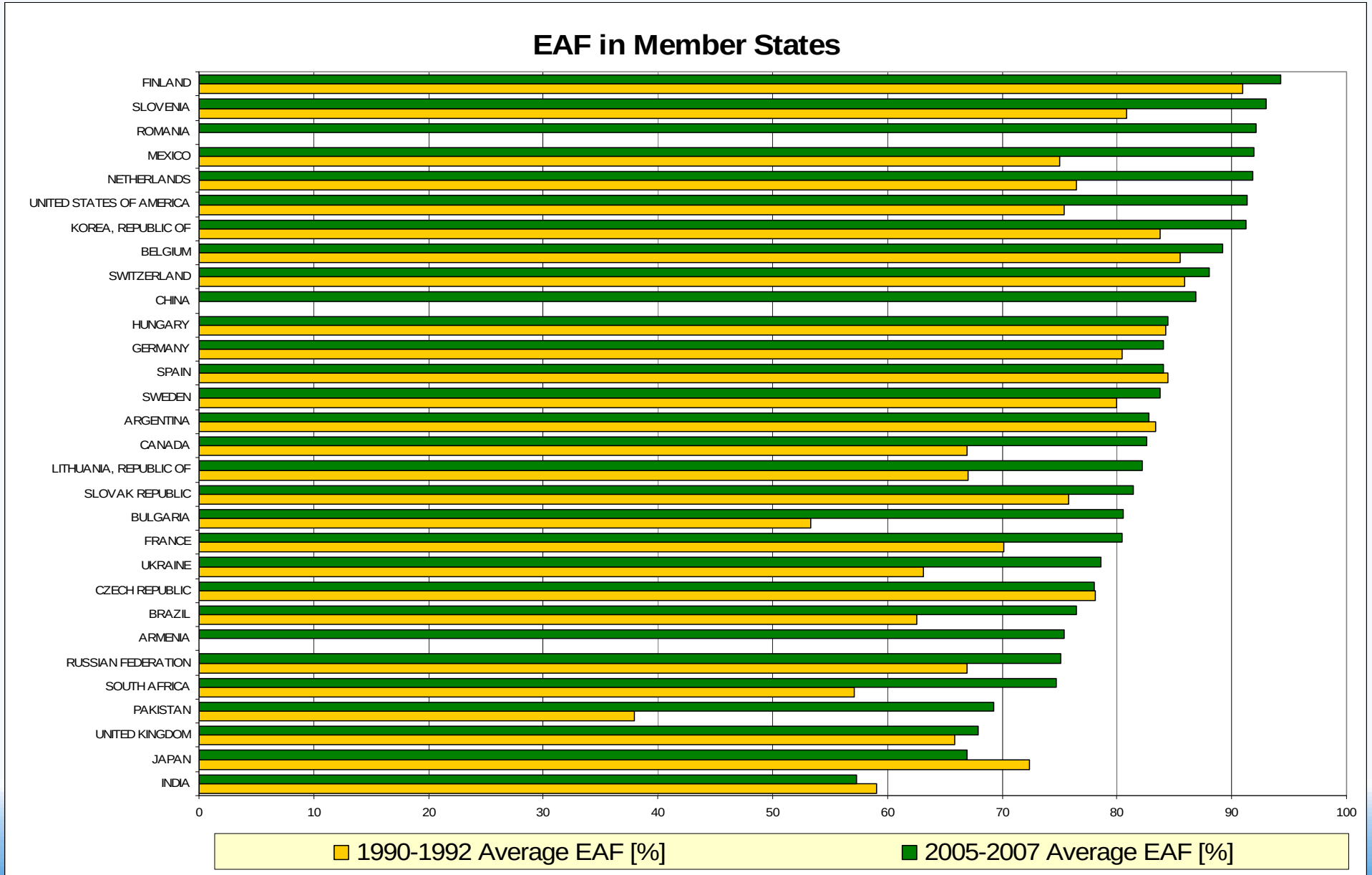
# Availability improvement

- The elimination of unplanned energy losses through effective failure prevention
- Optimisation of planned outages
- Exchange and dissemination of operating experiences end emulation of best practices
- Consolidation in the nuclear industry such that more plants are operated by those who do it best

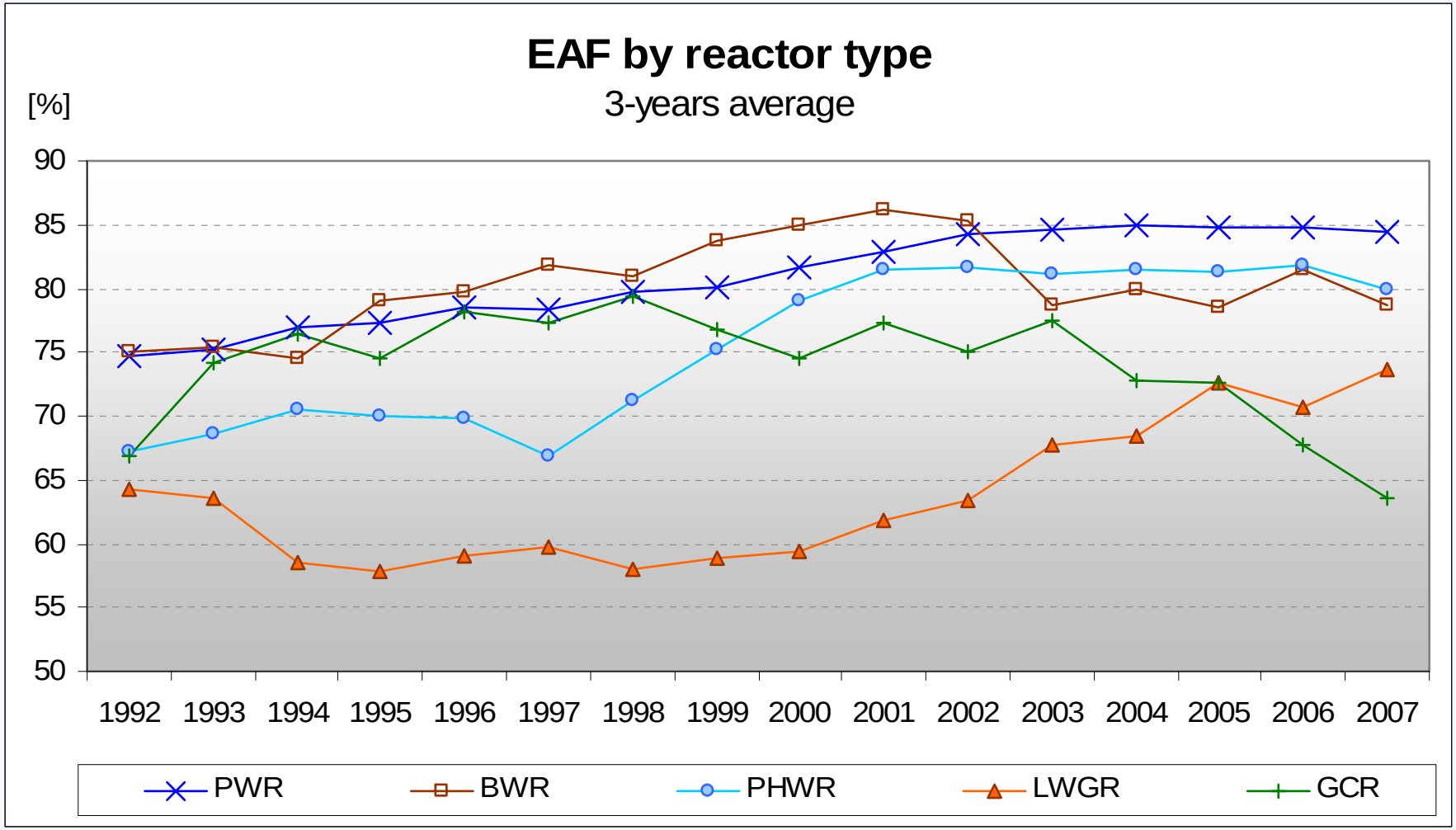
# Regional trends



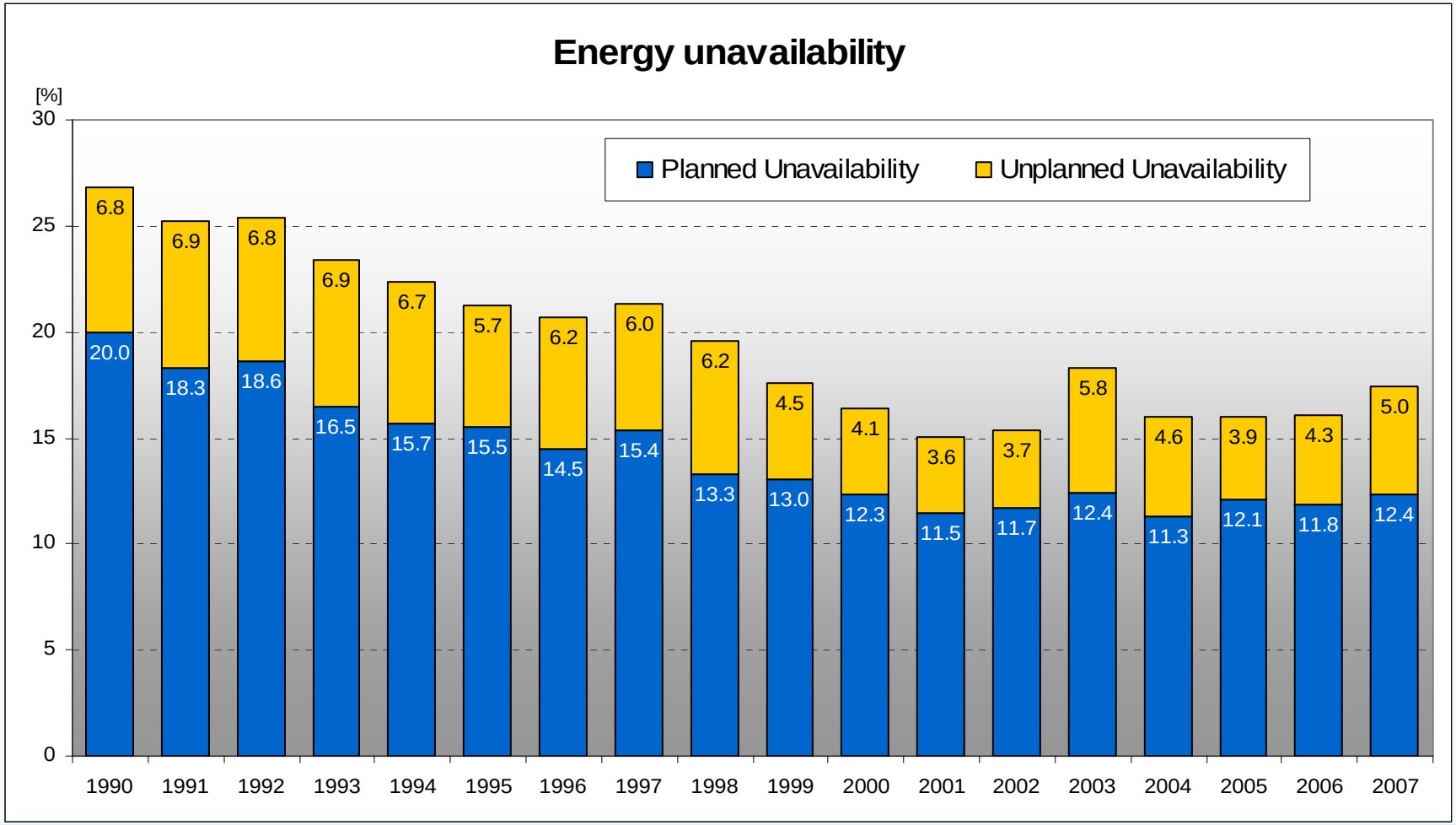
# Availability by country



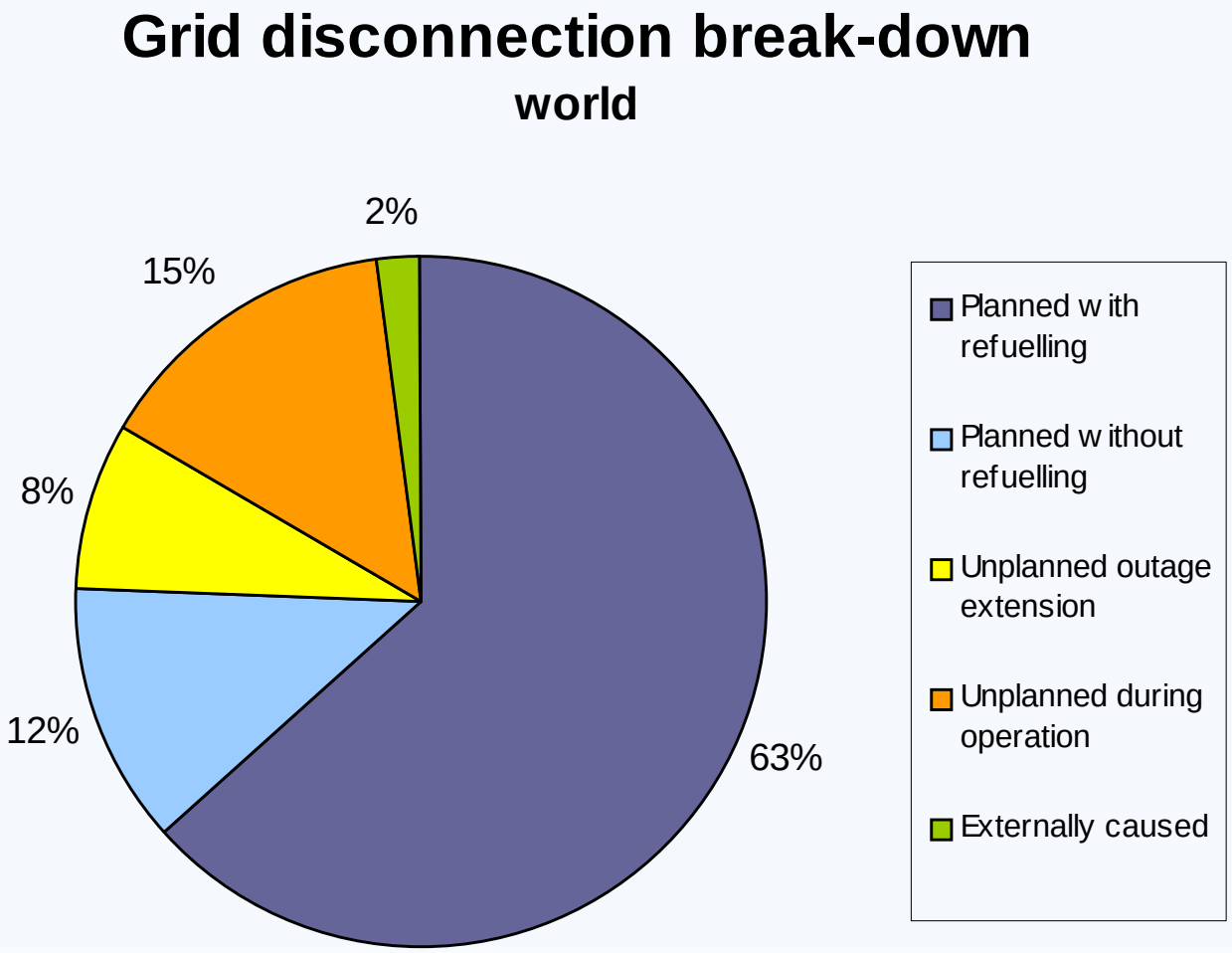
# Technology


EAF by reactor type
3-years average
[%]
90
85
80
75
70
65
60
55
50
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
PWR
BWR
PHWR
LWGR
GCR

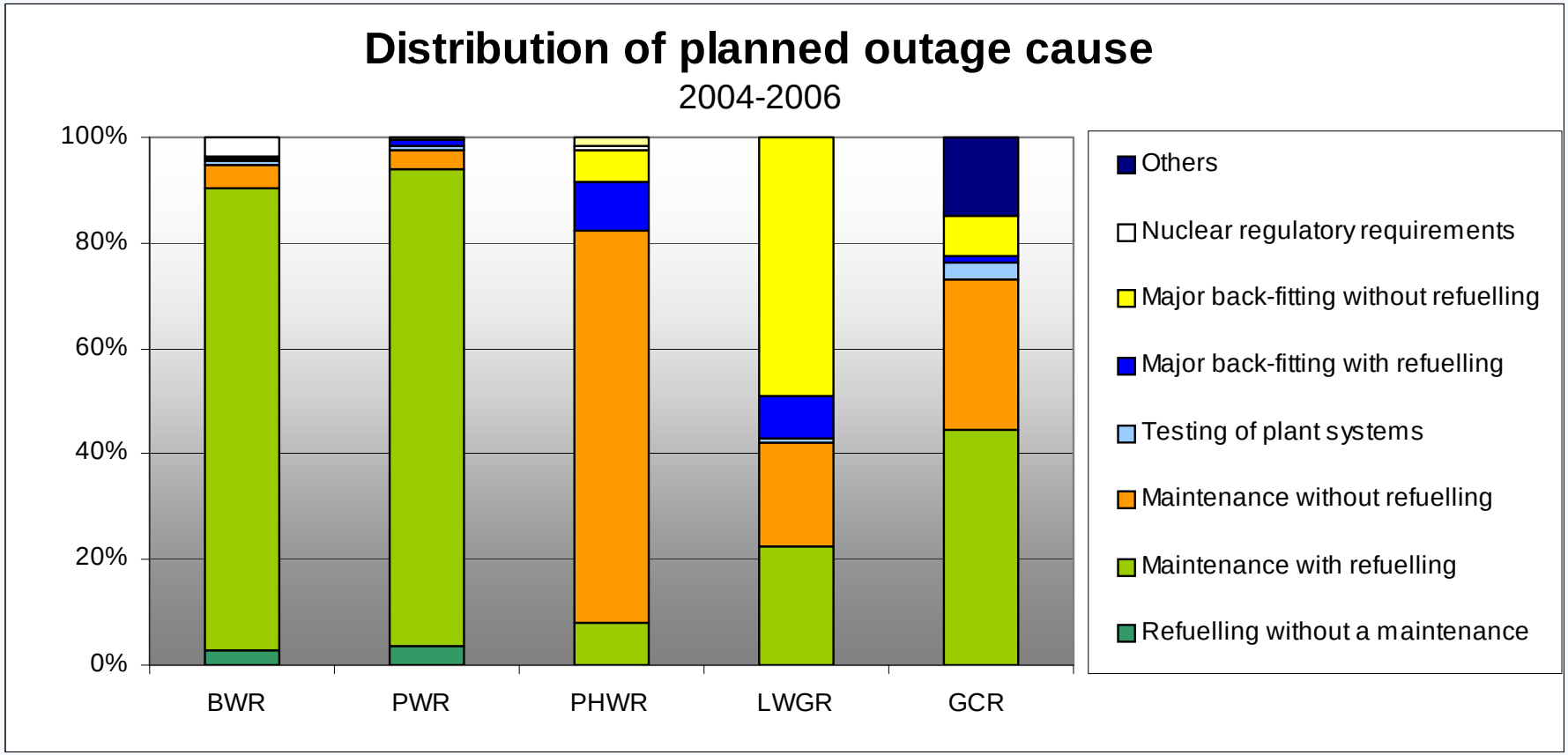
# Unavailability trends



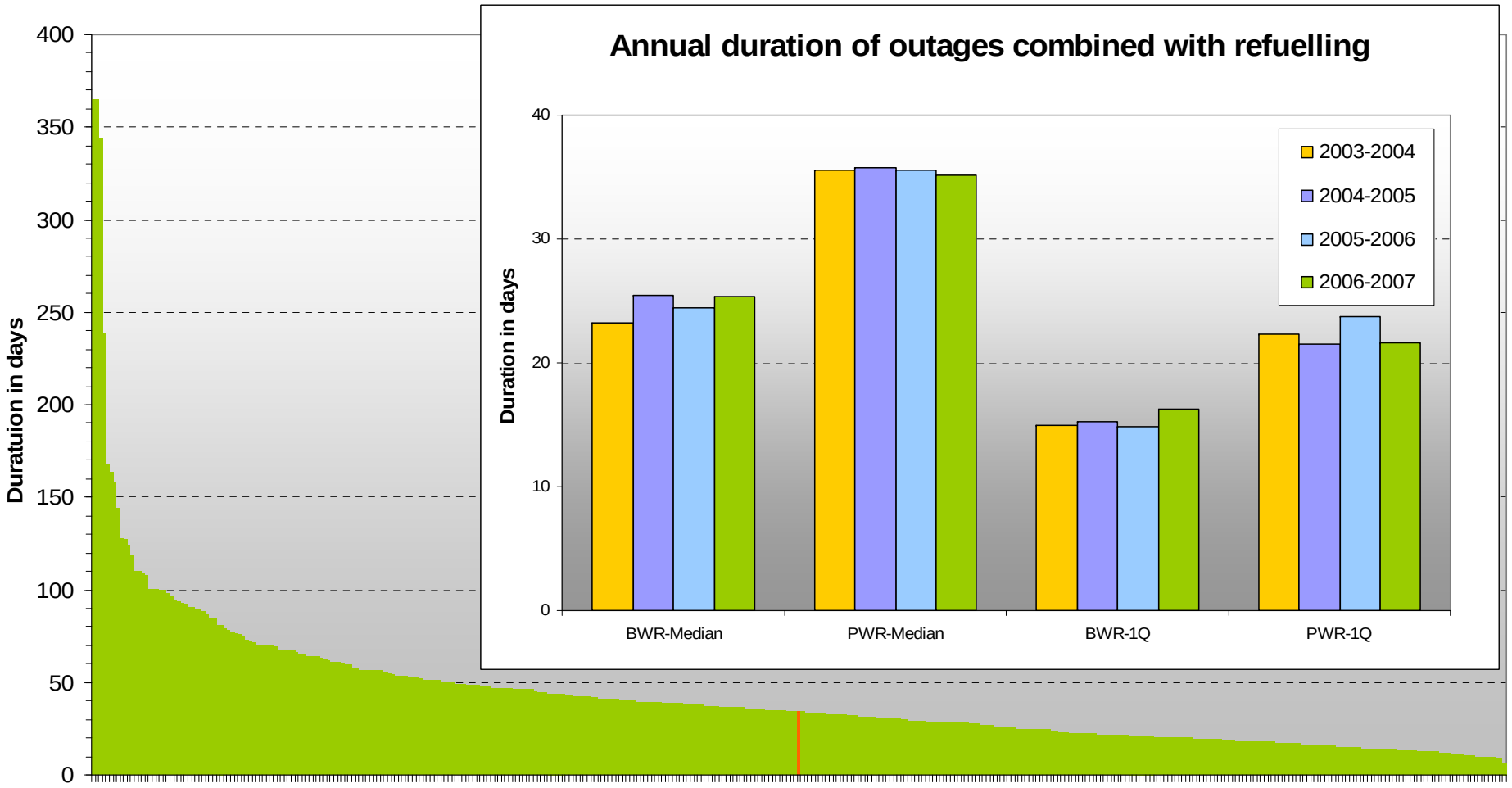
# Full energy loss by type



# Causes of planned outages



# Refuelling outages



# Nuclear Energy Trend

- Extensive development in 1870s and 1980s was changed to intensive development in 1990s
- Rising expectations
- Regional factors
- Lifetime management and license renewal
- Nuclear energy production growth:
  - Capacity increase
    - New units – large capacity, shutdown units – small capacity
    - Existing capacity modification (uprating, derating)
  - Availability increase
    - Planned outage optimization
    - Minimization of forced energy losses
- Maintenance optimization is a key for improvement