# THE ECONOMICS OF NUCLEAR POWER

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1. Introduction
2. History: Technological learning?
3. Recent developments of costs and construction times
4. Nuclear costs vs market prices
5. Nuclear vs PV
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# 1. INTRODUCTION

- **In the past: Nuclear is VERY cheap!**

- **Today: Nuclear is cheaper than the alternatives**

**→ Objective of this presentation: show practical developments of (monetary) costs and construction times**

# A history of mistaken forecasts

"It is not too much to expect that our children will enjoy in their homes [nuclear generated] electrical energy ***too cheap to meter***."

*Lewis Strauss*
*Chairman*
*US Atomic Energy Commission*
*1954*

Source: Rogner IAEA (2006)

Energy Economics Group

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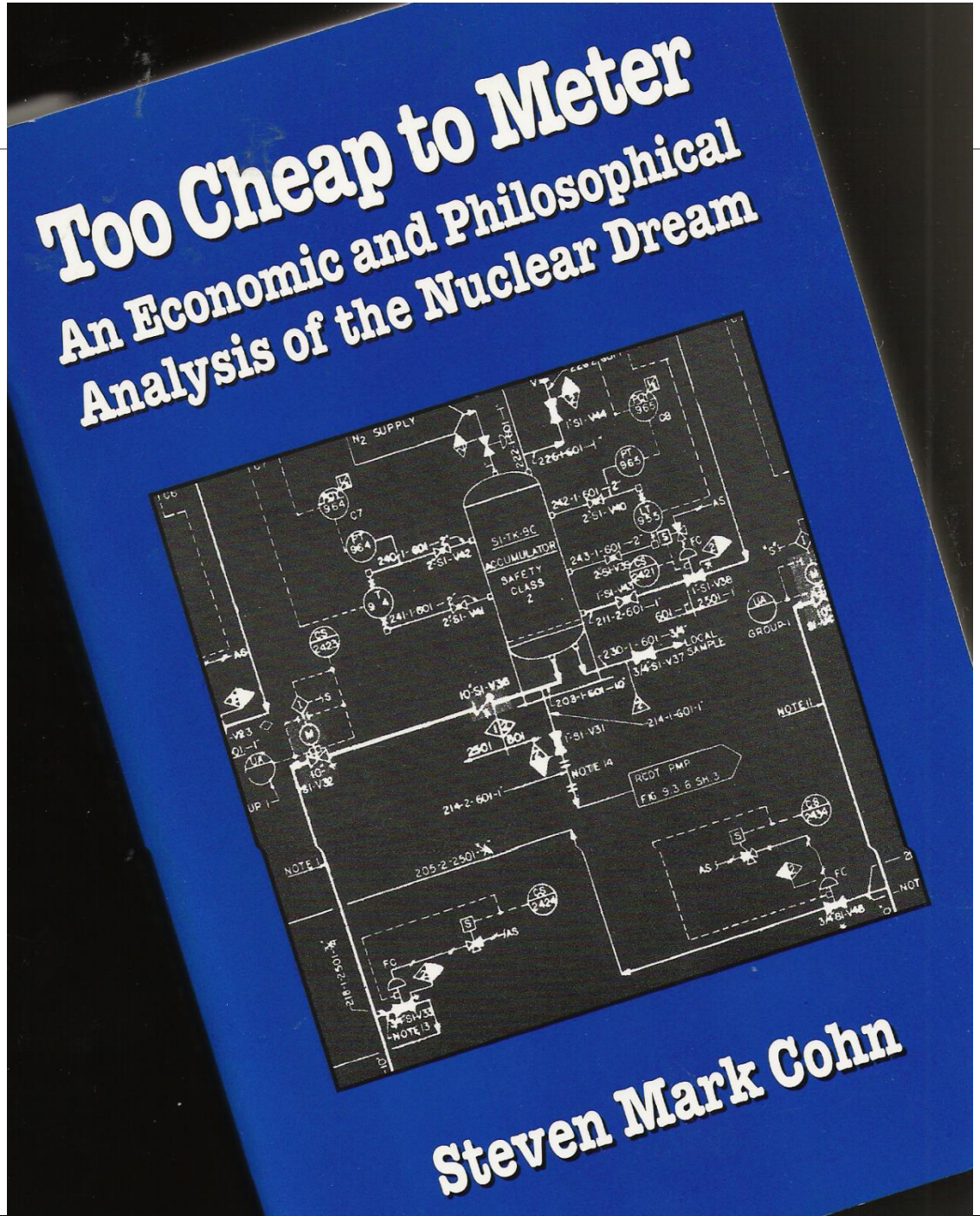
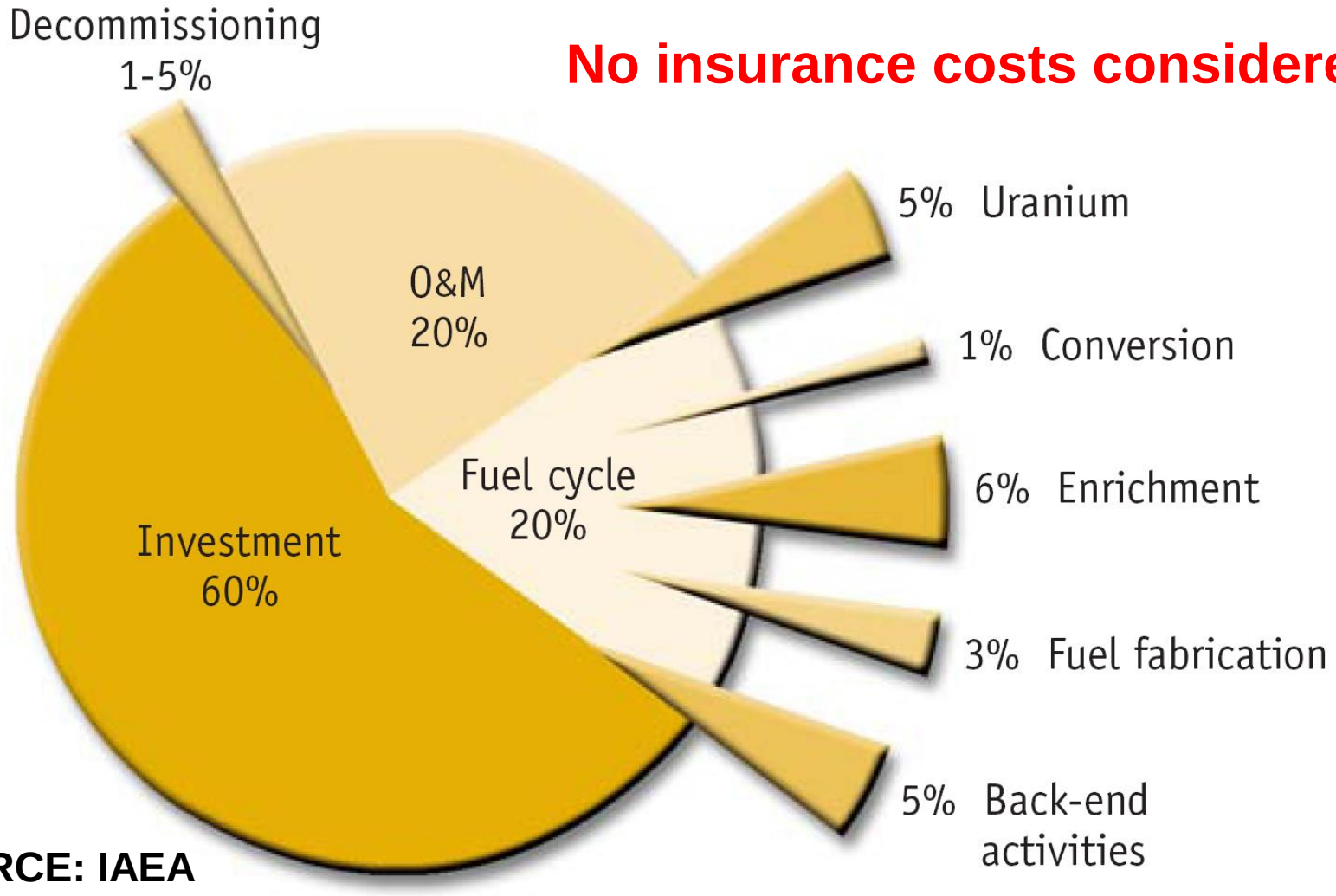


# Typical nuclear electricity generation cost breakdown

**No insurance costs considered!**




**SOURCE: IAEA**

# With respect to external/ social costs:

## Benefits Privatized, Costs Mutualized

The total cost of a nuclear kWh most likely will never be known. Costs for waste management, decommissioning and clean-up are constantly on the rise and are generally expected to be paid for by the taxpayer, while in many countries beneficial power generation has been privatized. However, according to most international cost assessments, nuclear power generates by far the most expensive delivered energy. For new nuclear power to become competitive it would need substantial State subsidies in particular to provide guarantees against substantial financial and economic risks. [4]

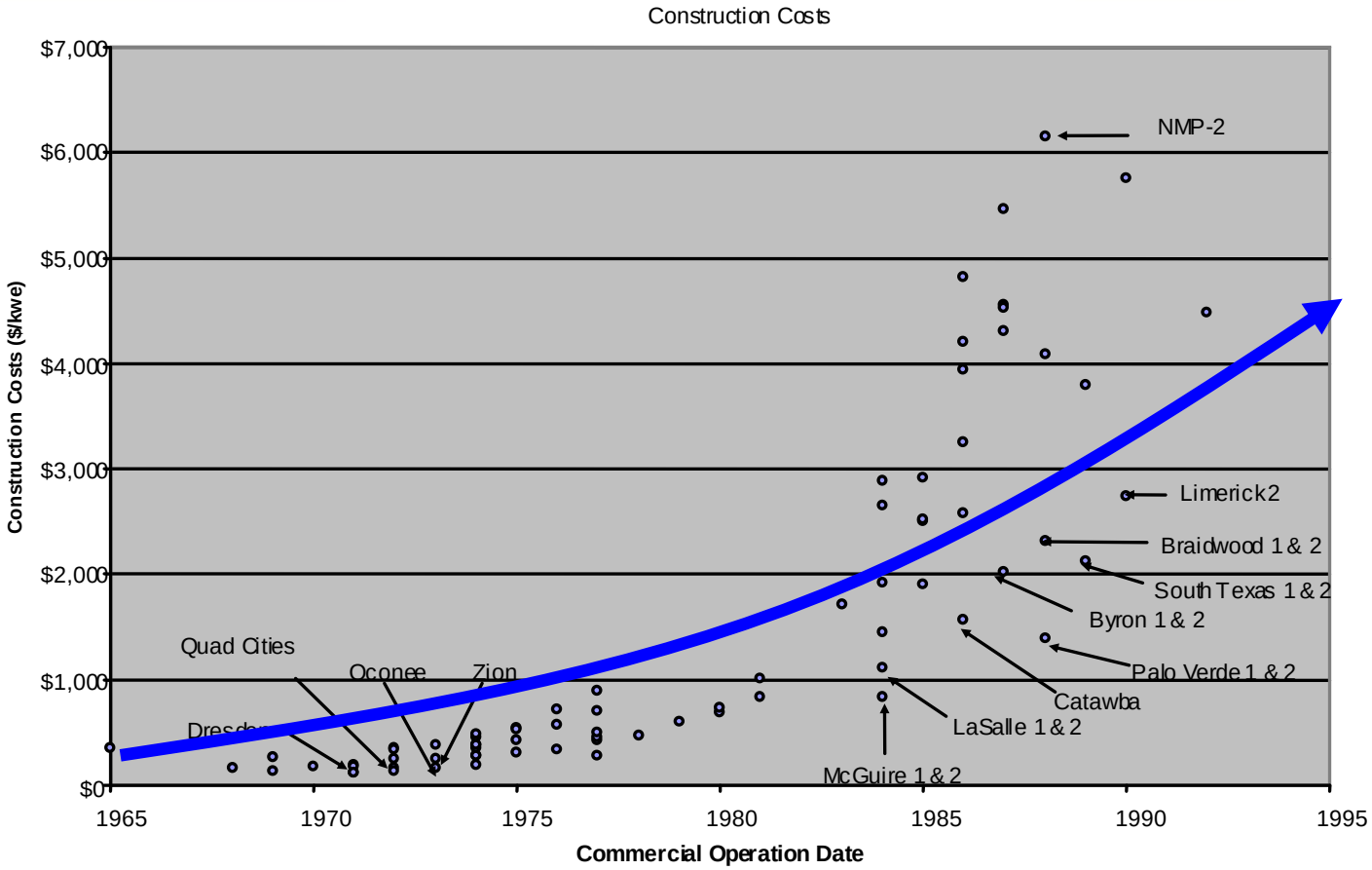
**Source: Mycle Schneider: The nuclear end game (2006)**

# 3. TECHNOLOGICAL LEARNING (OR NOT)

# HOW DID INVESTMENT COST DEVELOP OVER TIME?

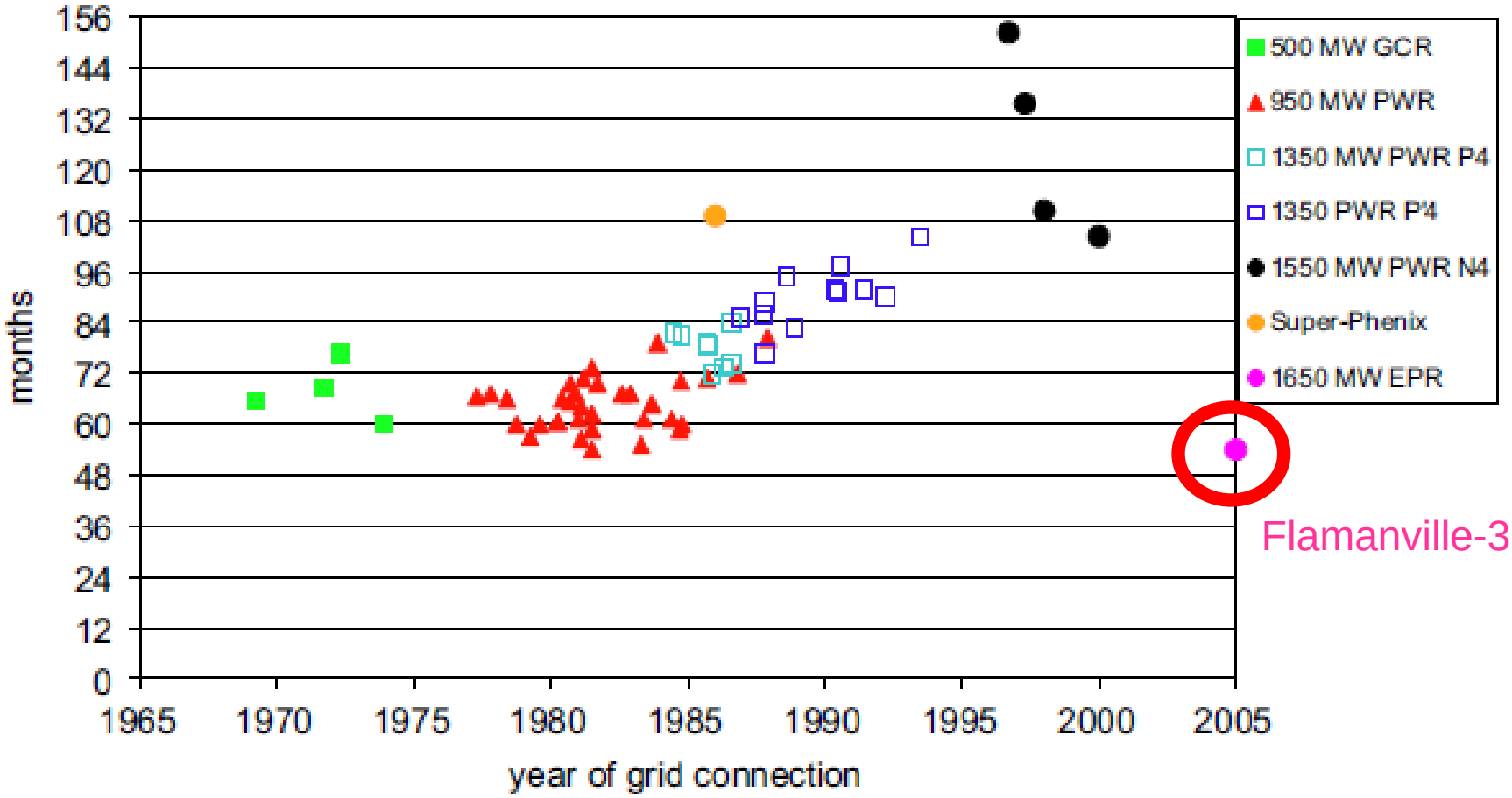
Constellation Energy — The way energy works.™

## Background – Industry Experience "Last Time"



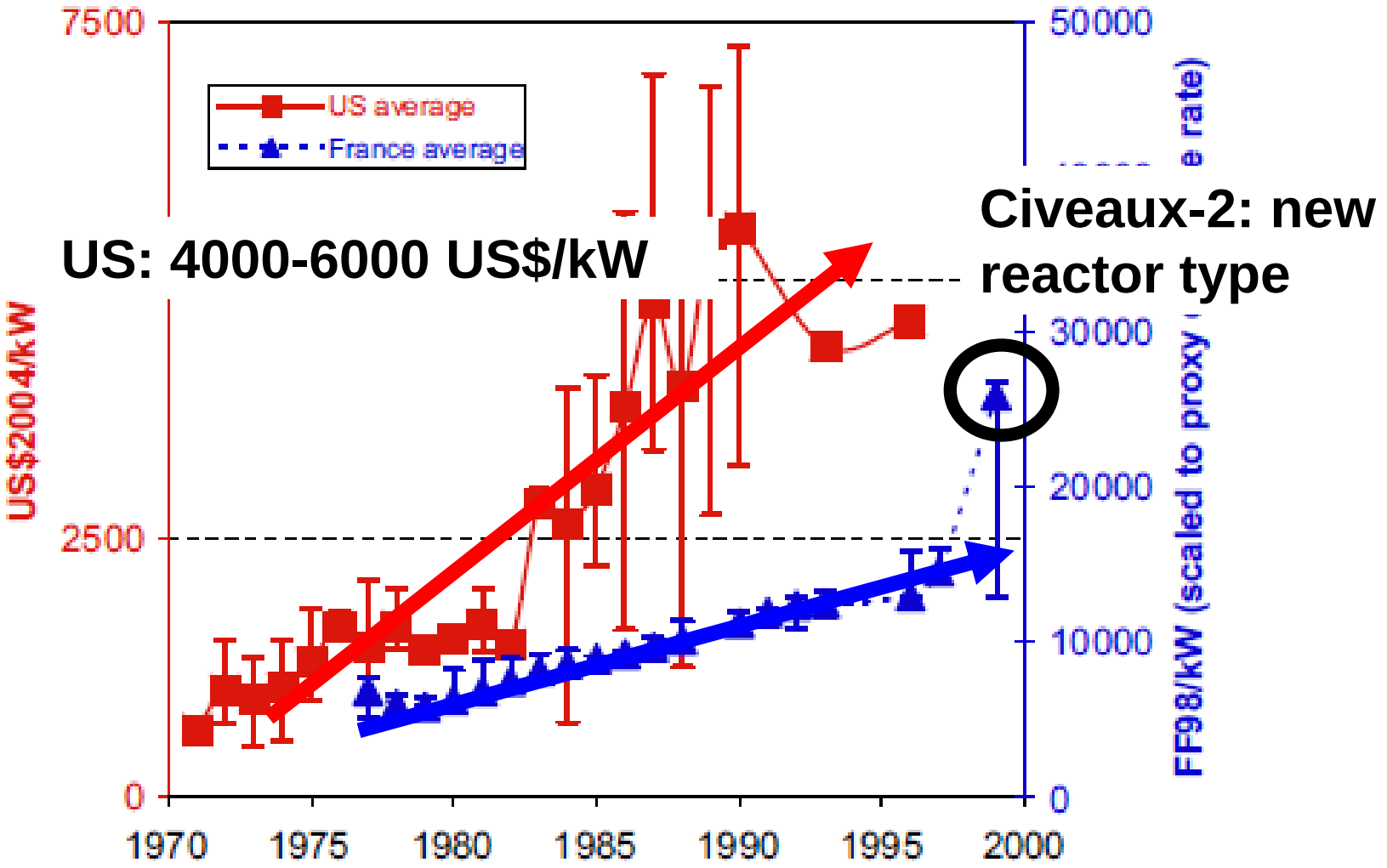

**Source: Jim Harding: Seven Myths of the Nuclear Renaissance (2007)**

# CONSTRUCTION TIMES OF PLANTS IN FRANCE BEFORE 2000



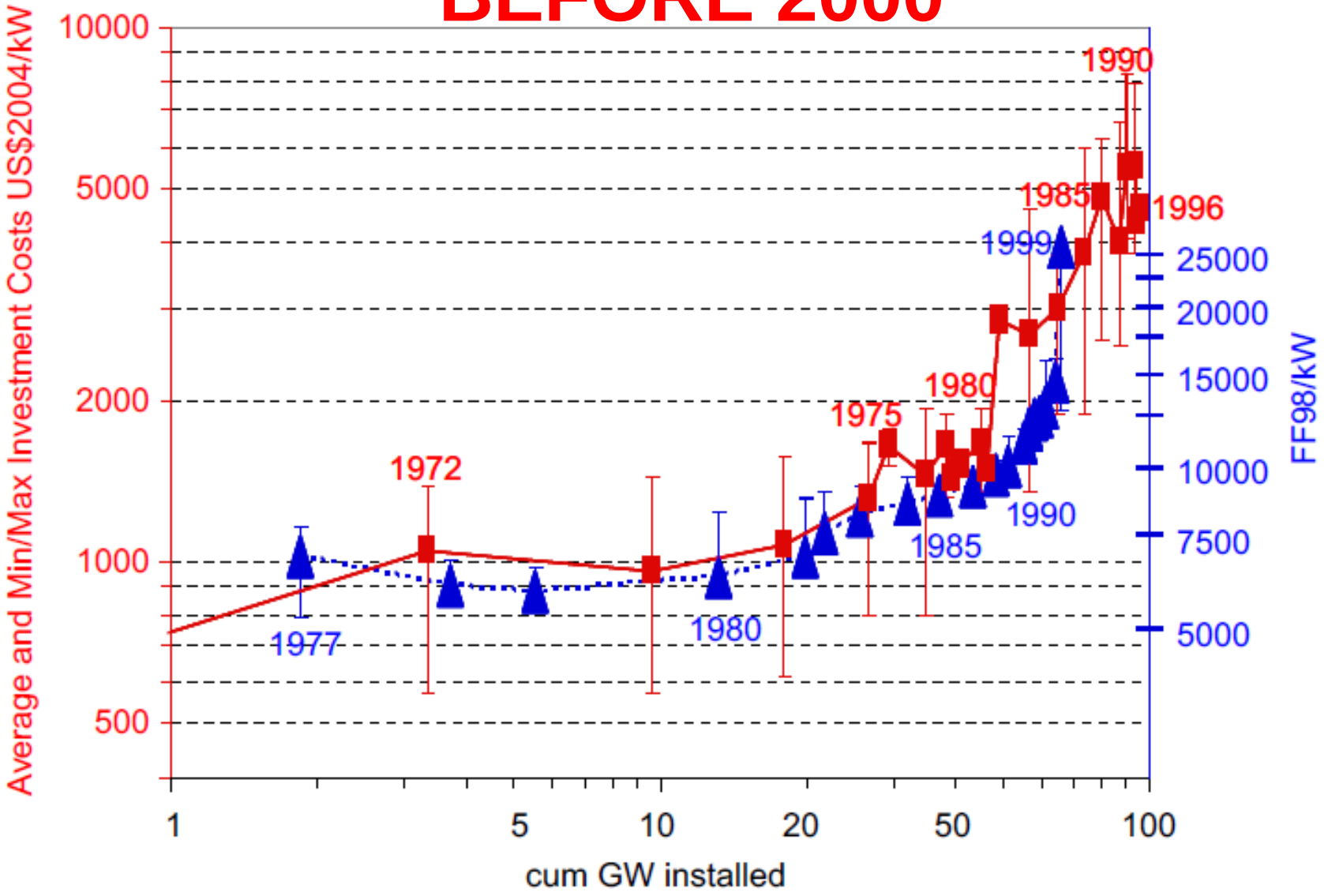

Source: Grübler 2010

# COST DEVELOPMENTS BEFORE 2000

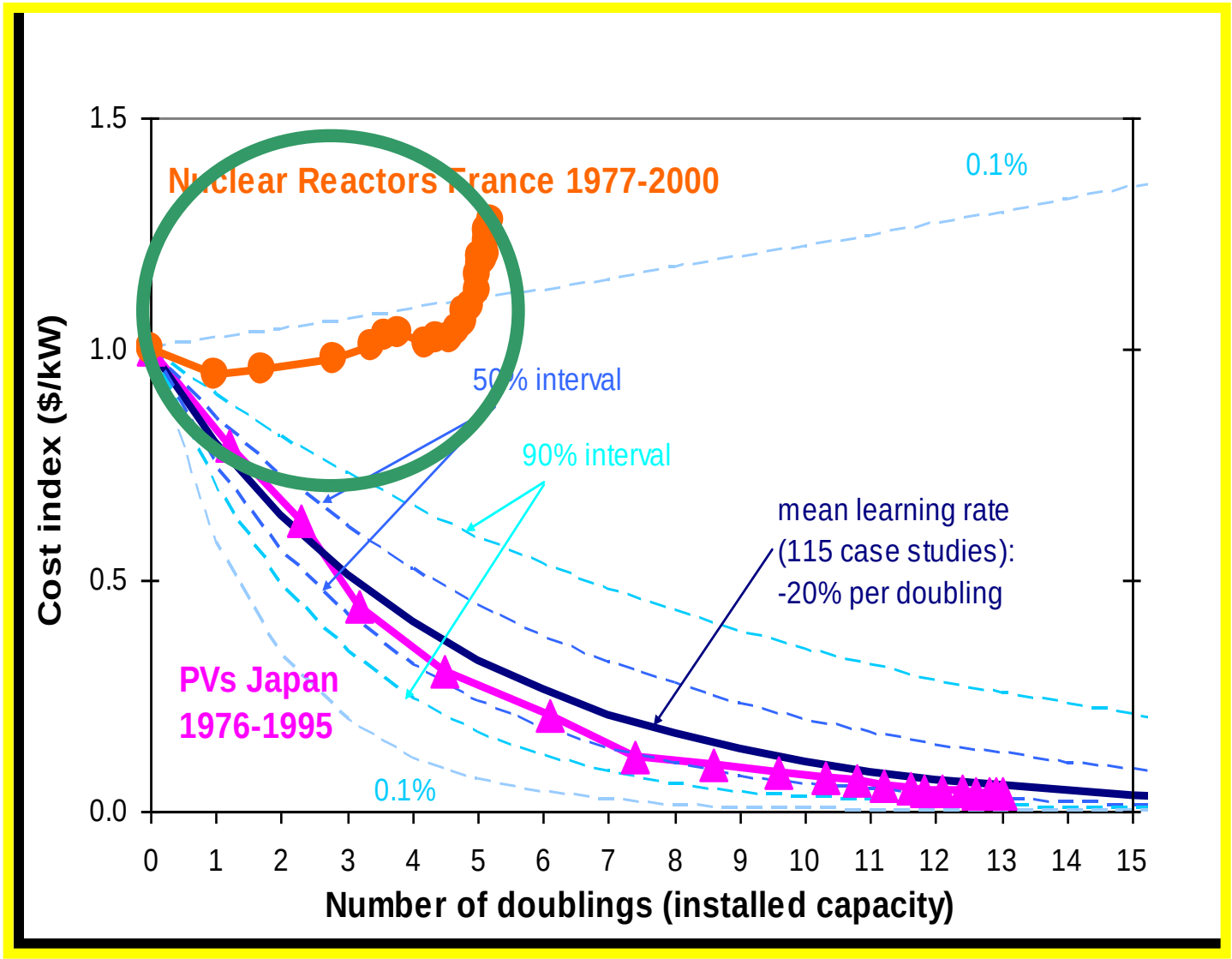



Source: Grübler 2010

# A CURVE OF FORGETTINGS BEFORE 2000

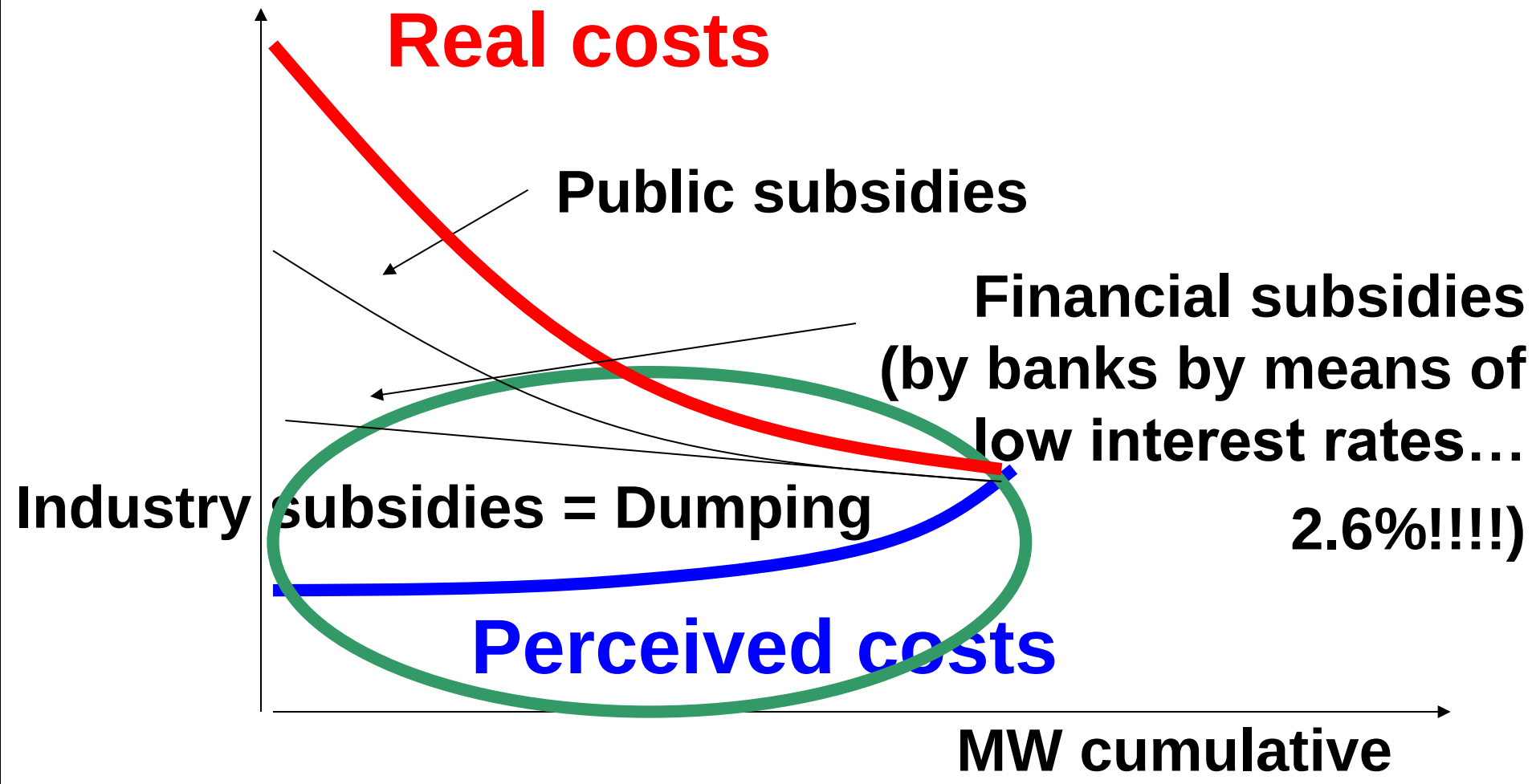


# Technological Uncertainties: Learning rates (push) and market growth (pull)




**Source: Nakicenovic, Schrattenholzer, Grübler various papers**

# Technological learning: why not for nuclear?




For further discussion of industry subsidies:
Steve Thomas: The economics of nuclear power (2005)

# COUR DE COMPTES CORRECTIONS

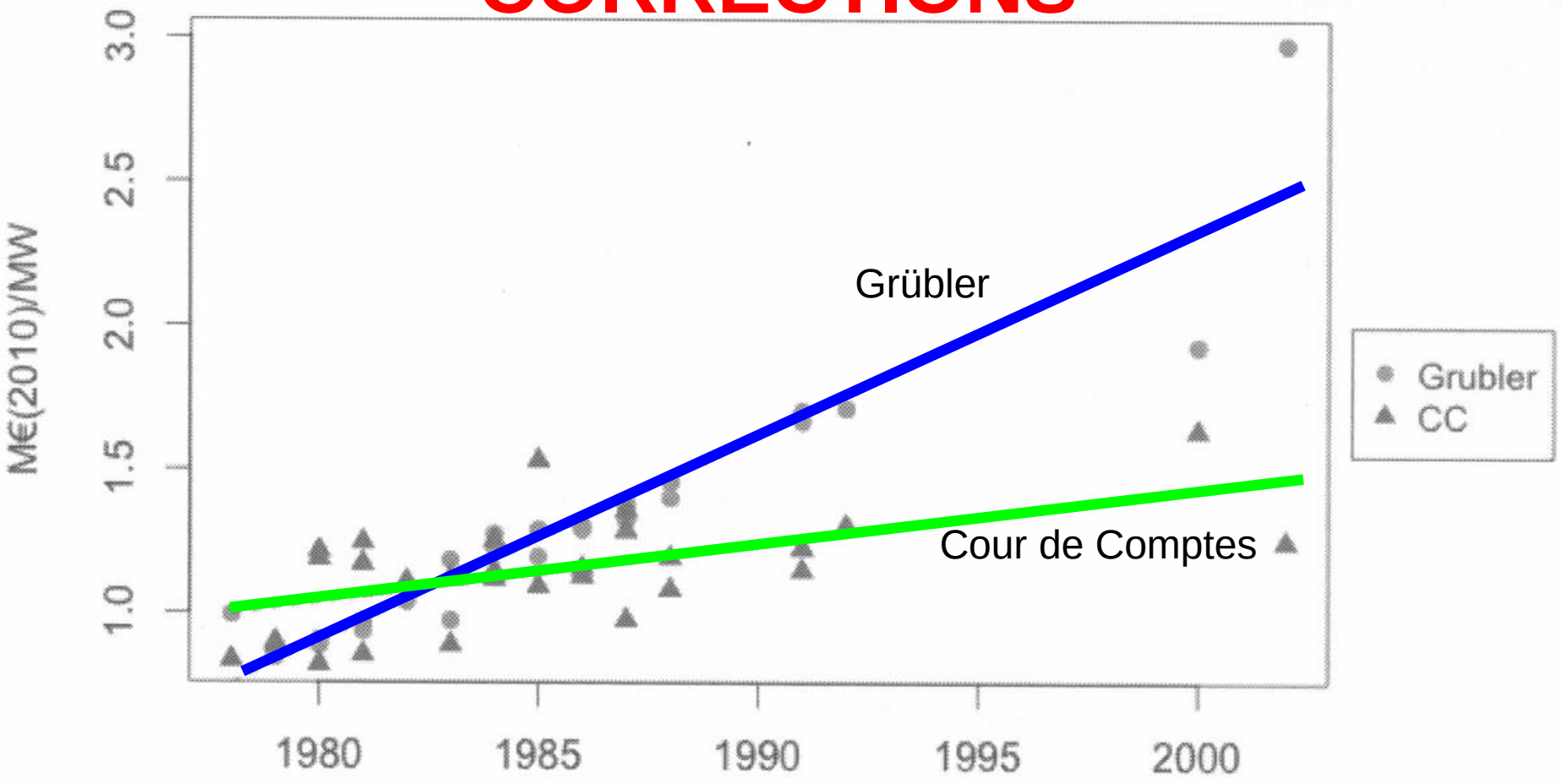



*Figure 1: Grubler's and Cour de Comptes Costs for the French Nuclear Fleet by Pair of Reactors*

# A comparison of costs (estimates) for (new) nukes in the USA

| | | |
|---|---|---|
| 1987-1997 | Grübler | $4000/kW-$6000/kW |
| 2003 | MIT study | $2000/kW (base case)<br>$1500/kW (optimistic) |
| Before 2007 | common | $4000/kW |
| 2007 | Moody's | $5000-$6000/kW |
| 2008 | Progress Energy | $6400/kW |

http://thinkprogress.org/climate/2011/04/06/207833/does-nuclear-power-have-a-negative-learning-curve/

| | | |
|---|---|---|
| 2009 | MIT study | $4000/kW (base case) |

http://web.mit.edu/nuclearpower/

# A conclusion:

**At any point-of-time the future costs of nuclear has been underestimated, at least in the Western countries**

# 3. RECENT DEVELOPMENT OF NUCLEAR COSTS AND CONSTRUCTION TIMES

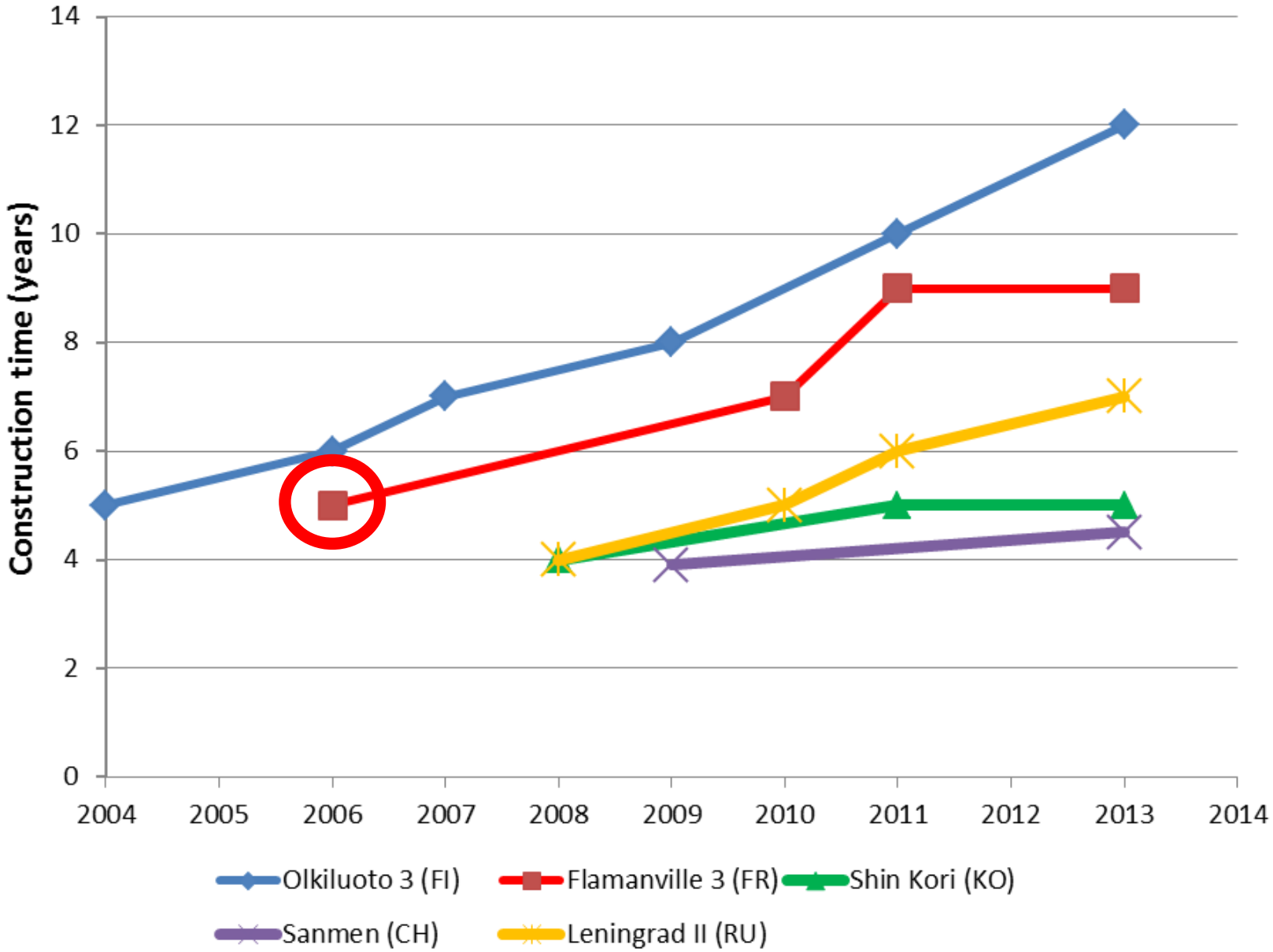
# SOME RECENT EXAMPLES

- Olkiluoto-3 (Finland): Construction started in 2004, now expected to be completed 2016 (originally: 2009); 1600 MW
- Flamanville-3 (France): Construction started in 2006, now expected to be completed 2016 (originally: 2011); 1600 MW
- Leningrad II-1(Russia): Construction started in 2008, now expected to be completed 2015 (originally: 2013); 1160 MW Russian-designed AES-2006 PWR
- Shin Kori (Corea): Construction started in 2008, now expected to be completed 2013 (originally: 2012); 1343 MW
- Sanmen (China): Construction started in 2009, now expected to be completed 2013 (half a year late); 1250 MW

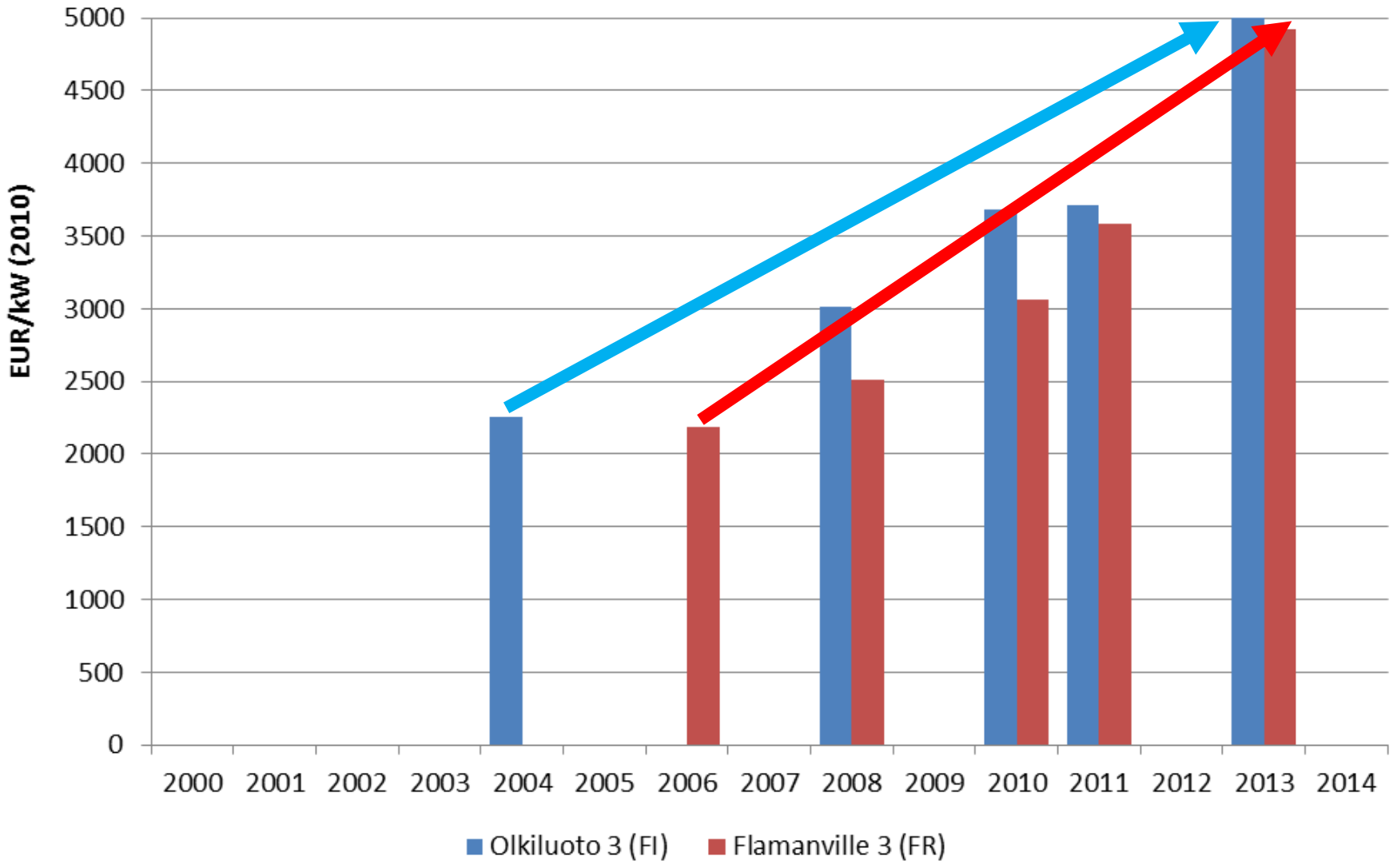
# SOURCES

- IEA/NEA: Projected costs of generating Electricity (2010)
- Platts: Power in Europe – power plant tracker (Last issue: April 2013)
- Platts: Energy in Eastern Europe – power plant tracker (Last issue: July 2013)
- World nuclear Association, World-nuclear.org

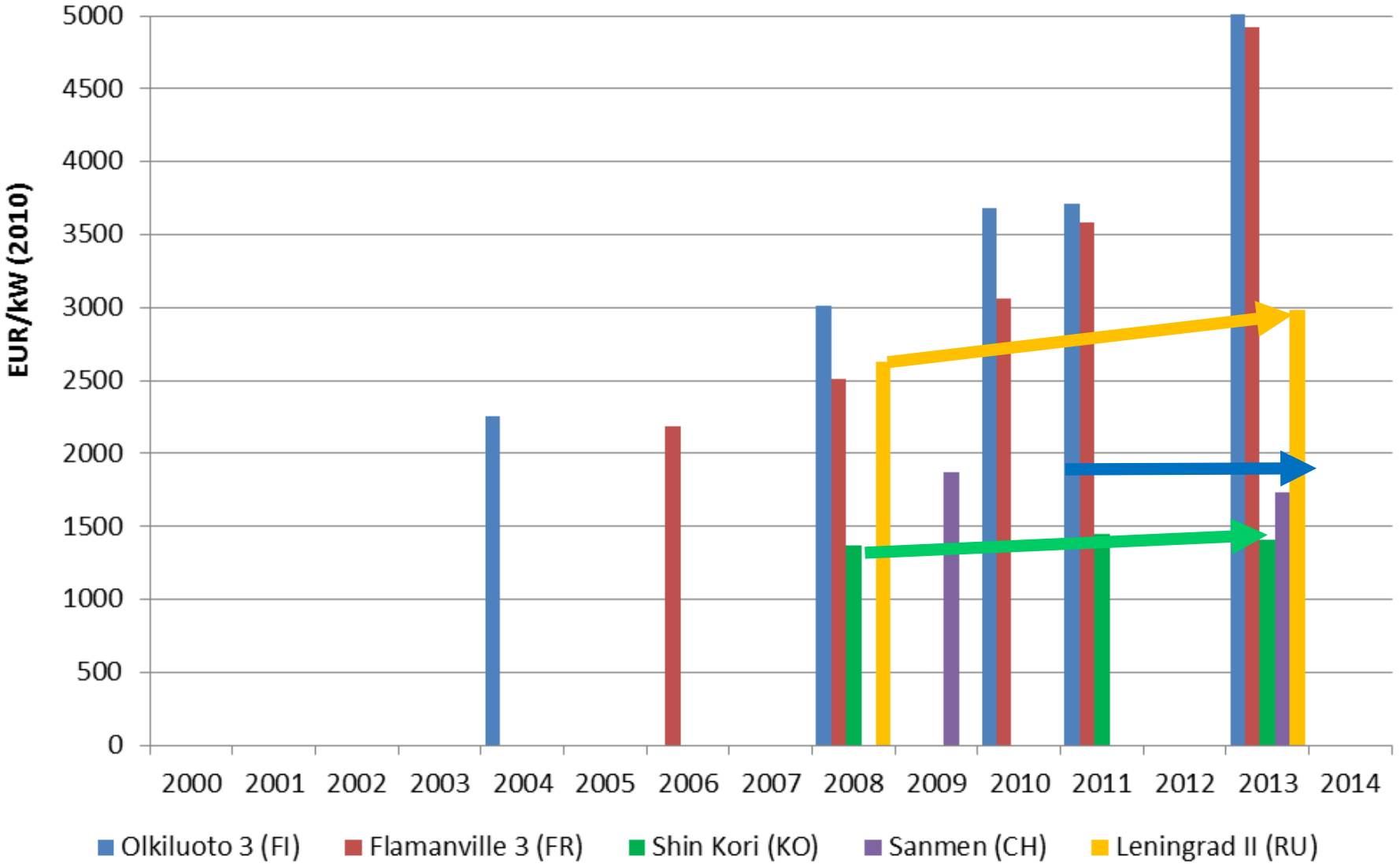
# Construction times



# Investment cost development Olkiluoto 3 vs Flamanville 3



# Investment cost development world-wide

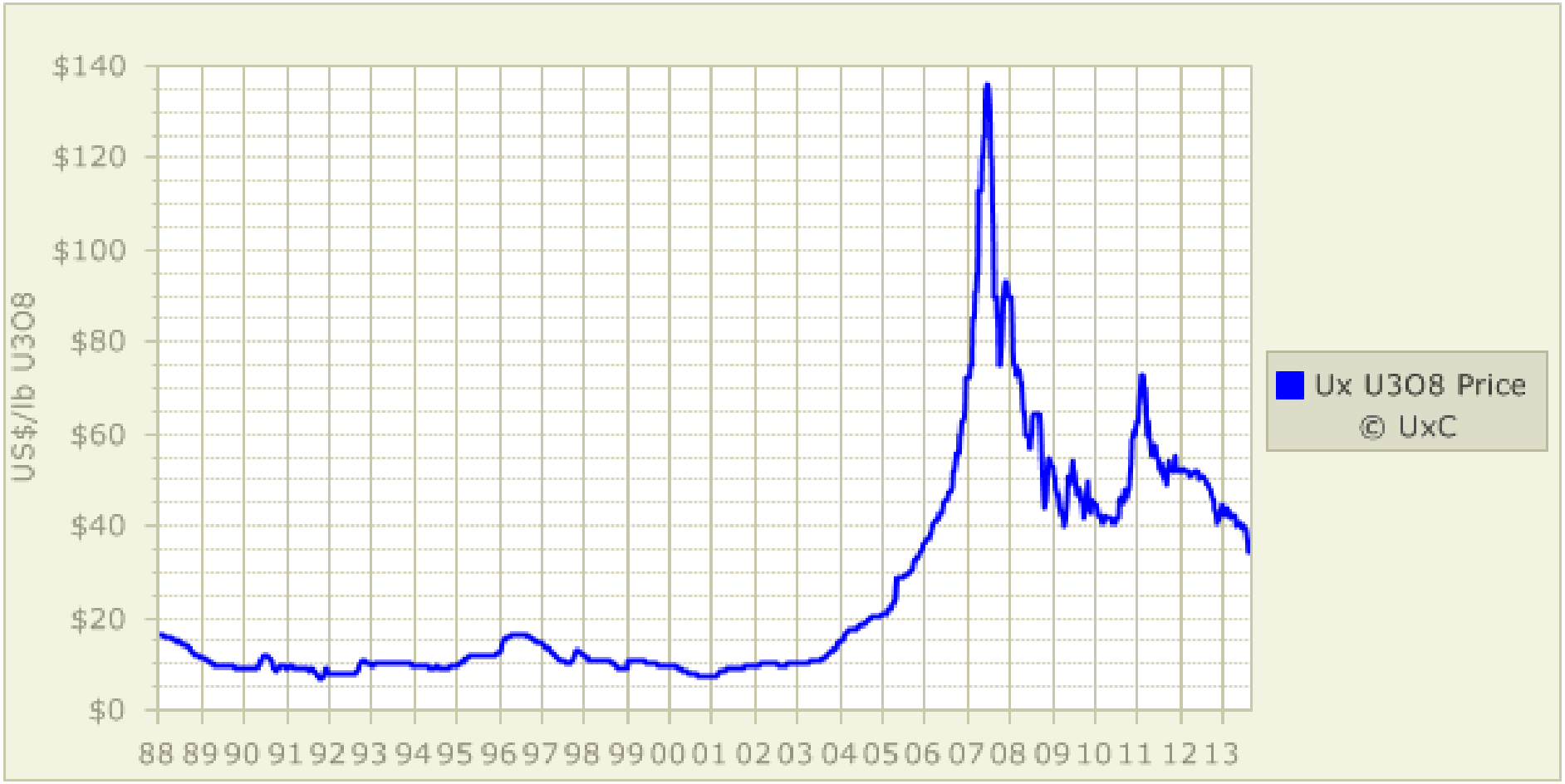


# SPECIFIC ASSUMPTIONS ON ECONOMIC ANALYSES

- **Interest rate: 8%, depreciation time 25 years;**
- **fuel costs: 12 EUR/MWh up to 2008, then following the price of uranium**
- **other O&M costs: 12 EUR/MWh**
- **decomissioning costs: 2 EUR/MWh**

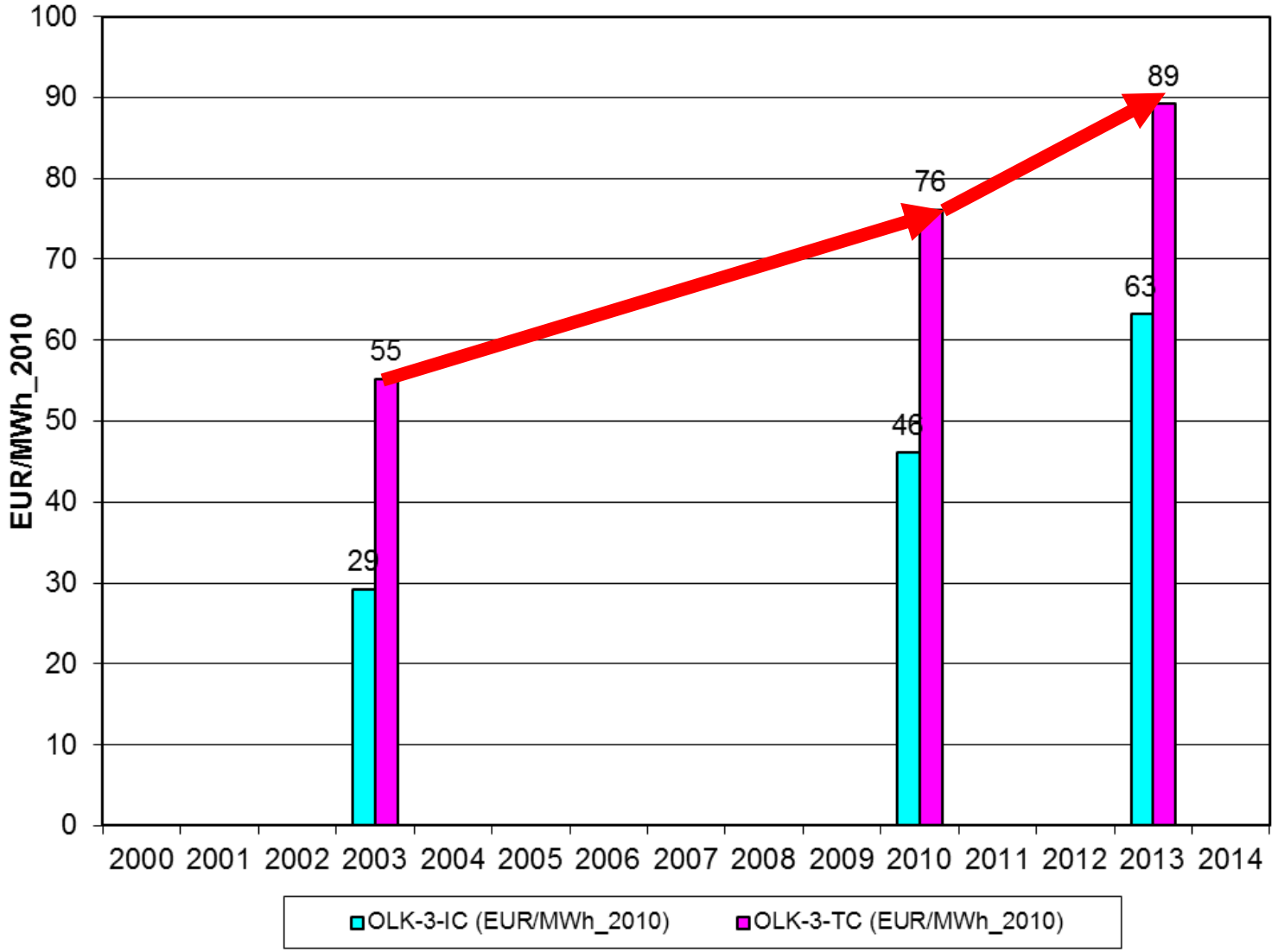
**all cost figures are of 2010!**

# The costs of uranium



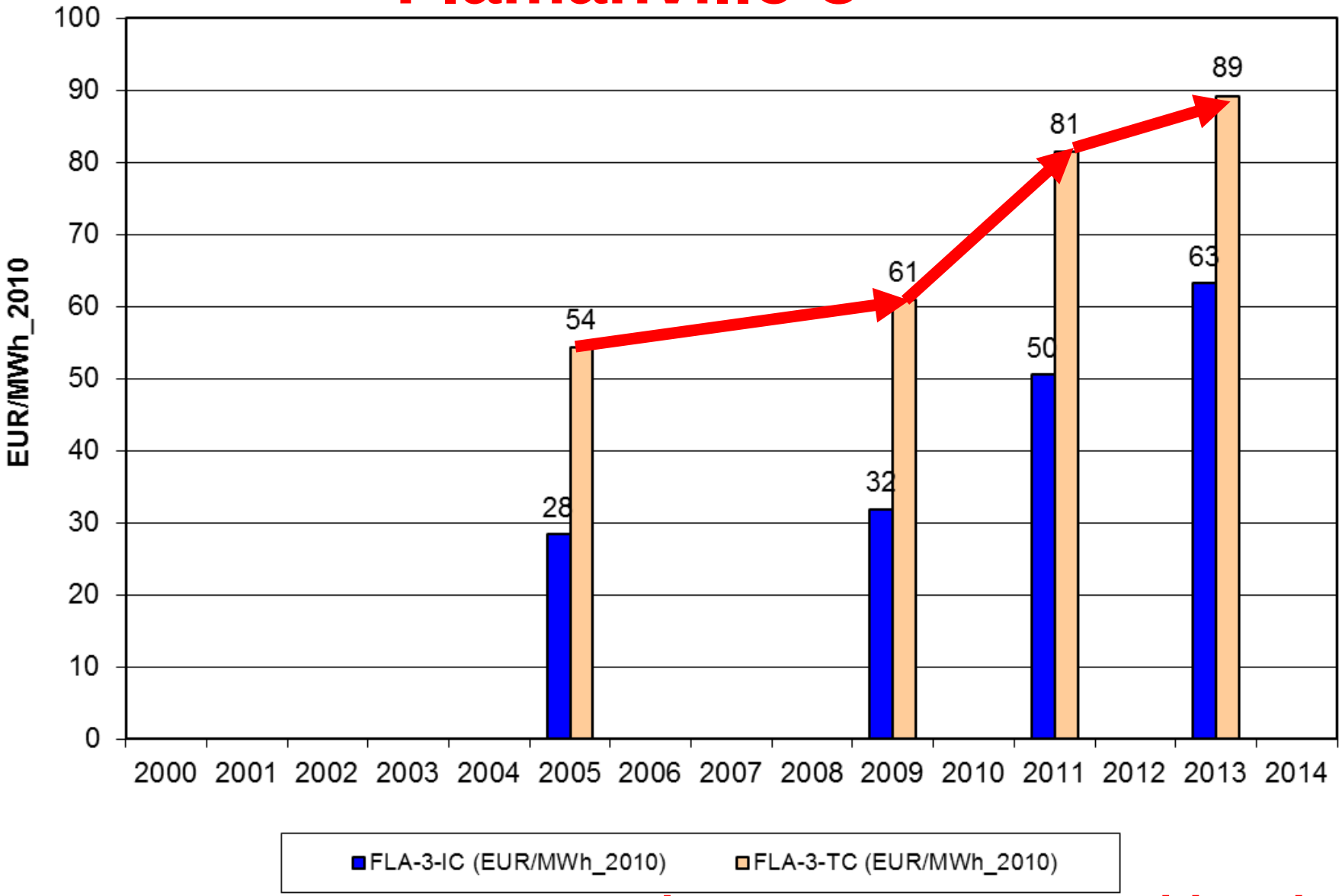

**Source: The Ux Consulting Company, LLC, http://www.uxc.com/**

# „Total“ Cost development Olkiluoto




**No insurance costs considered!**

# „Total“ Cost development Flamanville-3

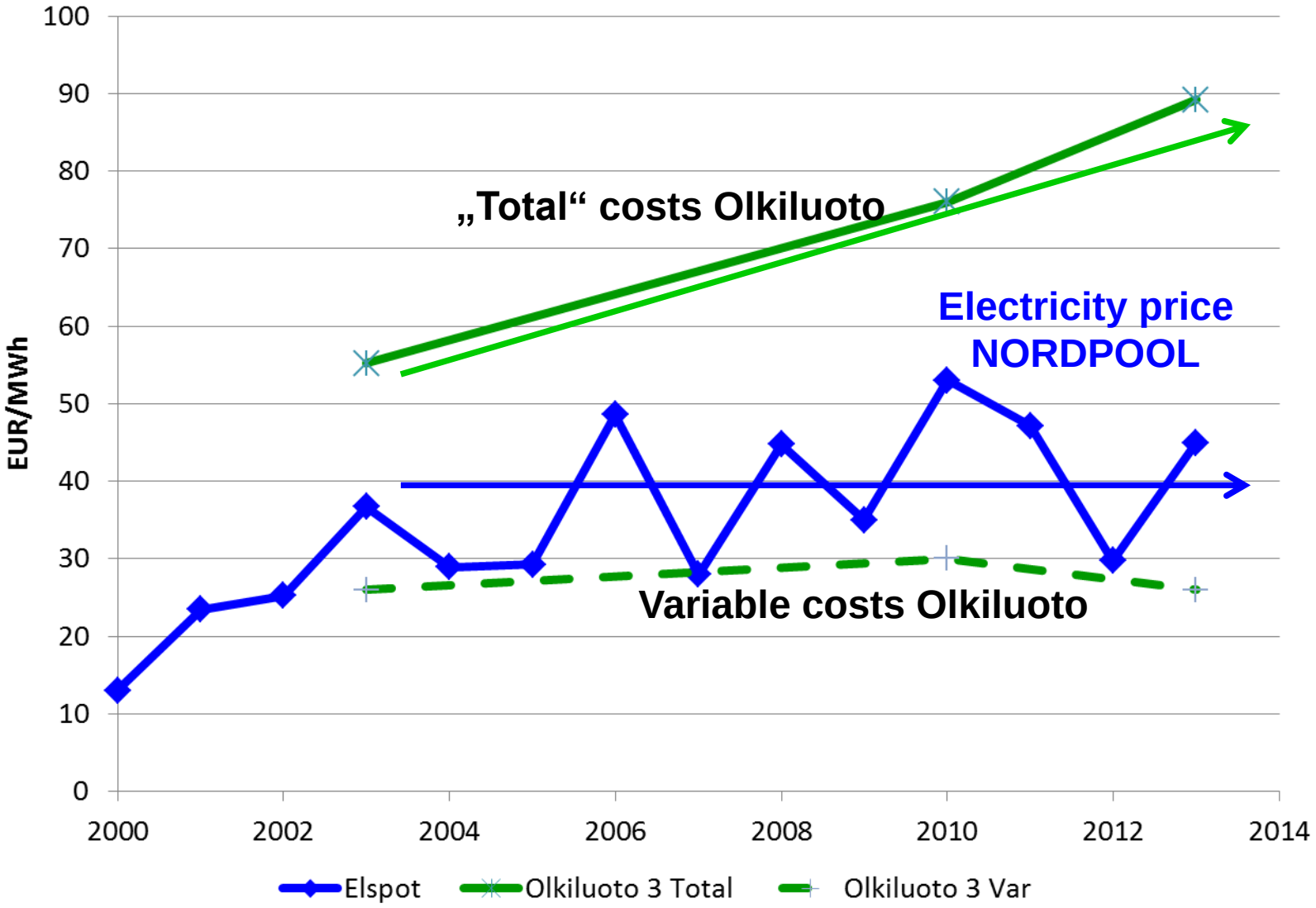



**No insurance costs considered!**

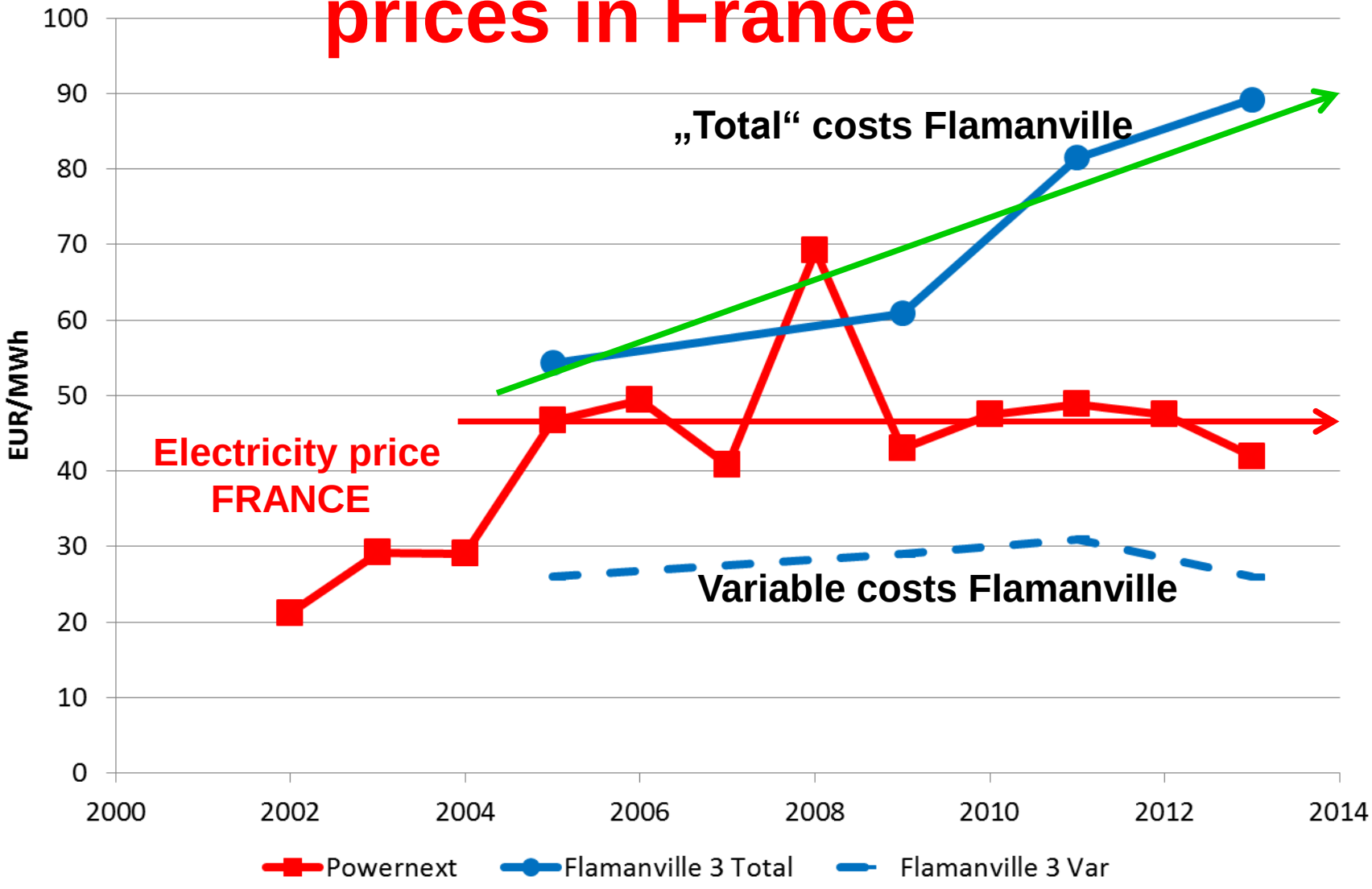
# 4. „Total“ nuclear costs vs market prices

## State aid, contracts for differences

# Costs vs market prices in Nordic countries



# Costs vs market prices in France



# 5. NUCLEAR VS RENEWABLES

# LEARNING: NUCLEAR VS PV

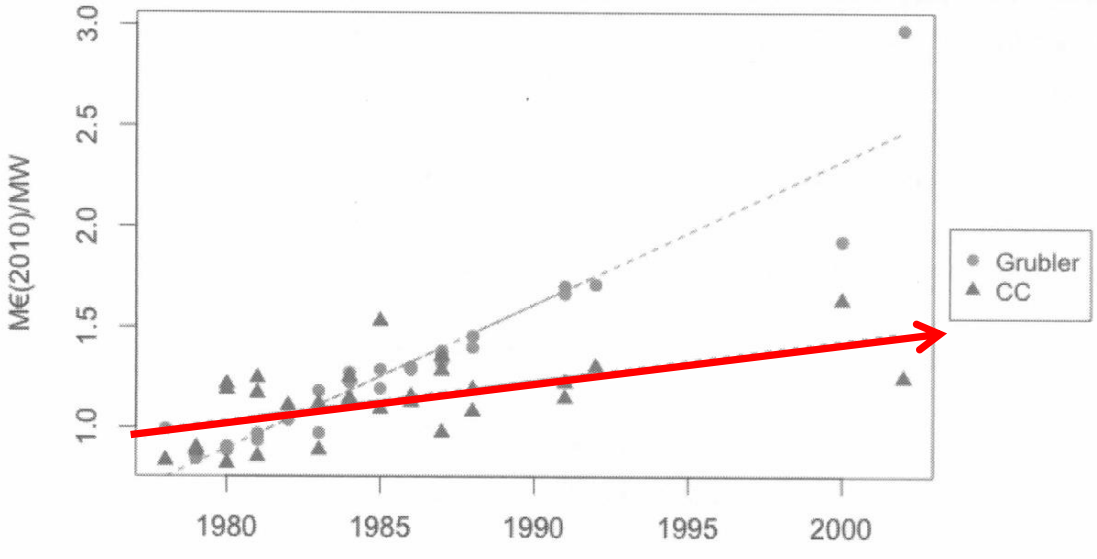
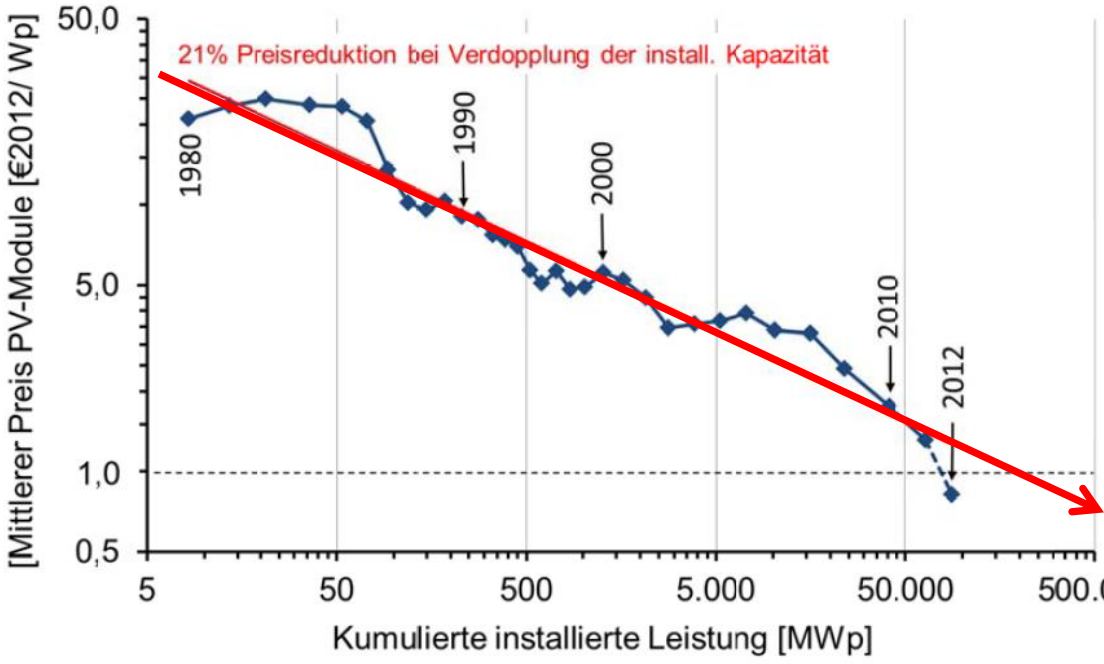



*Figure 1: Grubler's and Cour de Comptes Cost*
*Nuclear Fleet by Pair of Reactors*



# 6. CONCLUSIONS

## Europe:

- No reliabilty regarding construction times.

- With respect to economics nuclear has NEVER in history in Western countries fullfilled its promises

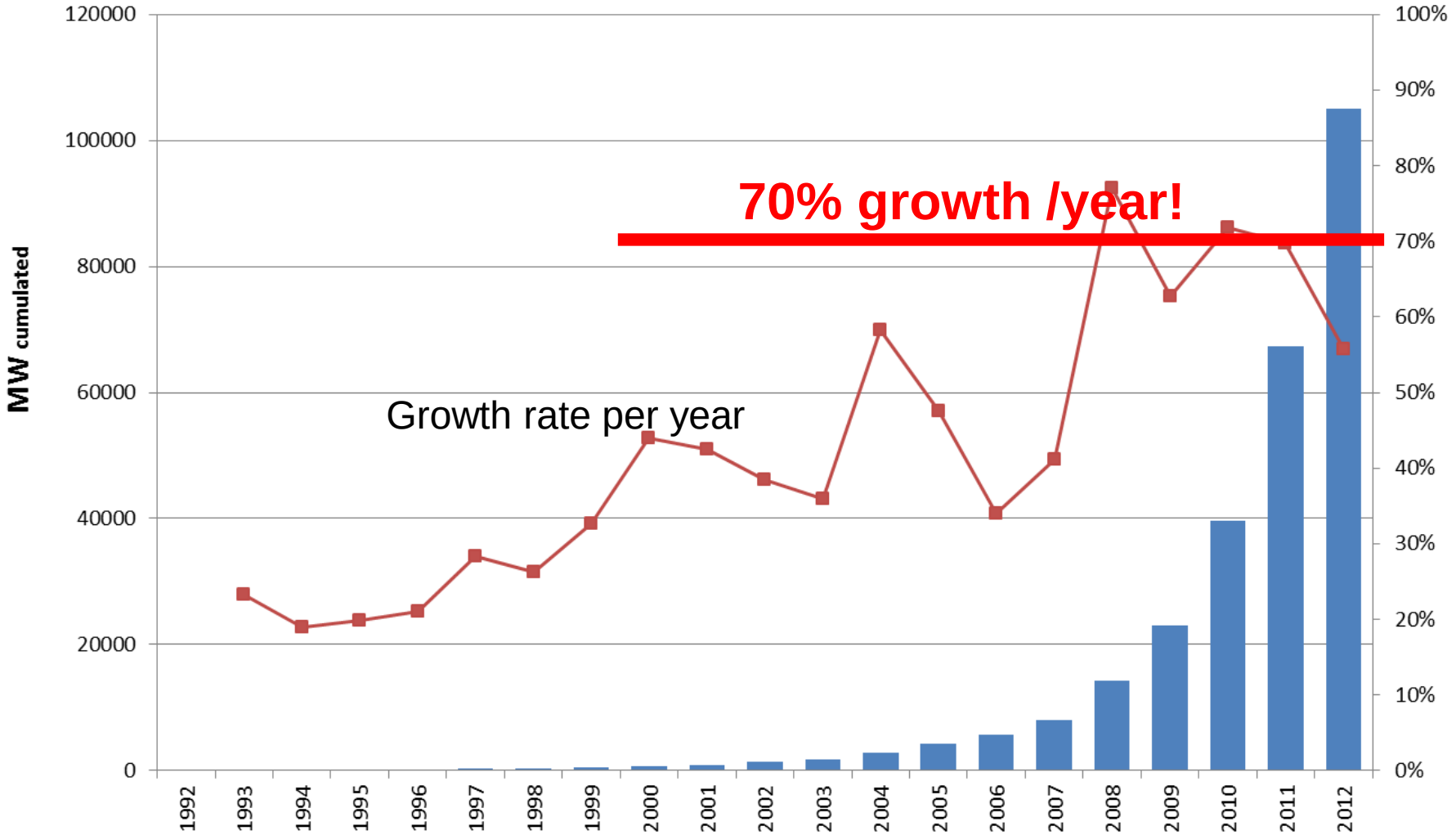
- Actual investment costs were always higher than costs announced

- Costs of nuclear as well as construction times are much higher than in the East – Why???

# 6. CONCLUSIONS

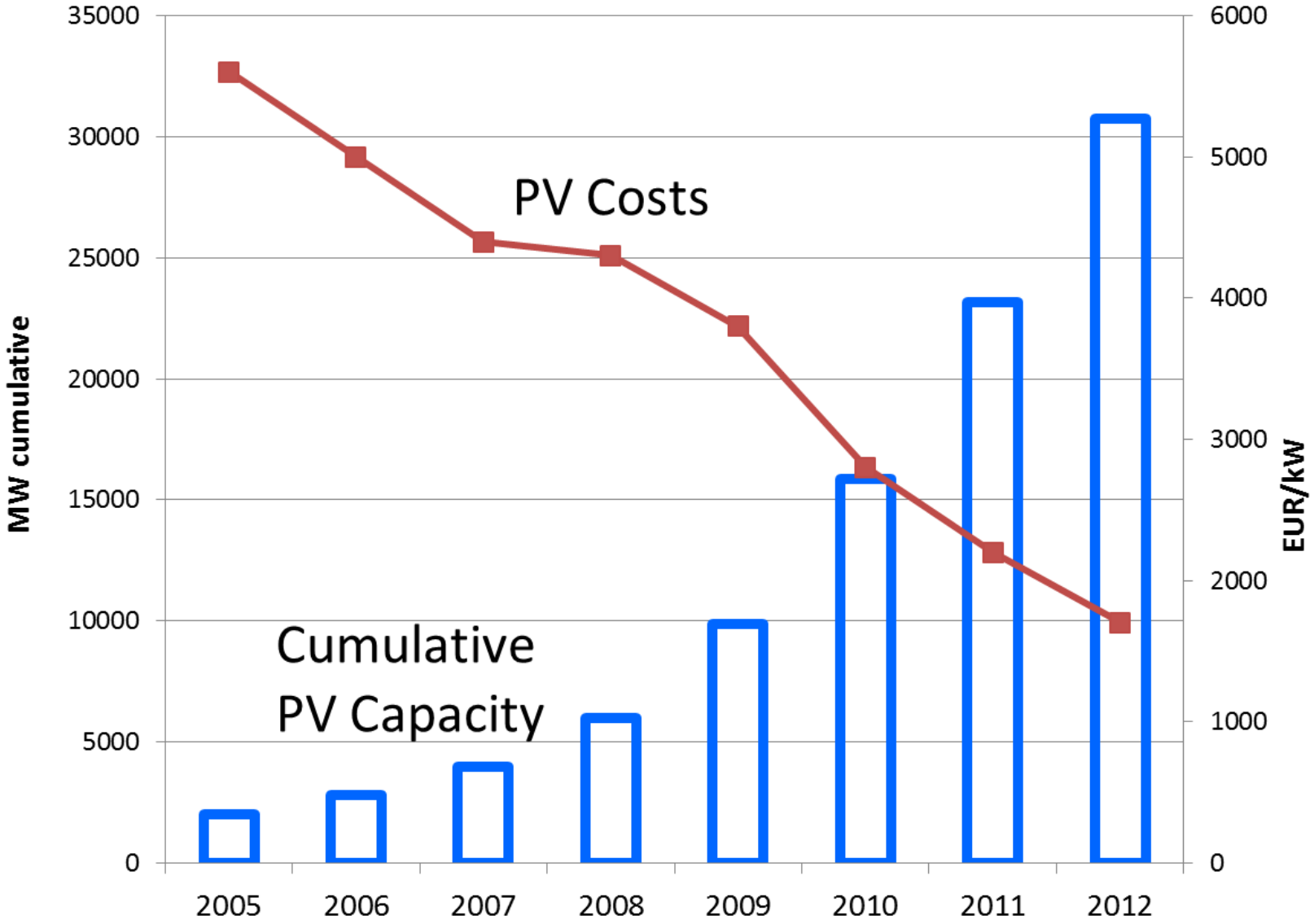
- There are no signs for a cost decrease – nowhere!
- “Forgetting rather than Learning!”
- Photovoltaics has continous opposite cost development
- It will be become much harder for nuclear to recover money in renewable-based electricity markets – much less base load needed;
- Who is the lobby for nuclear (in the West) today?

# WORLDWIDE PV-CAPACITIES

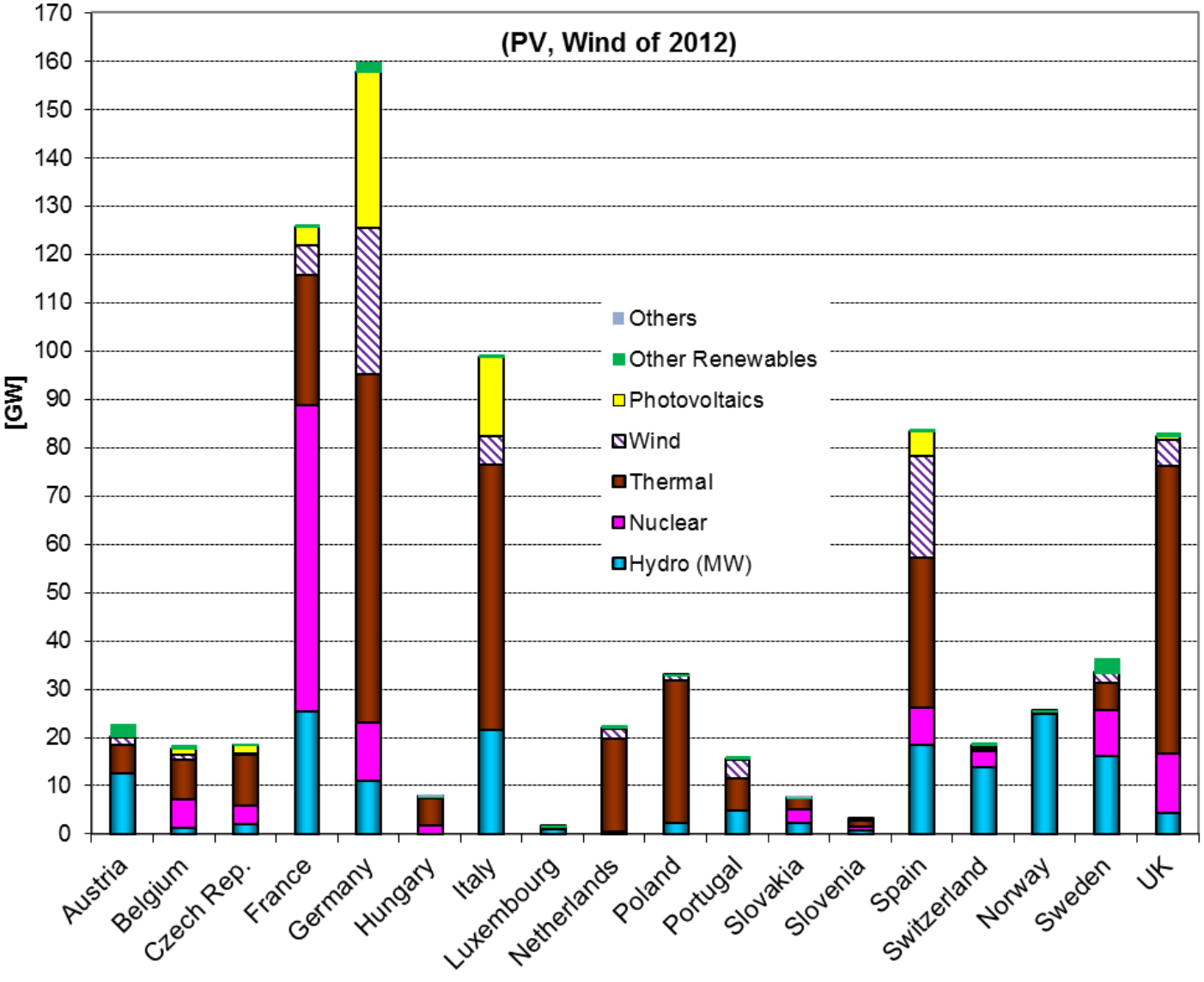



* Figures of 2012 preliminary

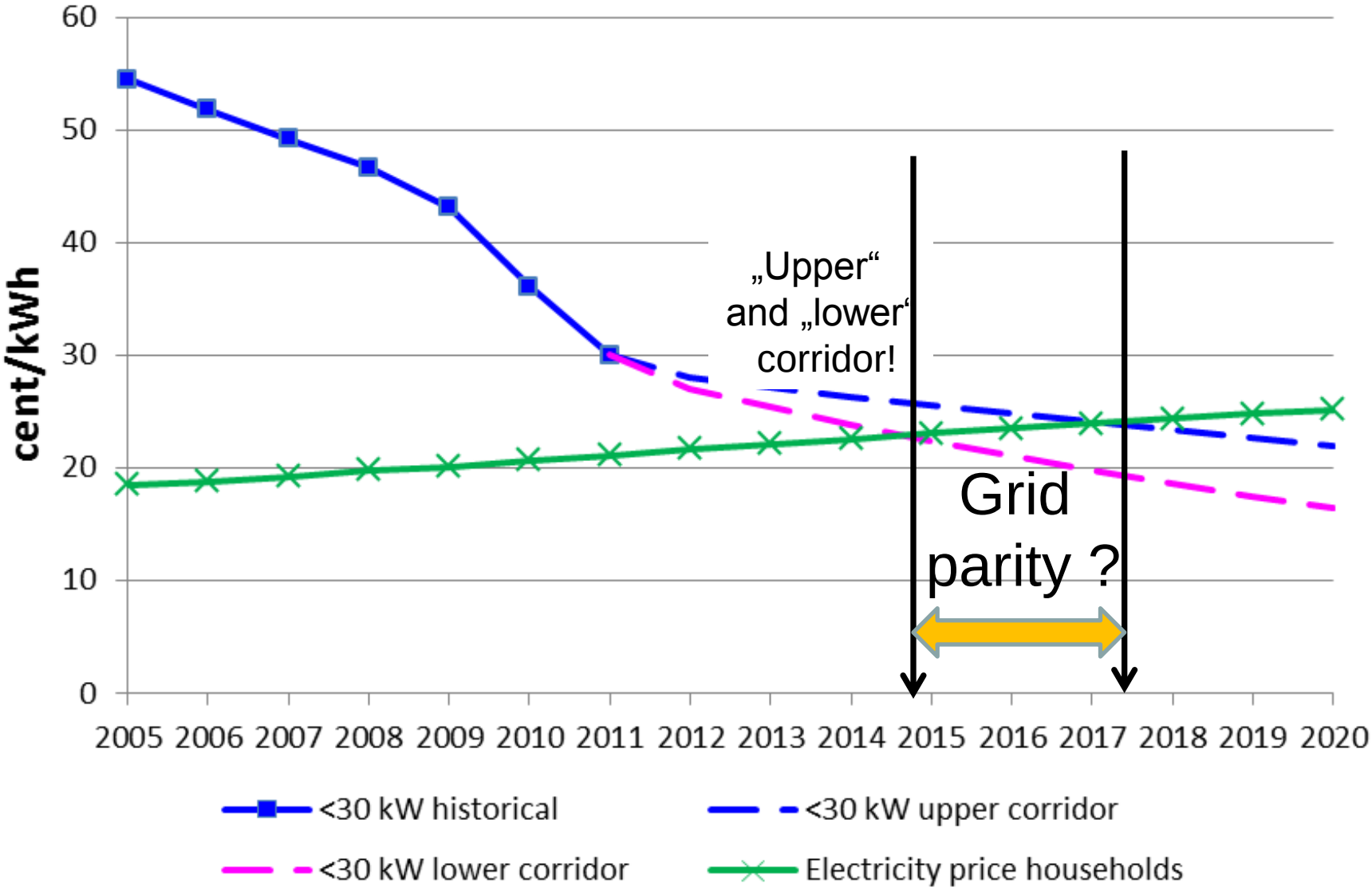
# Entwicklung in Deutschland



# Power plant capacities in Western Europe 2011



# PV costs vs household electricity price in Germany



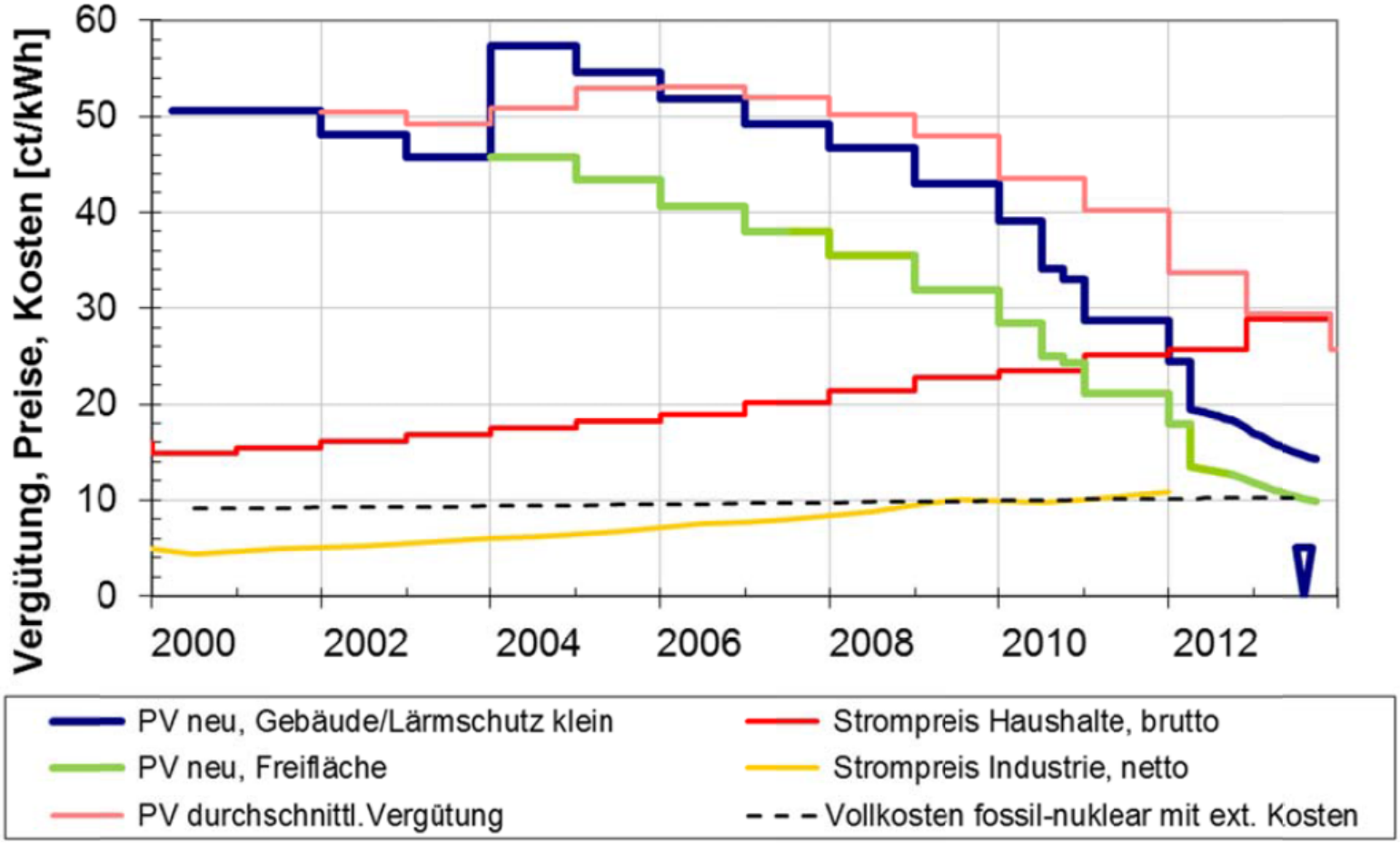



**Abbildung 5: Vergütung von PV-Strom nach dem Datum der Anlageninbetriebnahme gemäß EEG, durchschnittliche Vergütung von PV-Strom für Anlagenbestand aus [BDEW4], [R2B], Strompreise [BMWi1], geschätzte Vollkosten der fossil-nuklearen Stromerzeugung [IFNE]**