

# The World Nuclear Industry Status Report

1<sup>st</sup> International Conference on Nuclear Risks – International Nuclear Risk Assessment Group (INRAG)  
Vienna, 16-17 April 2015

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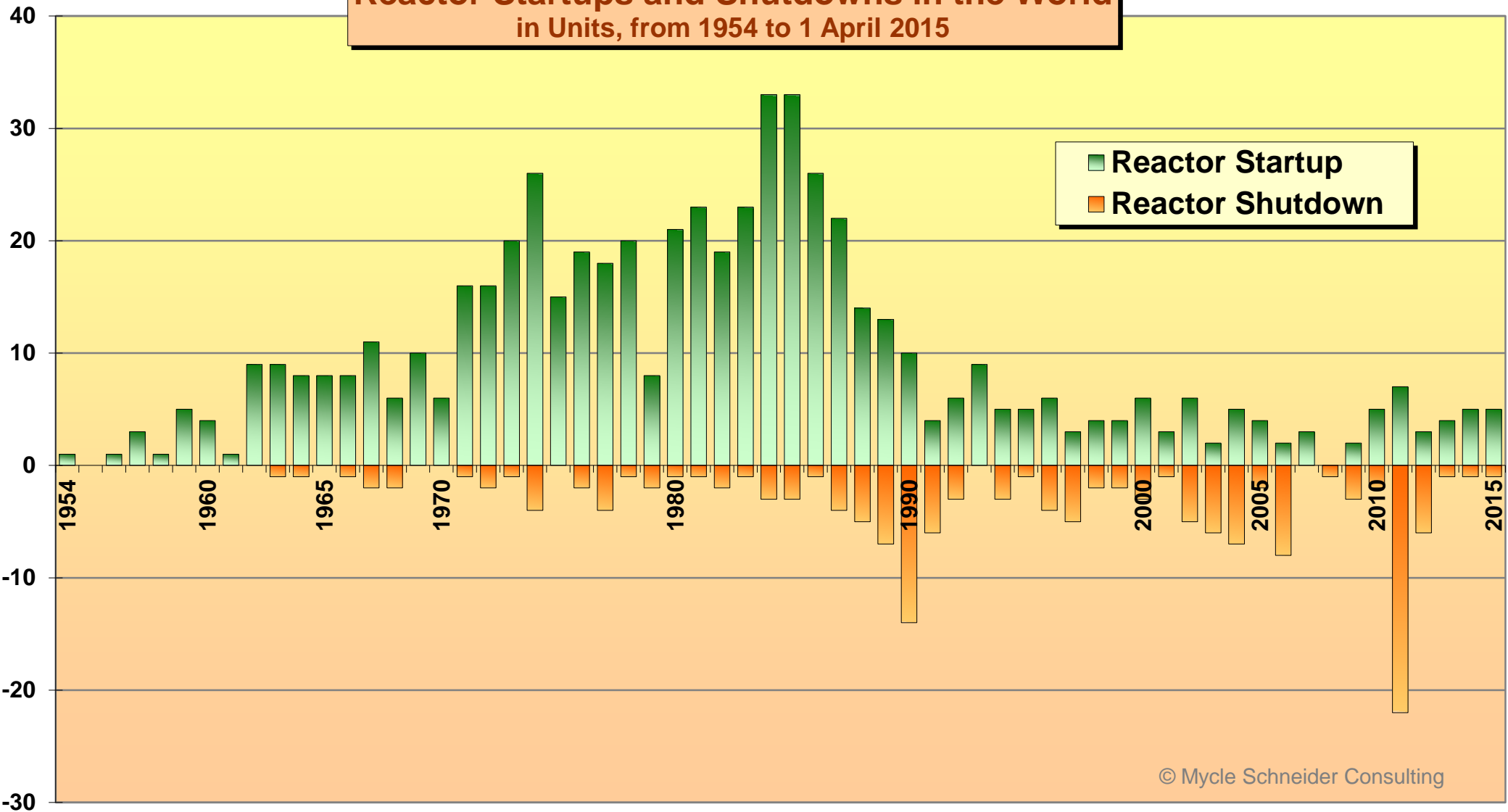
*Convening Lead Author and Publisher of the World Nuclear Industry Status Report (WNISR)*

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# Outline

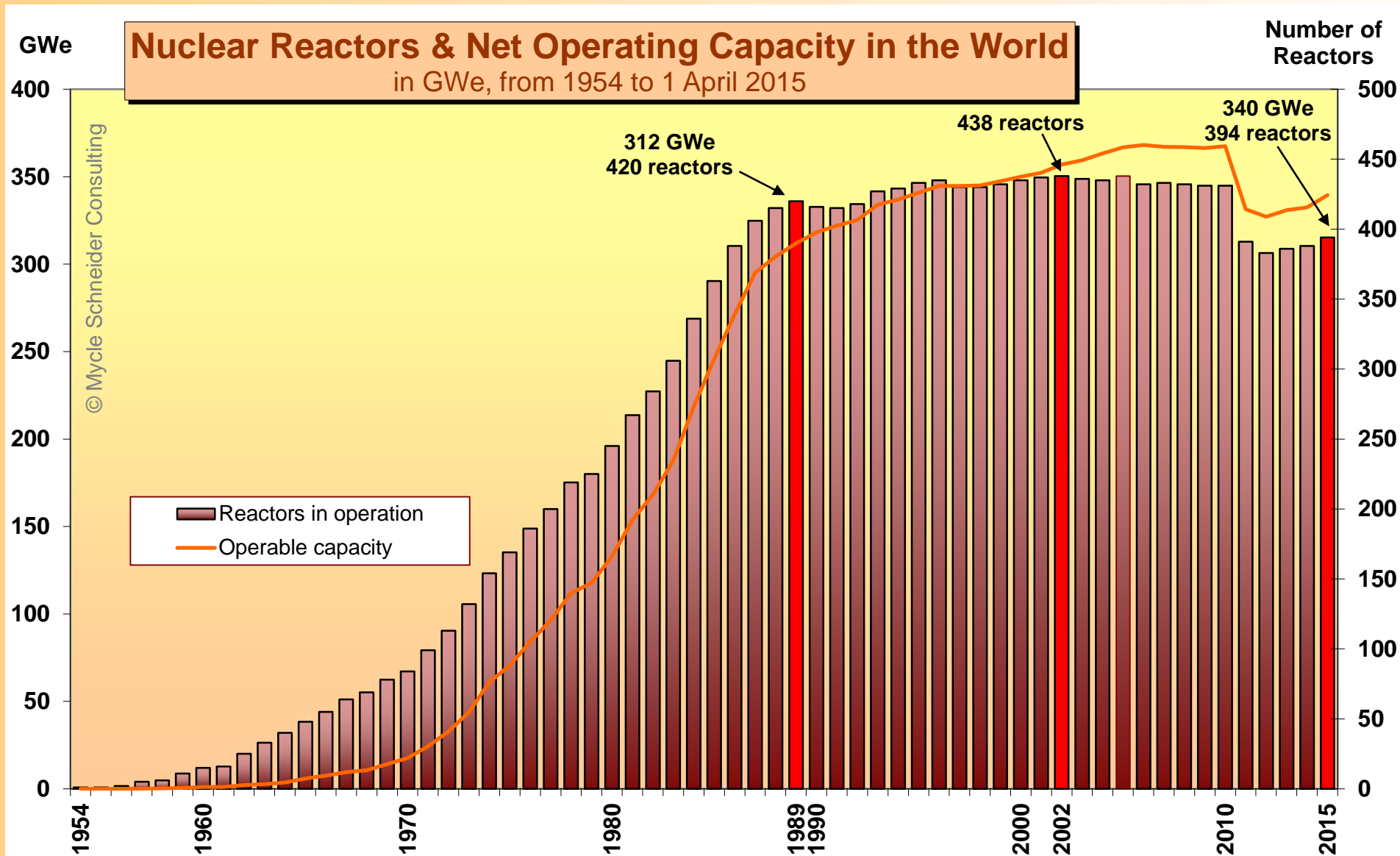
- **Global Status of Nuclear Power**
- **The French Case**
- **The UK Case**
- **Nuclear vs. Renewable Energy Development**

# Reactor Startups and Shutdowns in the World in Units, from 1954 to 1 April 2015



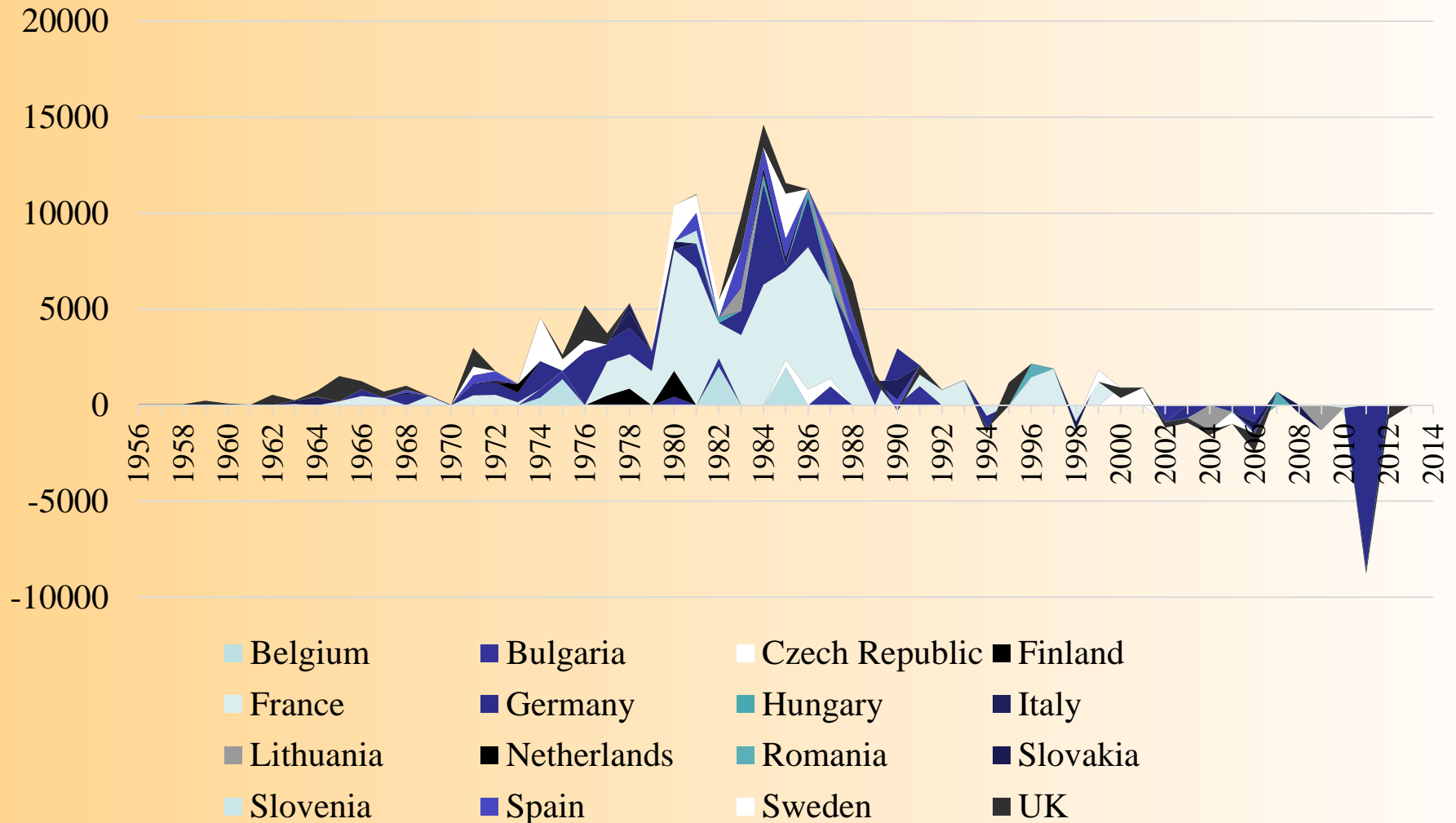
© Mycle Schneider Consulting

Source: IAEA-PRIS, MSC, 2015



Source: IAEA-PRIS, MSC, 2015

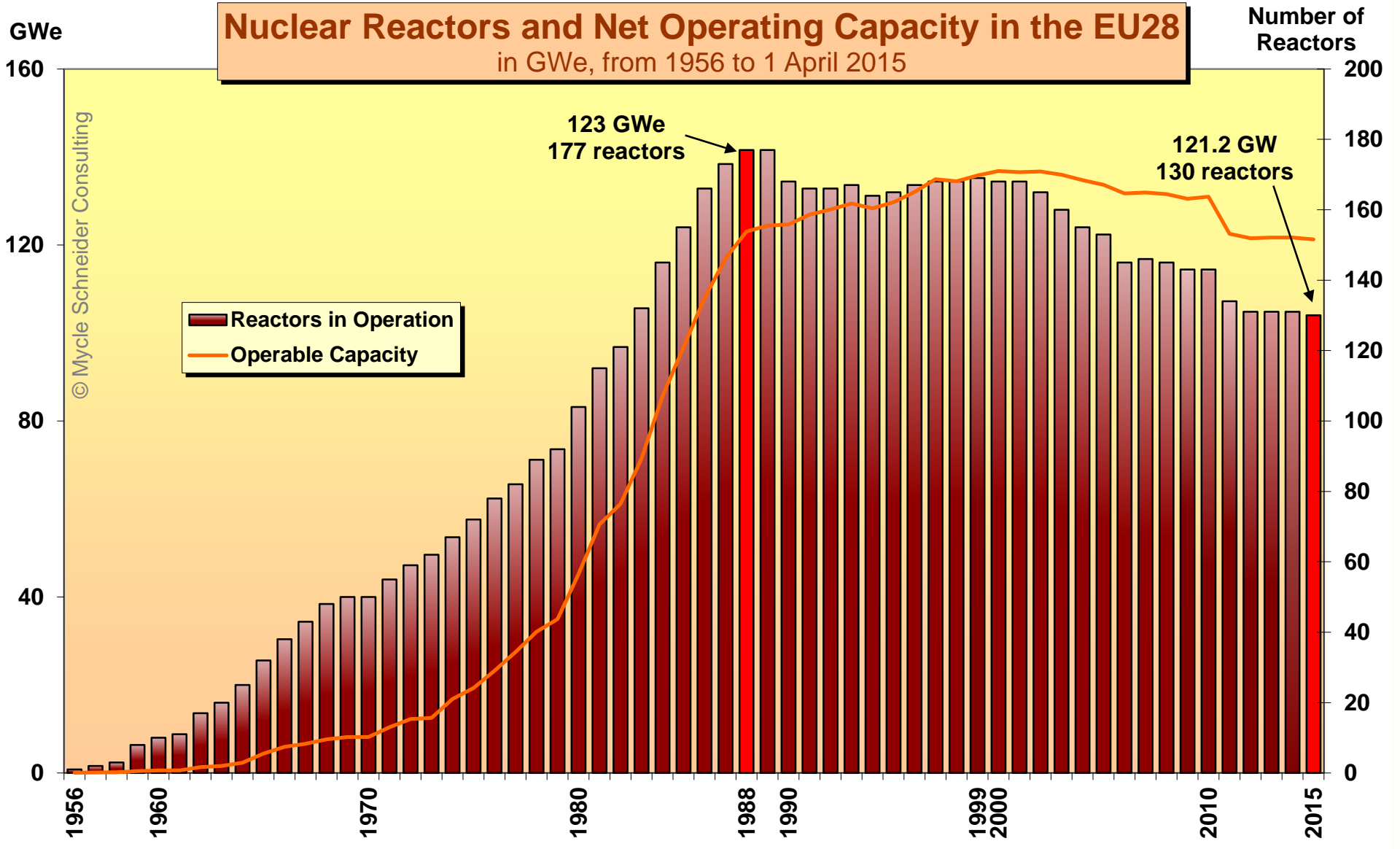
# Capacity Changes in Nuclear Capacity (MW)



Source: PRIS 2015

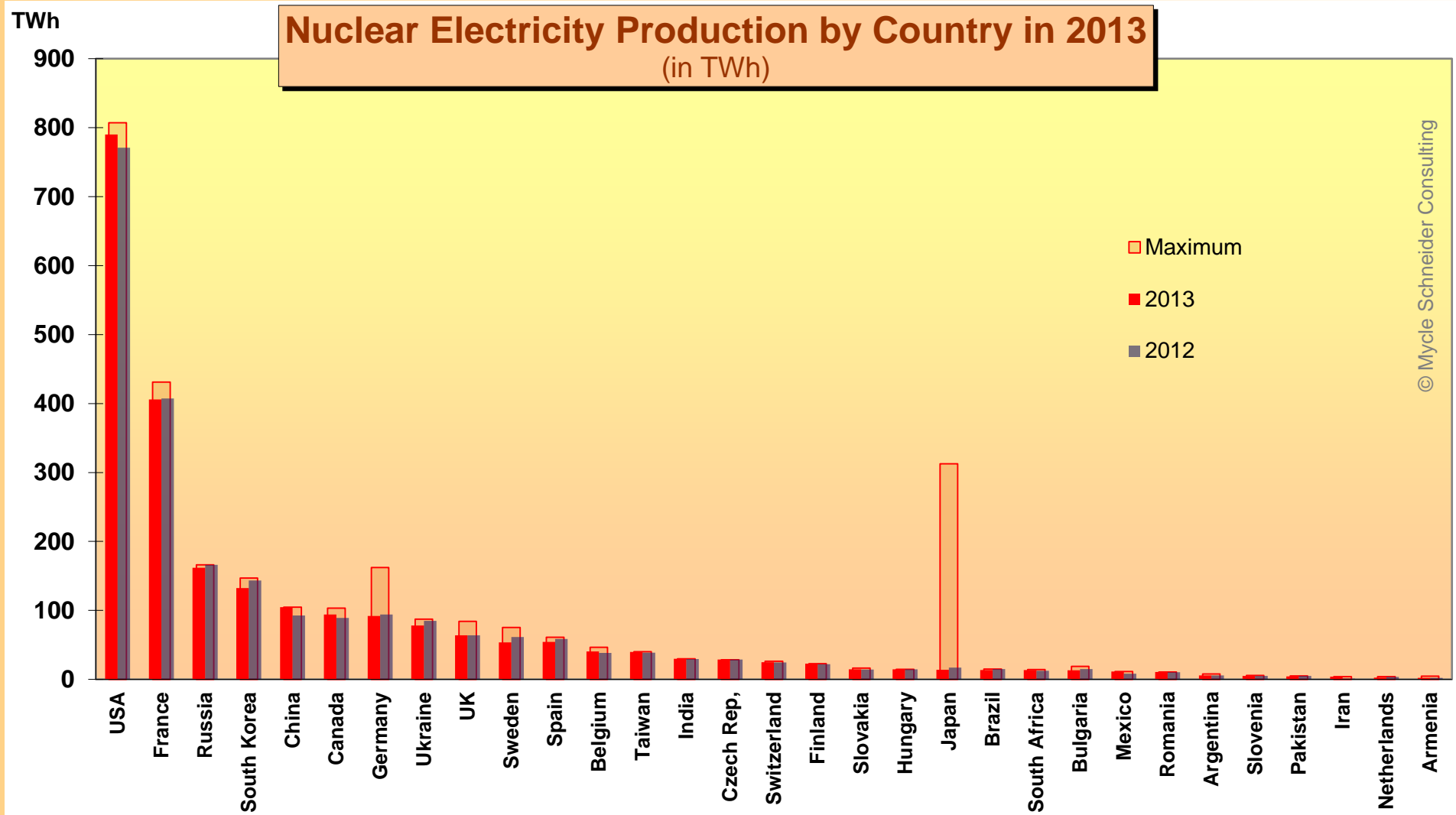
# Nuclear Reactors and Net Operating Capacity in the EU28

in GWe, from 1956 to 1 April 2015



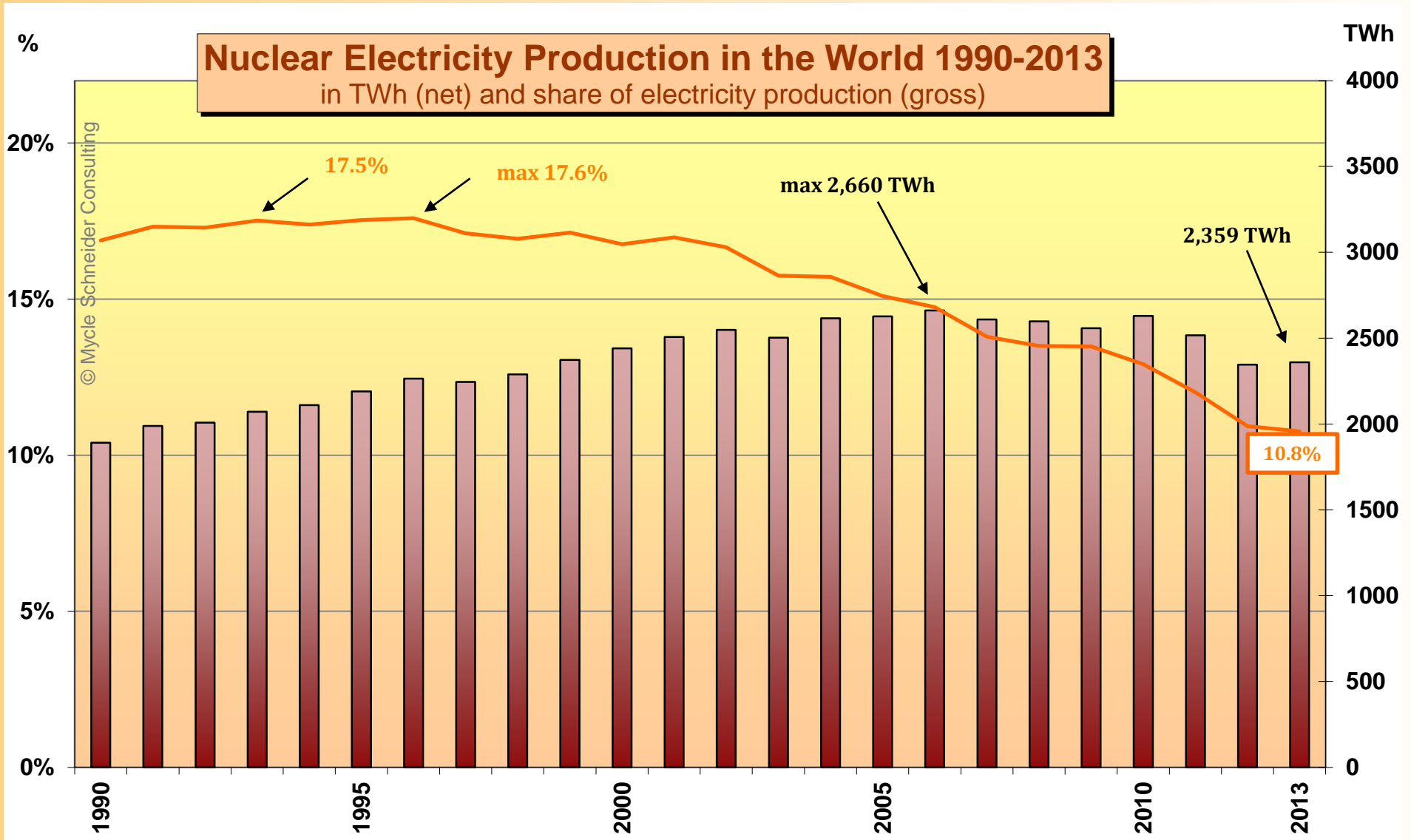
Source: IAEA-PRIS, MSC, 2015

# Nuclear Electricity Production by Country in 2013 (in TWh)



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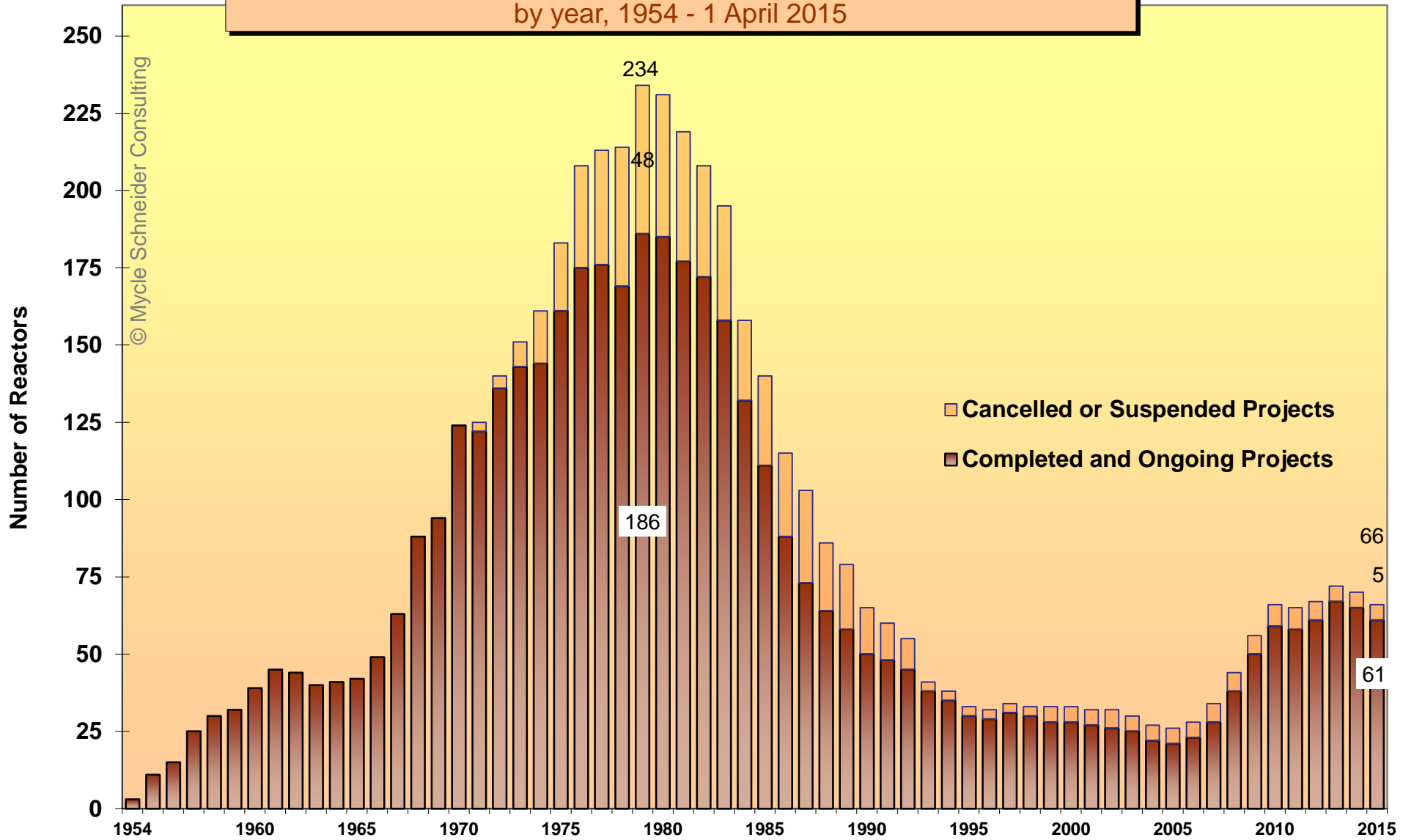
Source: IAEA-PRIS, MSC, 2015



Source: IAEA-PRIS, MSC, 2015



# Number of Nuclear Reactors Listed as "Under Construction" by year, 1954 - 1 April 2015



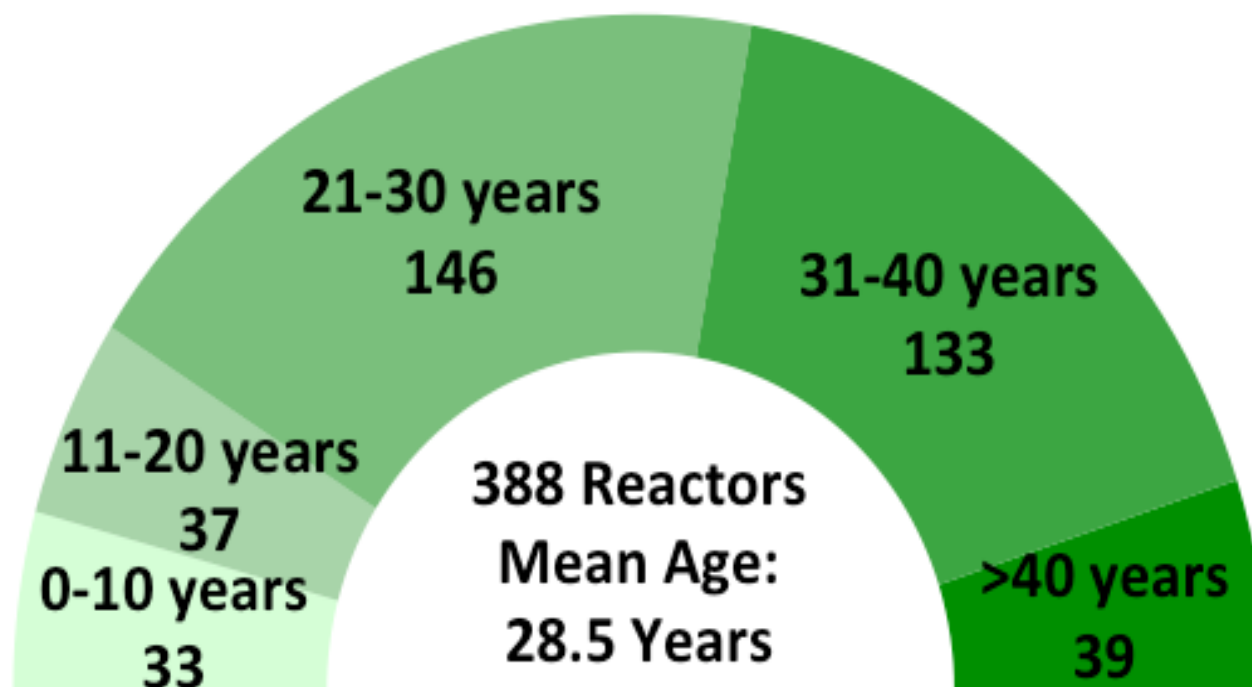
Source: IAEA-PRIS, MSC, 2015

## Reactors « Under Construction » in the World (1 April 2015)

| Country            | Units     | MWe (net)     | Construction Start | Grid Connection  | Delayed   |
|--------------------|-----------|---------------|--------------------|------------------|-----------|
| <b>China</b>       | 23        | 22,738        | 2009-2015          | 2015-2021        | 20        |
| <b>Russia</b>      | 8         | 6,262         | 1983-2009          | 2015-2019        | 8         |
| <b>India</b>       | 6         | 3,907         | 2002-2011          | 2015-2016        | 2         |
| <b>USA</b>         | 5         | 5,633         | 1972-2013          | 2015-2020        | 5         |
| <b>South Korea</b> | 4         | 5,360         | 2008-2013          | 2015-2018        | 4         |
| <b>UAE</b>         | 3         | 4,035         | 2012-2014          | 2017-2019        | ?         |
| <b>Belarus</b>     | 2         | 2,218         | 2013-2014          | 2019-2020        | ?         |
| <b>Pakistan</b>    | 2         | 630           | 2011               | 2016-2017        | 2         |
| <b>Slovakia</b>    | 2         | 880           | 1985               | 2015-2016        | 2         |
| <b>Ukraine</b>     | 2         | 1,900         | 1986-1987          | 2019             | 2         |
| <b>Argentina</b>   | 1         | 25            | 2014               | 2018             | ?         |
| <b>Brazil</b>      | 1         | 1,245         | 2010               | 2018             | 1         |
| <b>Finland</b>     | 1         | 1,600         | 2005               | 2018             | 1         |
| <b>France</b>      | 1         | 1,600         | 2007               | 2016             | 1         |
| <b>Total</b>       | <b>61</b> | <b>58,033</b> | <b>1972-2015</b>   | <b>2015-2021</b> | <b>49</b> |

*Source: IAEA-PRIS, MSC, 2015*

# Age of World Nuclear Fleet as of 1 July 2014



*Source: IAEA-PRIS, MSC, 2015*

# Operating Costs and Markets

- *Market Prices Barely Cover Costs*
- **Belgium:** GDF-Suez lost court case against fuel tax  
--> Now “considers all options” for its 7 reactors
- **Sweden:** at least 3 reactors operated at loss in 2 of 4 past years  
--> New 17% tax increase might lead to earlier shutdowns
- *Forcing Shutdowns*
- **Germany:** E.ON decides to shut down Grafenrheinfeld in May 2015,  
--> seven months earlier than required by law
- **USA:** Five shutdown decisions, incl. 2 reactors licensed to operate beyond 2030

## Traditional Utilities Under Pressure

The 20 largest European energy utilities lost over half of the €1 trillion stock market value since 2008, some a lot more.

*Utility business models are threatened by the dramatic growth in the deployment of technologies that generate electricity onsite or at the distribution grid level.*

Navigant Research, Boulder, USA, August 2014

*A new technological paradigm in electricity and the end of the reign of the large-scale utilities.*

Institute for Public Policy Research, London, September 2014

*Energy storage for electricity systems prices potentially dropping to \$230/kWh by early next decade, which would make it cheaper than the average household electricity bill*

Citi Research 2014

# The French Case: Nuclear Companies in Trouble

## EDF (2014)

- 4.5%/a operating cost increase 2007-2012
  - Loss of €1.5 billion in 2012
  - Need for significant tariff increases
- Stock value plunged >70% (up to 85%) since 2007
- High debt €34.2bn for turnover of €73bn

## AREVA (2014)

- Loss of €4.8bn (almost €8bn in 4 years = annual turnover)
- High debt €5.8bn for turnover of €8.3bn
- Stock value plunged by > 85% since 2007
- Standard & Poor's downgraded AREVA shares to BB+ (“junk”) in November 2014 and again to BB- in March 2015

*Sources: Company websites; Standard & Poor's*

# Hinkley Point C

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- In 2006 Government process to commission new nuclear
- Currently, one firm proposal for £24.5 billion project at Hinkley C, built by Areva for EDF
- Government support, £10 billion debt financing, price guarantee for 35 years, £92.5/MWh (2012,) annual increase index linked - Expected price at start of operation in 2024, £121/MWh
- Approved by European Commission, but finance package still not agreed
- FT reported, CGN and CNNC to sign investment contract in March,,,,
- Further delays due to situation in France

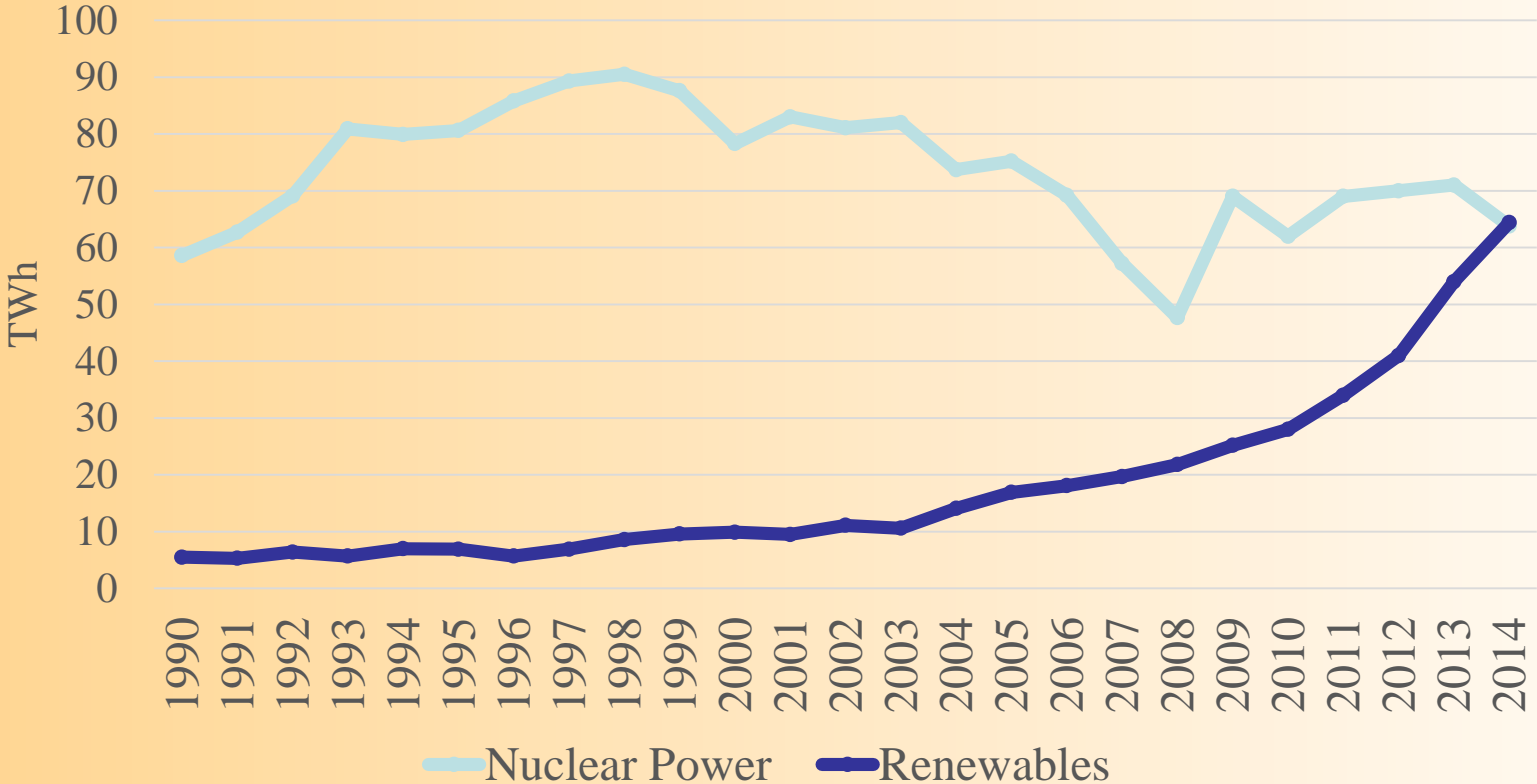




# Importance of UK to international industry

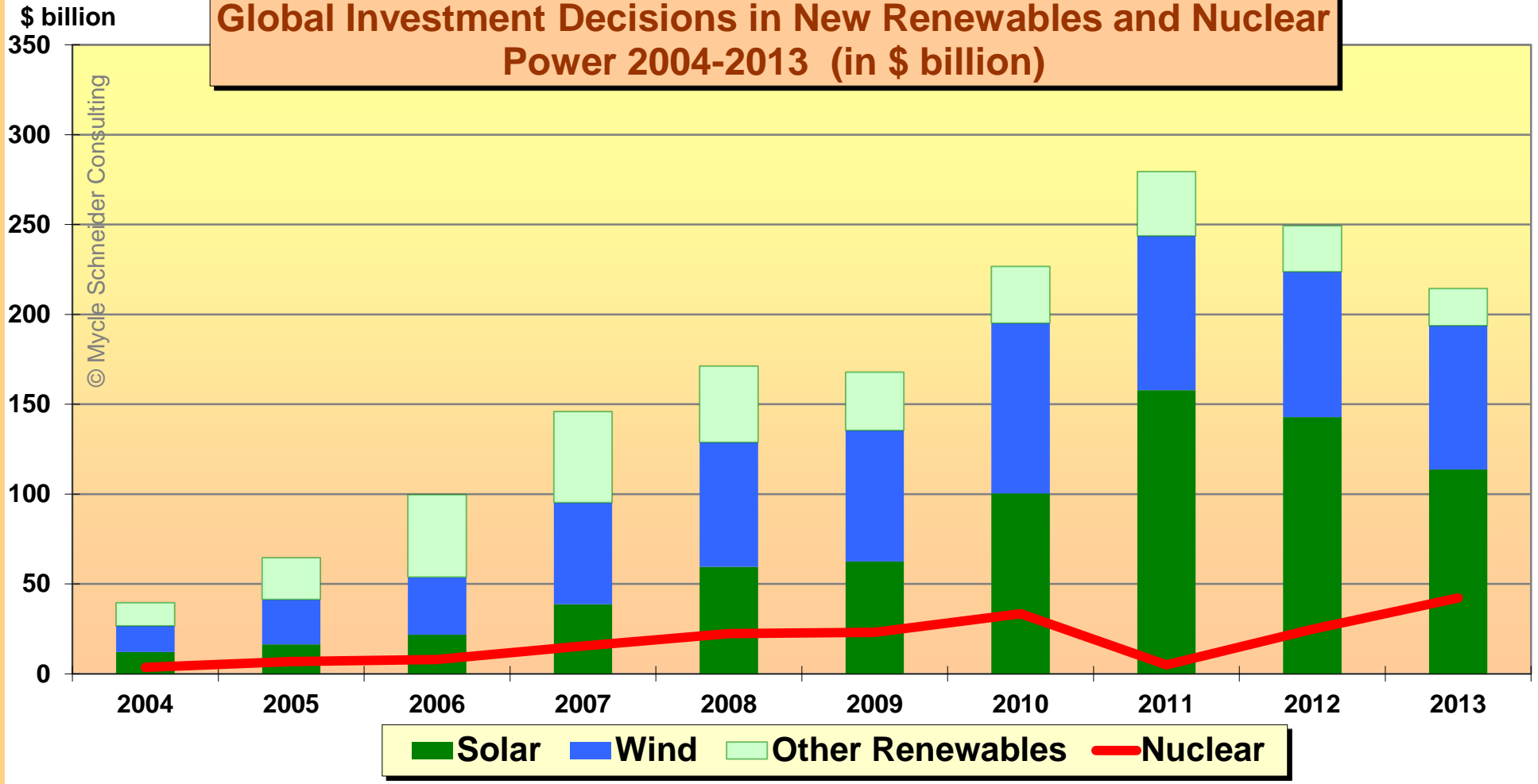
- EDF Energy (4 reactors at Hinkley and Sizewell)
  - EDF Group: 45-50%
  - AREVA: 10%
  - China General Nuclear Corporation (CGN), China National Nuclear Corporation (CNNC): 30-40%
  - Discussions are also taking place with a shortlist of other interested parties who could take up to 15% - Saudi Arabia ?
- Horizon (4 reactors at Wylfa and Oldbury)
  - Hitachi takes over E.on and RWE shares
- NuGen (3 reactors at Moorside – Cumbria)
  - January 2014, new ownership structure with Toshiba-Westinghouse (60%) and GDF Suez (40%); Iberdrola sold their shares
- Test case for EU State Aid

# Historic Renewable-Nuclear Cross-over in UK



# Nuclear Vs Renewables

# Global Investment Decisions in New Renewables and Nuclear Power 2004-2013 (in \$ billion)



# Global Investment Decisions in New Renewables and Nuclear Energy 2004-2013 (in \$ billion)

\$ billion

700

600

500

400

300

200

100

0



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US

Brazil

America  
(excluding US  
and Brazil)

Europe

Middle East and  
Africa

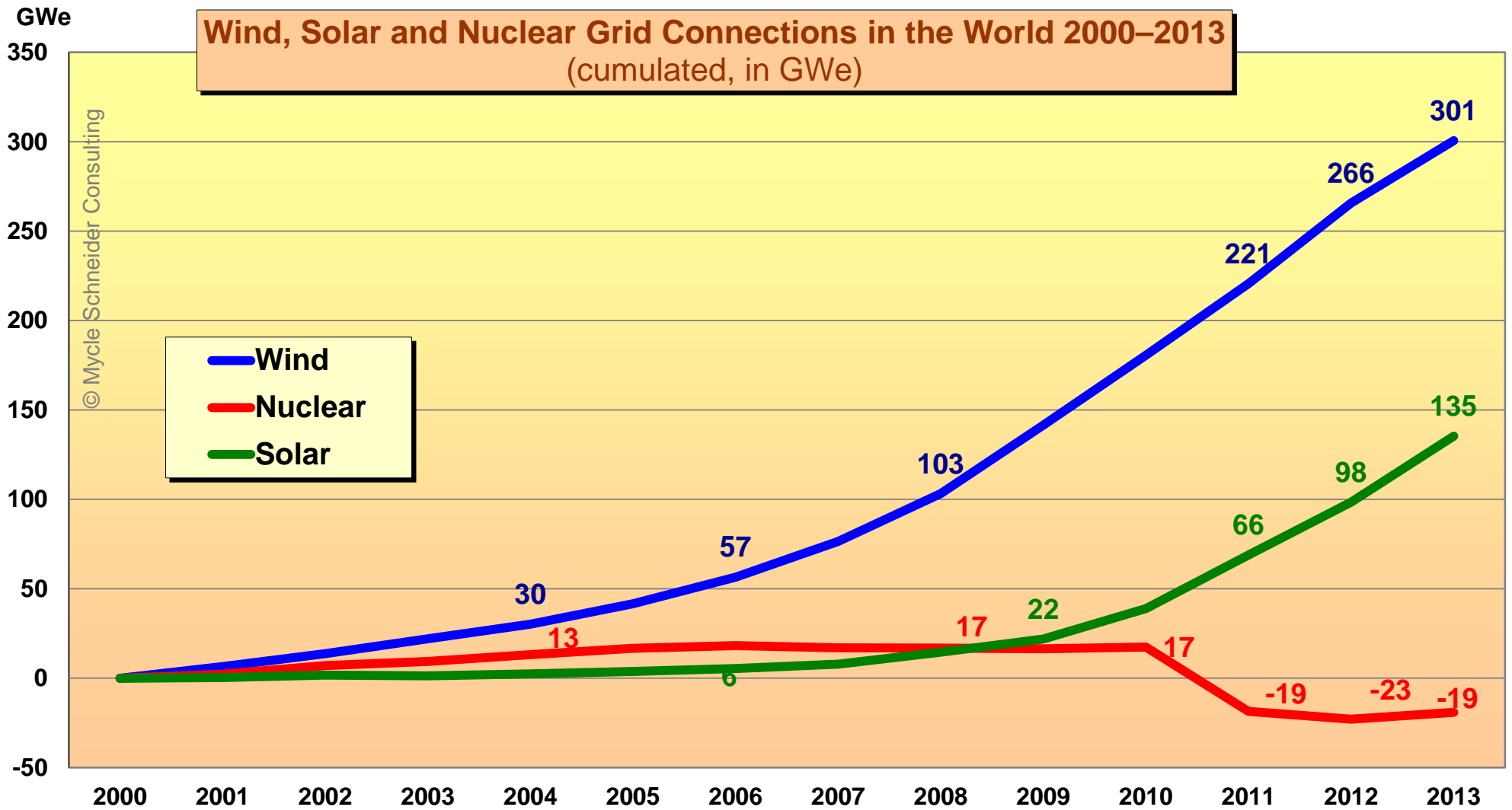
China

India

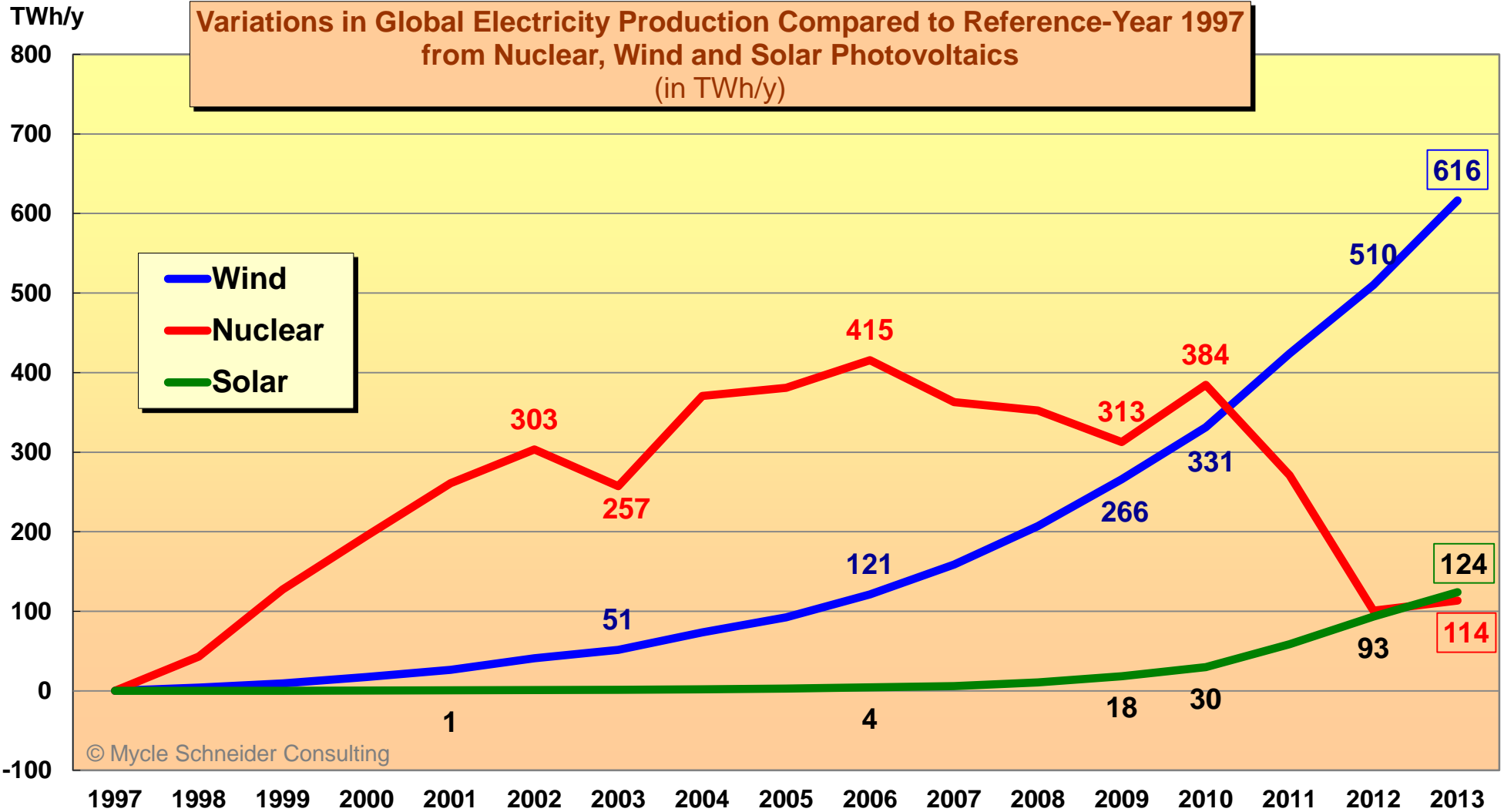
Asia (Excluding  
China and India)

Sources: UNEP 2014 and WNISR original research

# Nuclear vs. Renewable Energy Development



Source: IAEA-PRIS, EPIA, GWEC 2014



Sources: BP, IAEA-PRIS, MSC, 2014

# Concluding Remarks

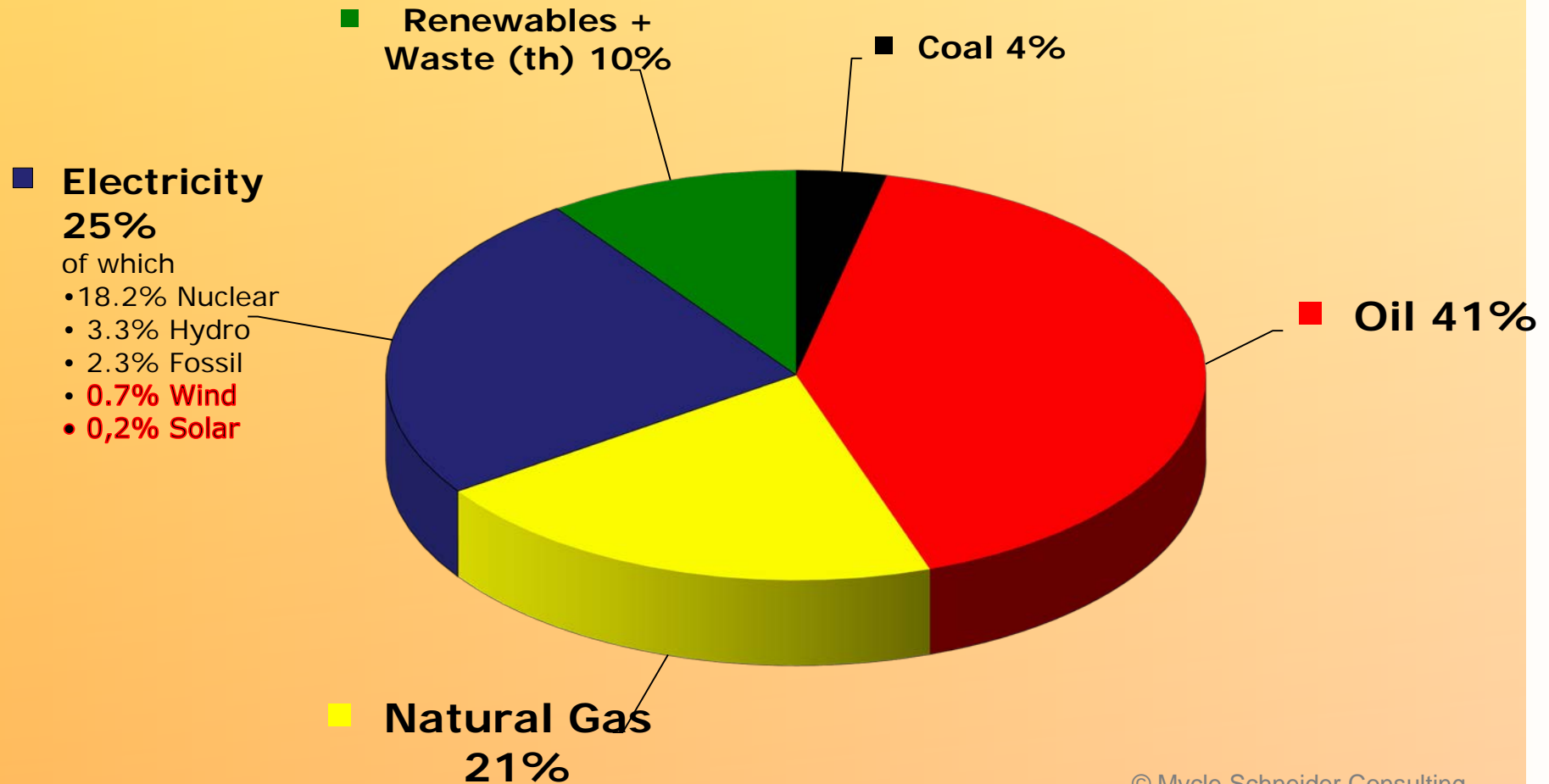
- Global nuclear industry remains on the decline, losing share of electricity market.
- Two countries produce half the world's nuclear electricity, in the EU France produces half the total.
- Nuclear construction dominated by China, three quarters of all projects delayed.
- Increasing pressure on operators: aging reactors becoming more expensive to operate, just as market price of electricity is falling, client base and consumption are shrinking.
- France is facing rough times: “nuclear champions” in trouble with high debts, degraded credit-rating, destroyed share value, upcoming large upgrading *and* decommissioning costs.
- UK is important for international nuclear new build with Chinese, French and Japanese companies interested in engaging/building
- Investment in new renewable energy far exceeds that of nuclear leading to significantly higher newly installed capacity.
- Since signing of Kyoto in 1997, power generation added from solar and nuclear is similar, while wind is 4 times greater.



# **Back up slides**

# Final Energy Consumption in France in 2013

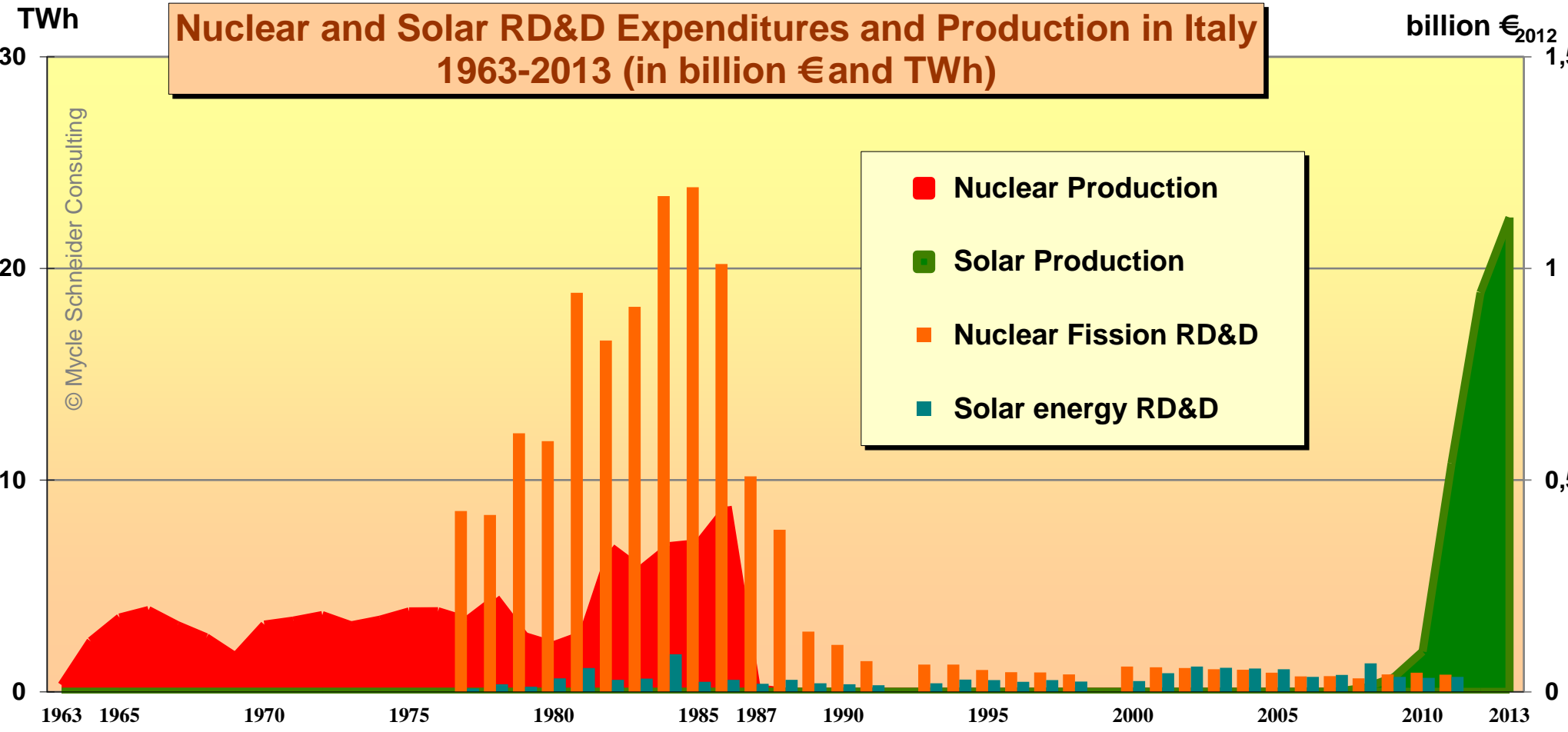
69% Fossil Fuels, 18% Nuclear



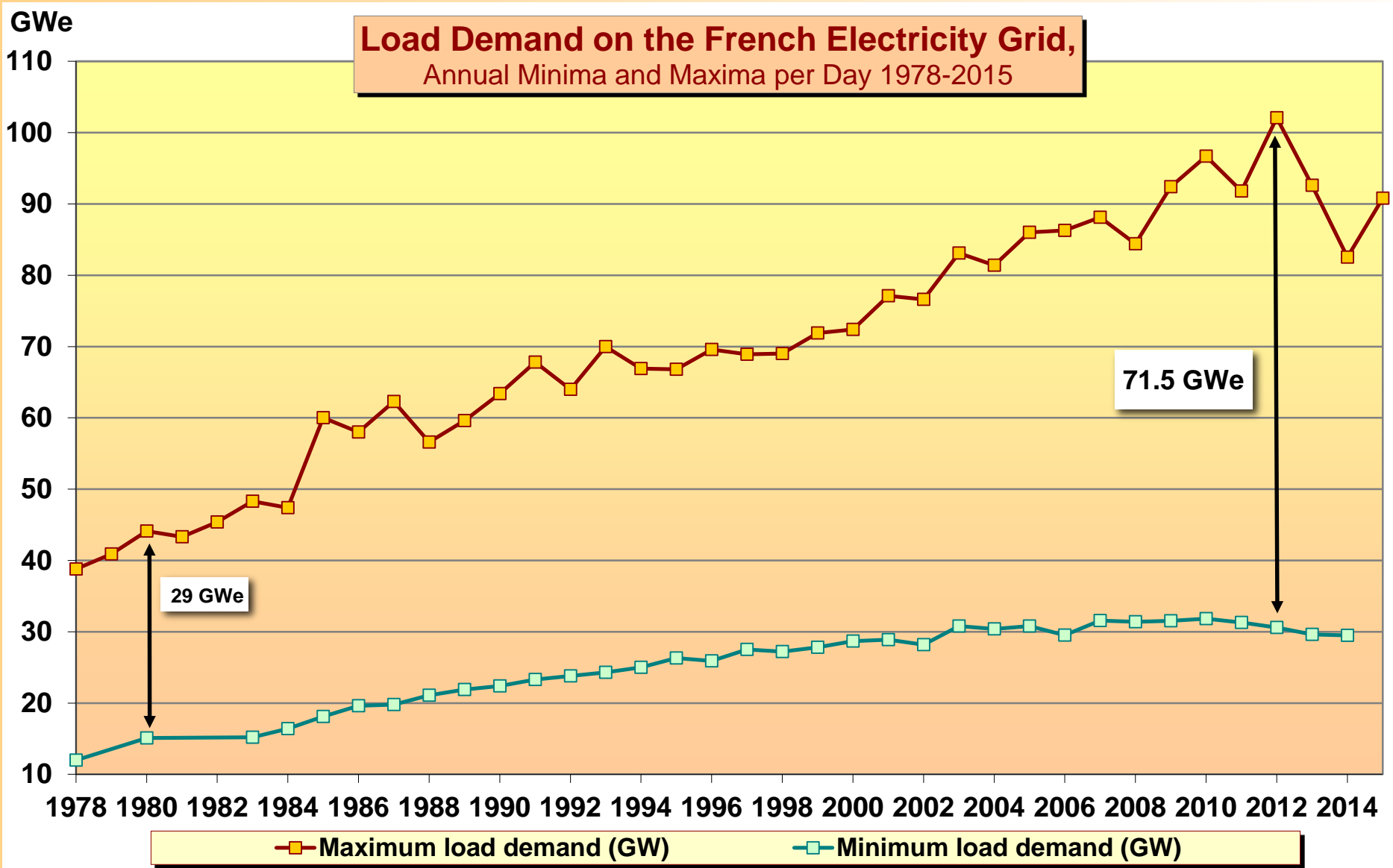
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Source: French Ministry of Ecology, Energy and Sustainable Development, "Bilan Energétique de la France 2013", 2014; MSC 2015

# Nuclear and Solar RD&D Expenditures and Production in Italy 1963-2013 (in billion € and TWh)



Sources: OECD, 2005, IEA & BP, 2014



Sources: RTE, various documents, compiled by MSC, 2015

# **Low Electricity Prices = High Electricity Bills**

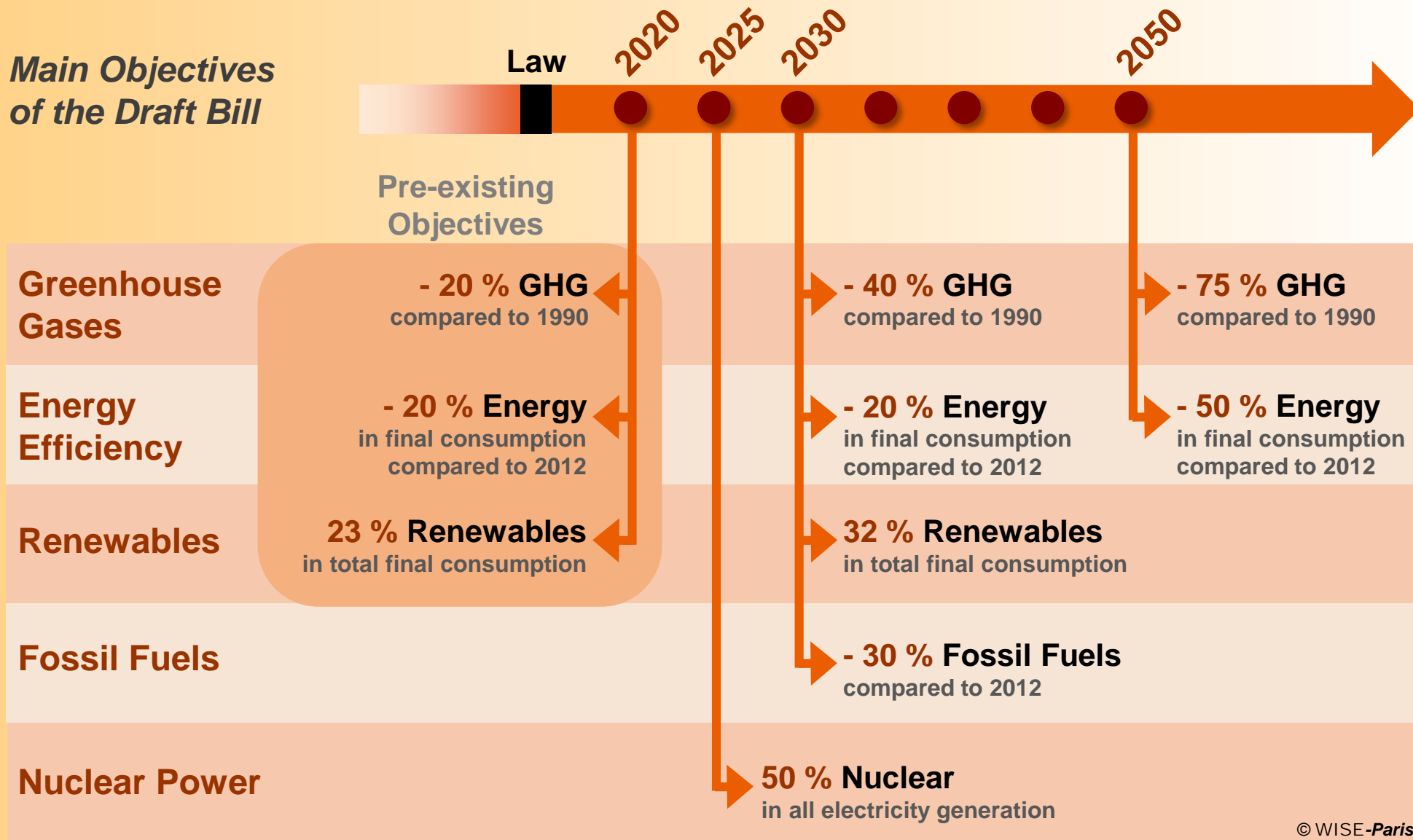
## *Case Study France*

- **Overcapacities** —> **Massive introduction of electric space heating**
  - >30% of all existing housing
  - 75% of all new build until recently
- **Electric space heating** —> **Large spread fuel poverty**
  - 5 million households officially in fuel poverty
  - 4 million households eligible for social tariffs (gas + electricity)
  - 3 million households recently difficulty to pay electricity bills (2013)
  - demands for assistance grow by 15% per year

*"The statistics of the National Housing Agency (ANAH) are affirmative: three million French are cold in winter".*

- **Gas prices +80%, electricity prices +20% in 5 years**
  - Electricity expected to rise by 30% until 2016-2017

## Main Objectives of the Draft Bill

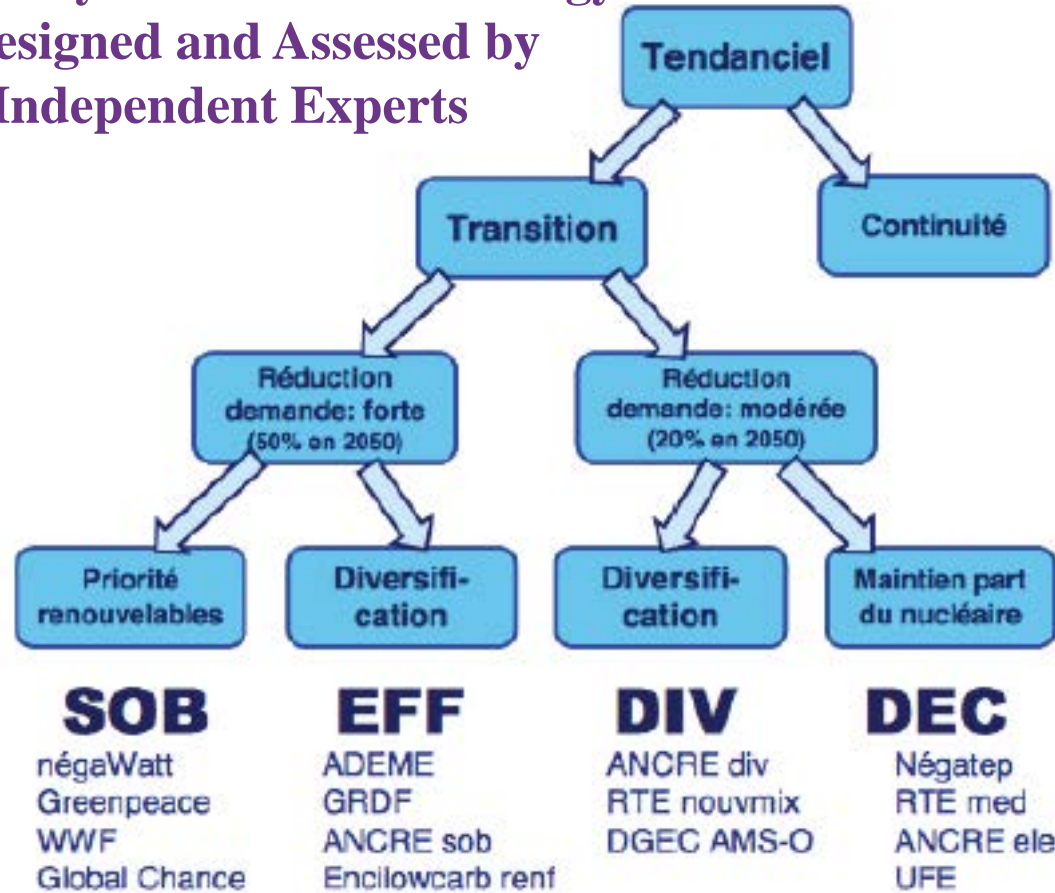


© WISE-Paris



## Possible Pathways of the French Energy Transition Designed and Assessed by Official and Independent Experts

The energy transition does not represent a cost but an investment into the future.



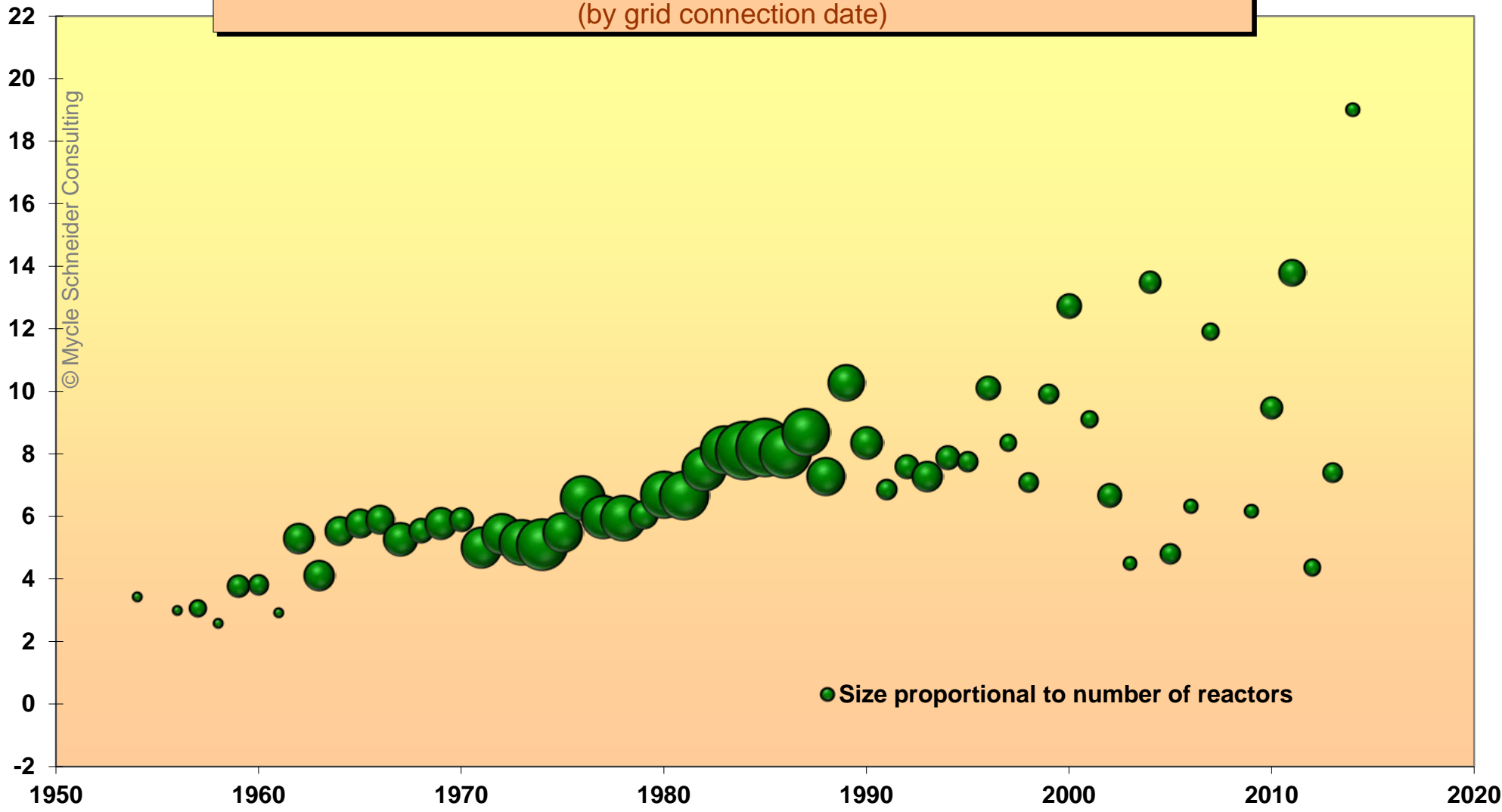
Les trajectoires sont explorées par les scénarios suivants:

|                                    | <b>SOB</b> | <b>EFF</b> | <b>DIV</b> | <b>DEC</b> |
|------------------------------------|------------|------------|------------|------------|
| <b>GHG Emissions Balance</b>       | ÷ 5.3      | ÷ 4.1      | ÷ 2.3      | ÷ 2.4      |
| <b>Net Investments (2012-2050)</b> | -€1,470bn  | -€1,389bn  | -€1,151bn  | -€1,145bn  |

Source: WISE-Paris 2015

# Average Annual Construction Times in the World 1954-2014

(by grid connection date)



Source: IAEA-PRIS, MSC, 2014



# The Energy Revolution is Underway... And it is Fast

## *New Players*

- Households (>2 million RE in Australia, 1.4 million in Germany)
- Farmers
- Municipalities
- Energy Coops (invested €1.4 billion in 5 years in Germany)
- Military (big player in micro-grid development in U.S.)

## *New Business/Financing Models*

- Leasing (dominant PV investment scheme in U.S., soon China?)
- YieldCos (bring RE investments to stock market, pay dividends)
- Green Bonds (GDF raised €2.5 billion, EDF €1.4 billion)

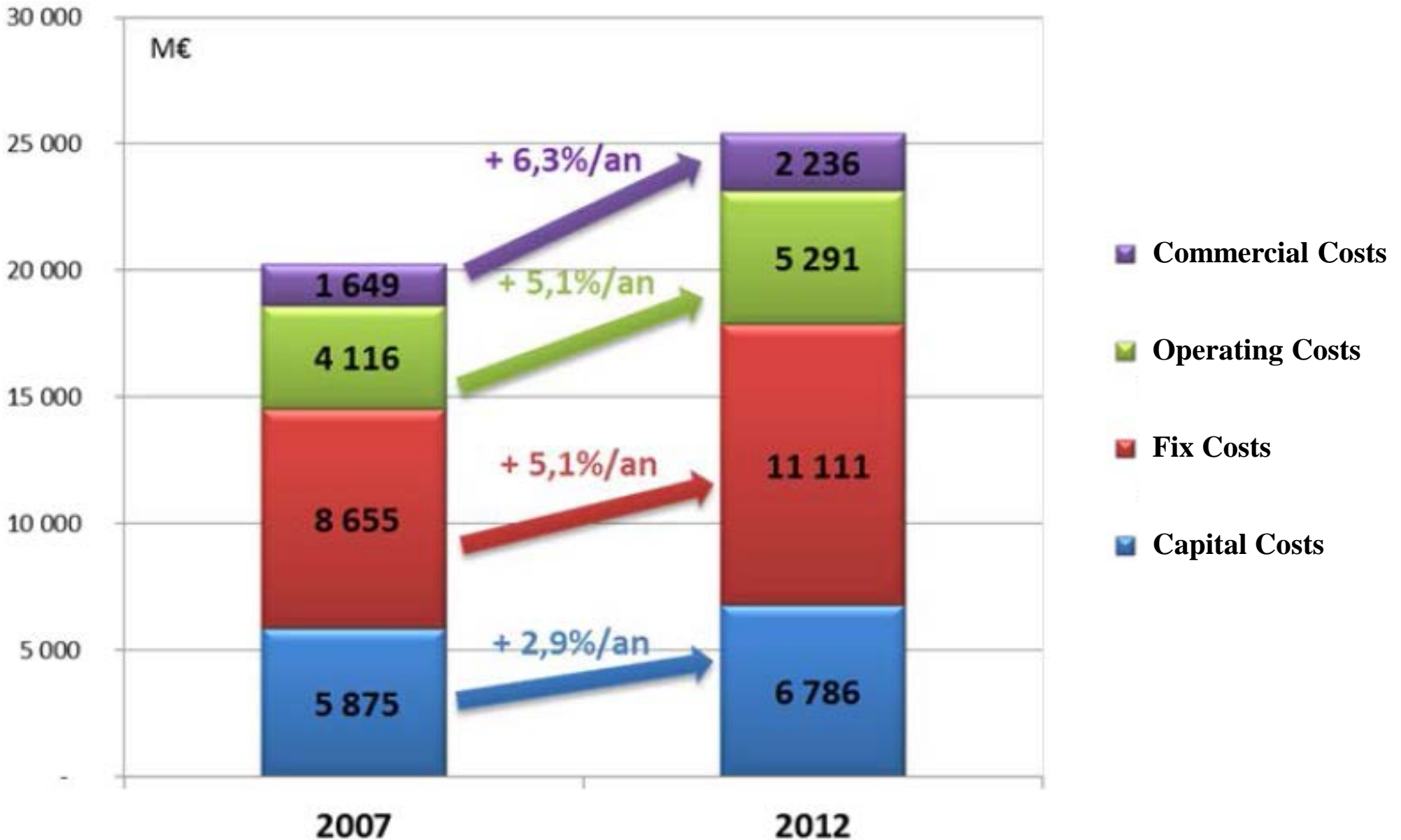
## *New Competitive Concepts*

- Decentralized storage (“fastest path to implement RE”, DNV)
- Electric vehicles + PV: Gas savings pay back for PV in 6-8 years

(UBS)

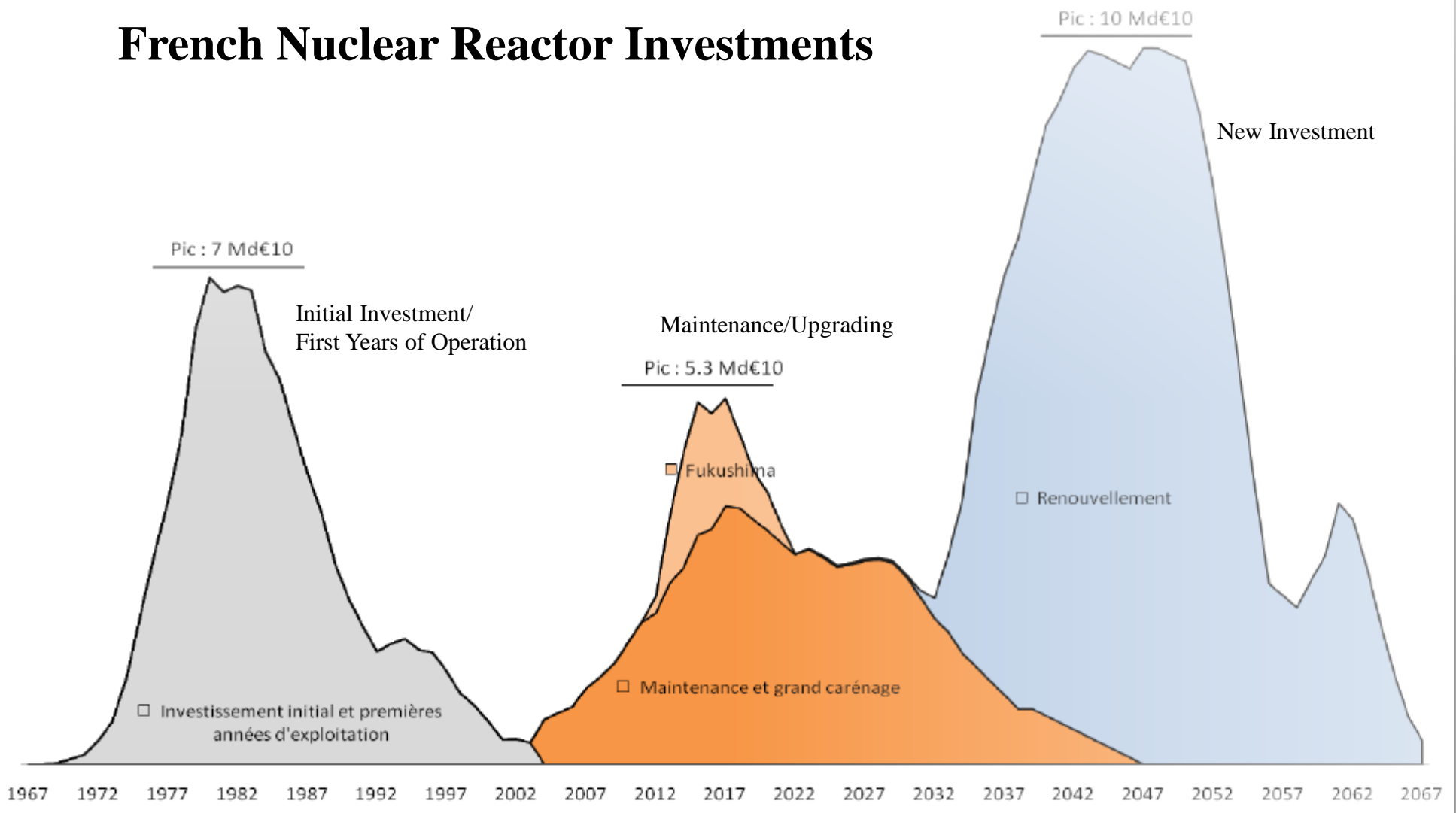
- Smart communication concepts

# French Electricity Generating and Marketing Costs 2007-2012: +4.5%/a

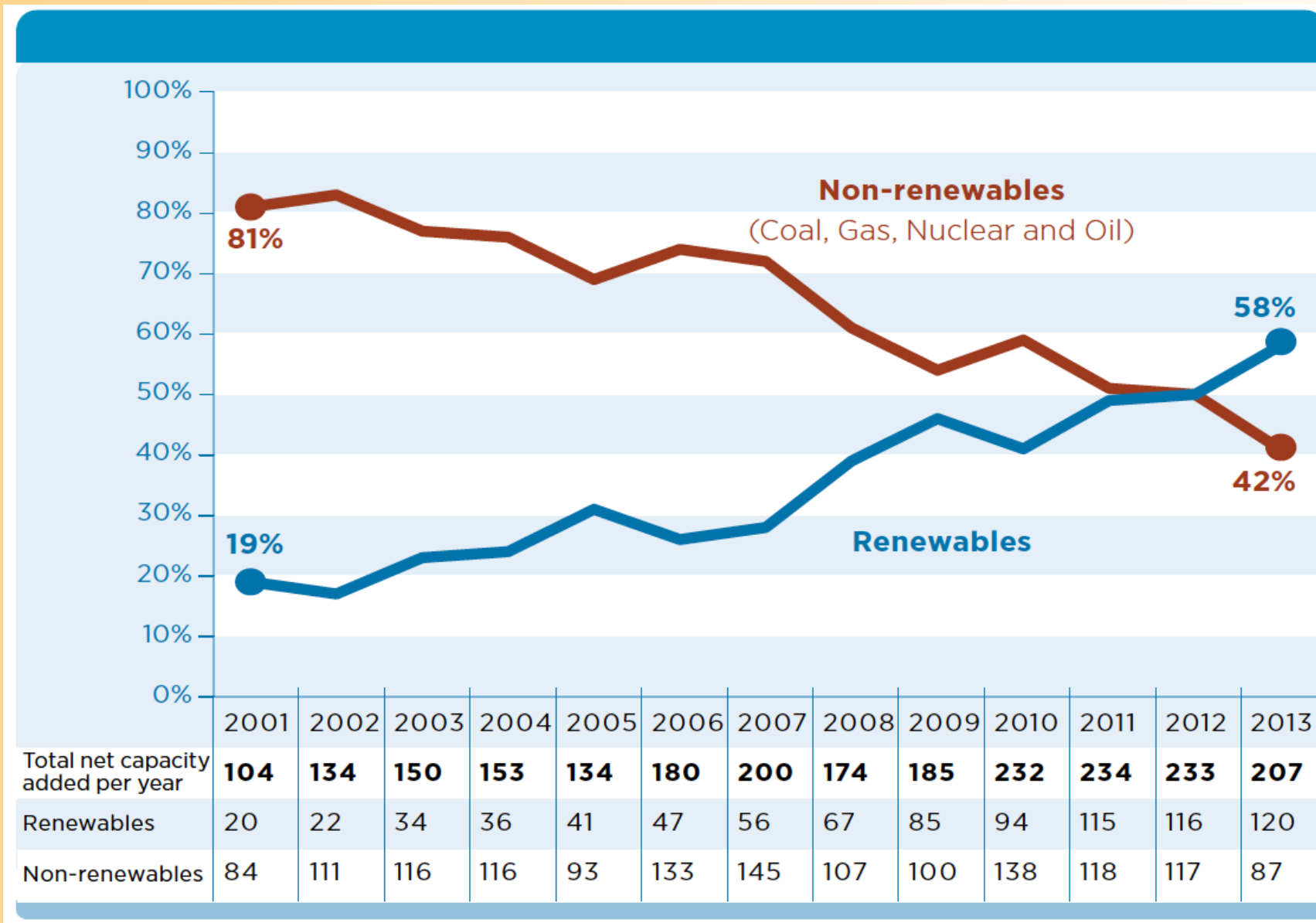


Source: Rapport de la Commission de régulation de l'énergie, 4 June 2013

# French Nuclear Reactor Investments

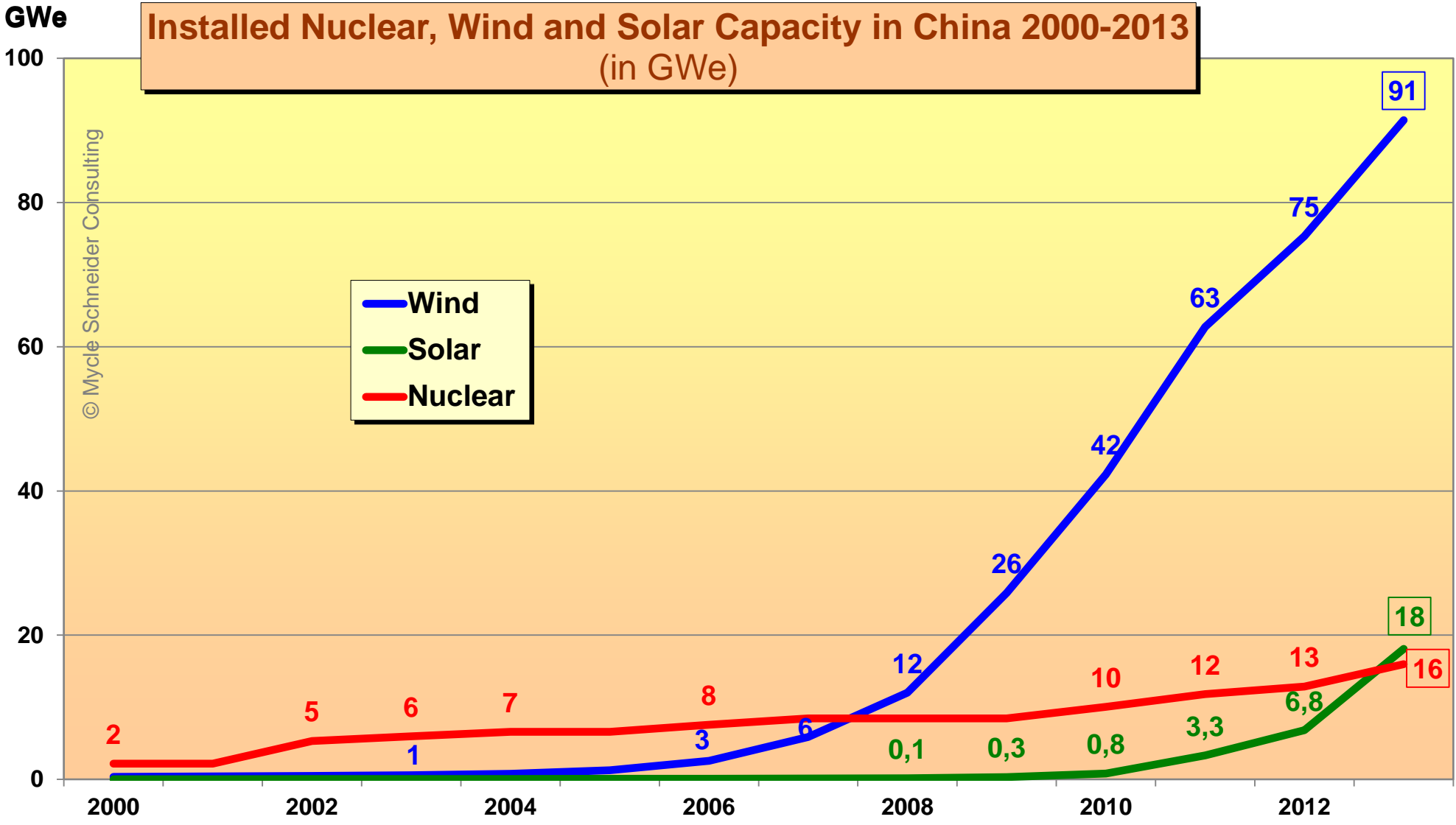


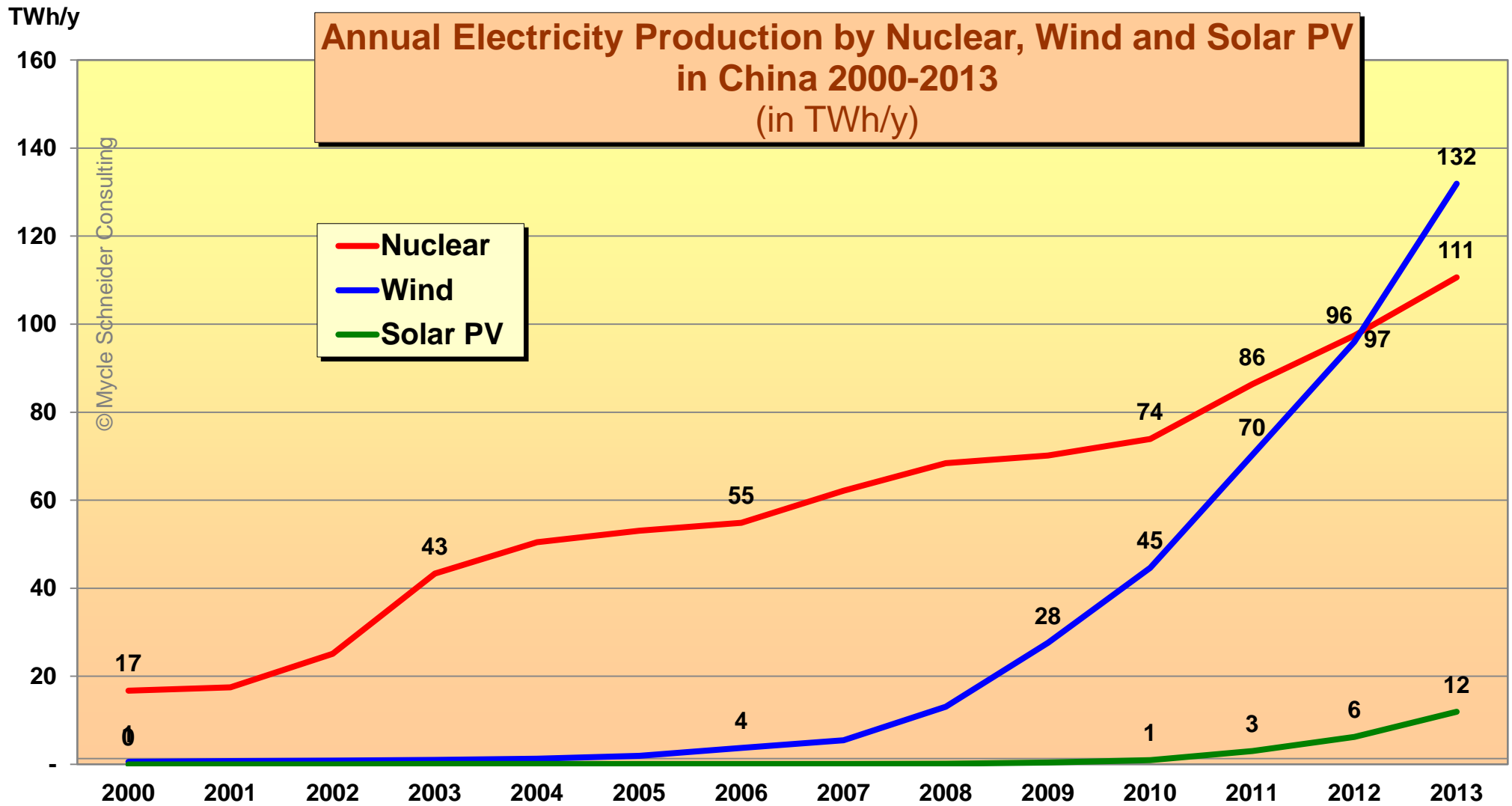
# Renewables Share of Global Electricity Generating Capacity Additions



Source: IRENA, Rethinking Energy, 2014

# Installed Nuclear, Wind and Solar Capacity in China 2000-2013 (in GWe)





Source: BP 2014

## Solar Photovoltaics in the U.S.

By 2017, more than half of the States could have rooftop solar that is as cheap as local electricity prices.

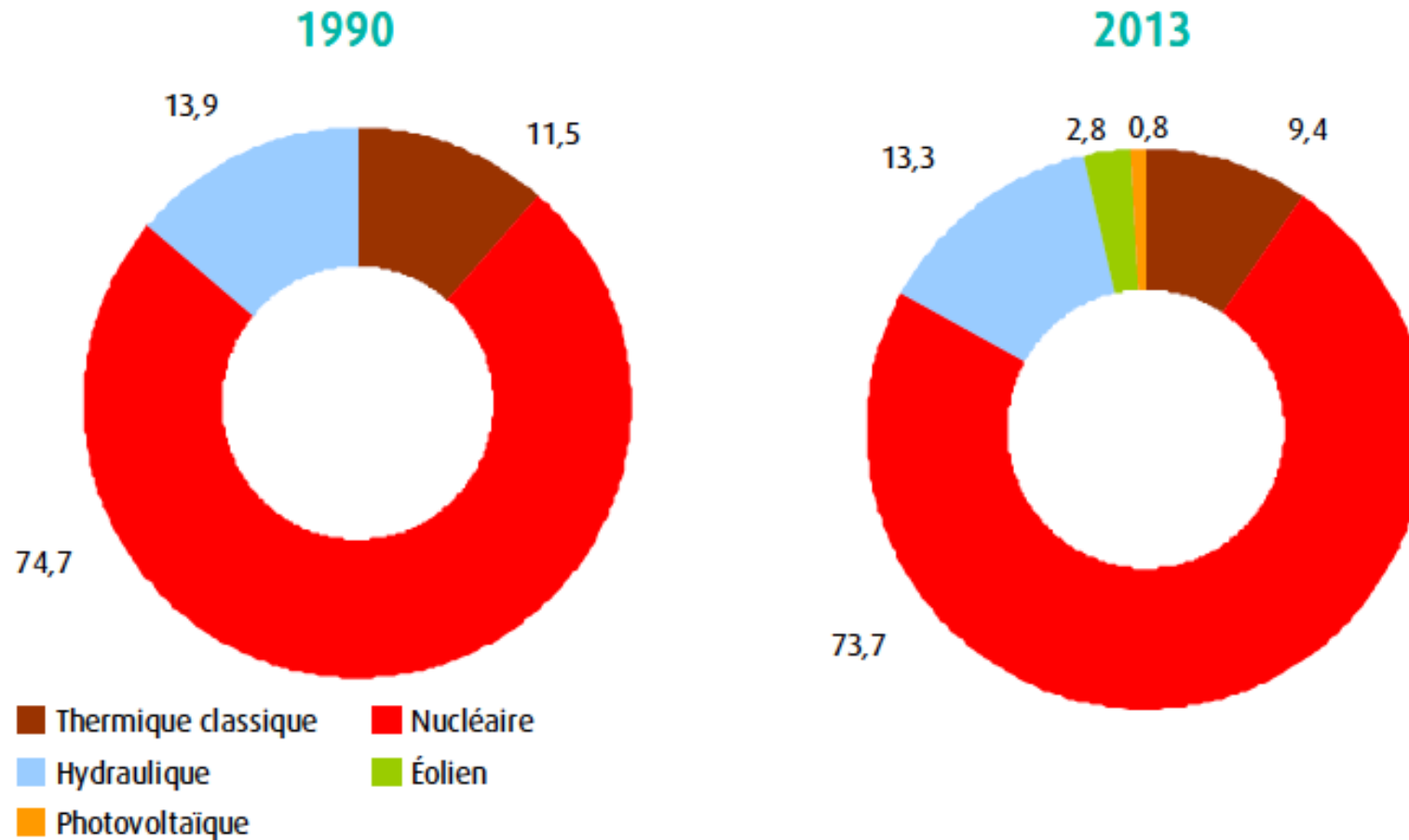
### THE NUMBER OF HOUSEHOLDS WITH ROOFTOP SOLAR IS SKYROCKETING



Projections assume 5 kilowatts per house;  
U.S. DOE Annual Energy Outlook 2014  
and SunShot Vision Study (2012) data.

Source: UCS,  
<http://www.ucsusa.org/>,  
2014

# Electricity Generation in France by Source

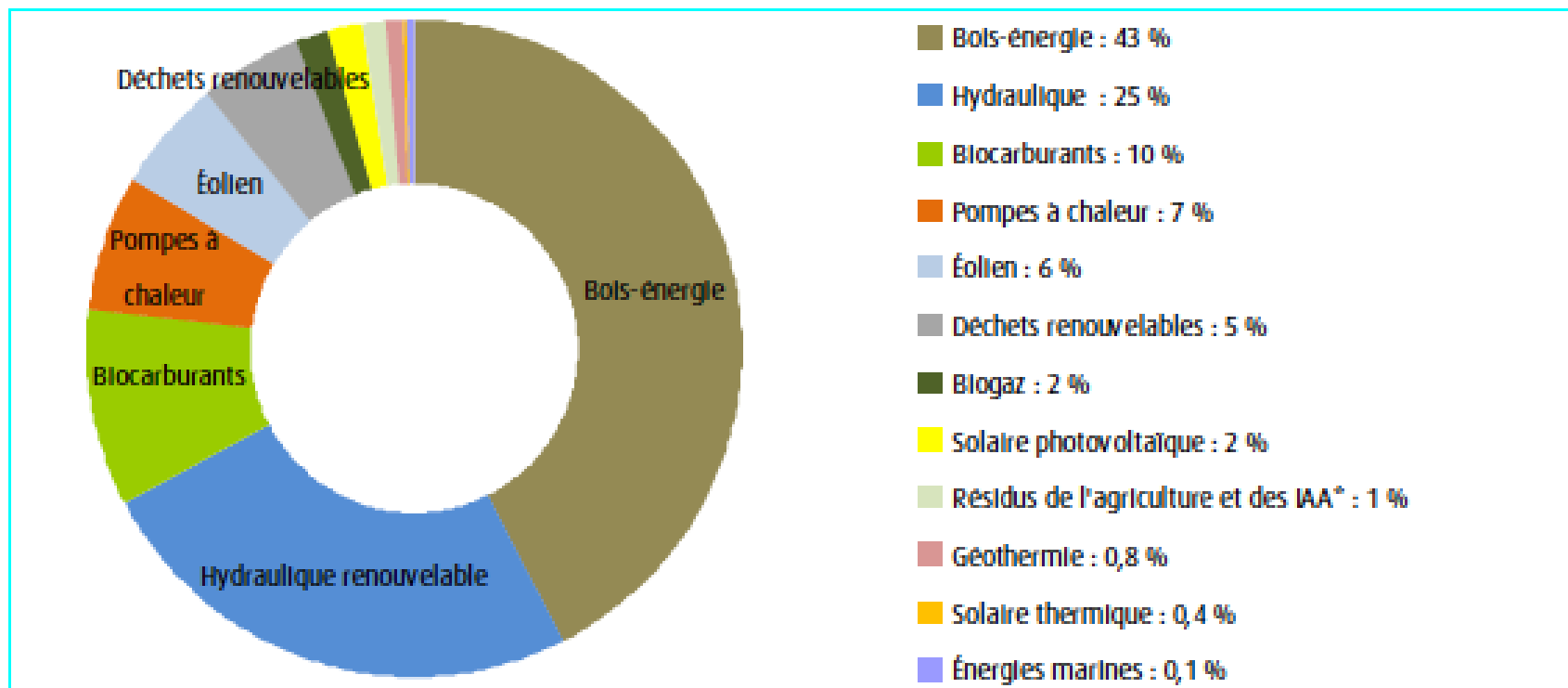


Source : RTE, EDF, SOeS (enquête annuelle sur la production d'électricité)



## Part de chaque filière dans la production primaire d'énergies renouvelables en 2013 (24,8 Mtep)

En %



\* Industries agroalimentaires.

Champ : métropole.

Source : SOeS, d'après les sources par filière

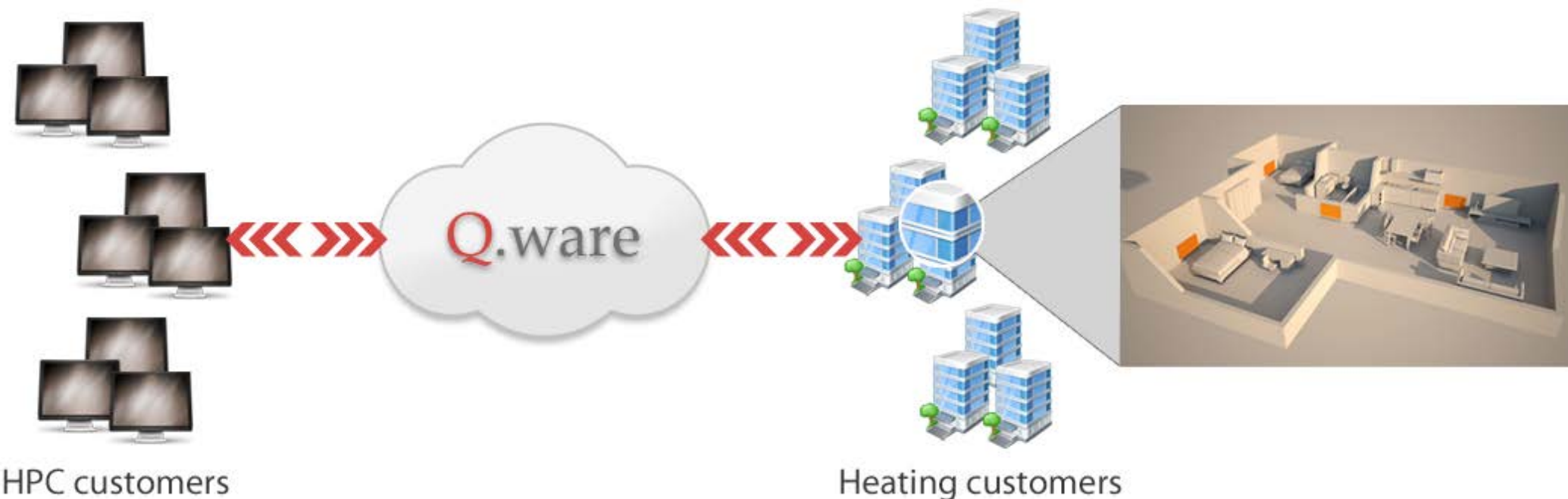
# Stock Price Development EDF vs. CAC40



Source: <http://finance.yahoo.com>, 13 March 2015

# New Competitive Concepts: Example Qarnot Computing

Heating with waste heat from processors placed in peoples' homes, rather than implementing expensive cooling for digital servers in huge data centers.



Source: <http://www.qarnot-computing.com>

Within two years, Qarnot Computing has built up a network of thousands of processors that are heating several hundred homes and offices in Paris for free and is providing commercial computing services far below market price.

**Thank You!**

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[www.WorldNuclearReport.org](http://www.WorldNuclearReport.org)

## About the Author



**Mycle Schneider** works as independent international consultant on energy and nuclear policy. He is the initiator and Convening Lead Author of the [World Nuclear Industry Status Reports](#) and the Coordinator of the Seoul International Energy Advisory Council (SIEAC). He is a member of the International Panel on Fissile Materials ([IPFM](#)), based at Princeton University, USA. In 2010-2011, he acted as Lead Consultant for the Asia Clean Energy Policy Exchange, implemented by [IRG](#), funded by [USAID](#), with the focus of developing a policy framework to boost energy efficiency and renewable energies. Between 2004 and 2009 he has been in charge of the Environment and Energy Strategies Lecture of the International Master of Science for Project Management for Environmental and Energy Engineering at the *Ecole des Mines* in Nantes, France.

From 2000 to 2010 he was an occasional advisor to the German Environment Ministry. 1998-2003 he was an advisor to the French Environment Minister's Office and to the Belgian Minister for Energy and Sustainable Development.

Mycle Schneider has given evidence or held briefings at national Parliaments in 14 countries and at the European Parliament. He has advised Members of the European Parliament from four different groups over the past 26 years. He has given lectures or had teaching appointments at 20 universities and engineering schools in 10 countries.

Mycle Schneider has provided information and consulting services to a large variety of clients including international institutions and organizations, think tanks and NGOs.

In 1997 he was honoured with the [Right Livelihood Award](#) ("Alternative Nobel Prize").