Lessons from System Analysis of Energy Policy in the US, France and Germany

Is Pursuing both Renewables *and* Nuclear Feasible?

Briefing at Diet of Japan, Tokyo, 13 October 2010

Mycle Schneider

International Consultant on Energy and Nuclear Policy, Paris, France

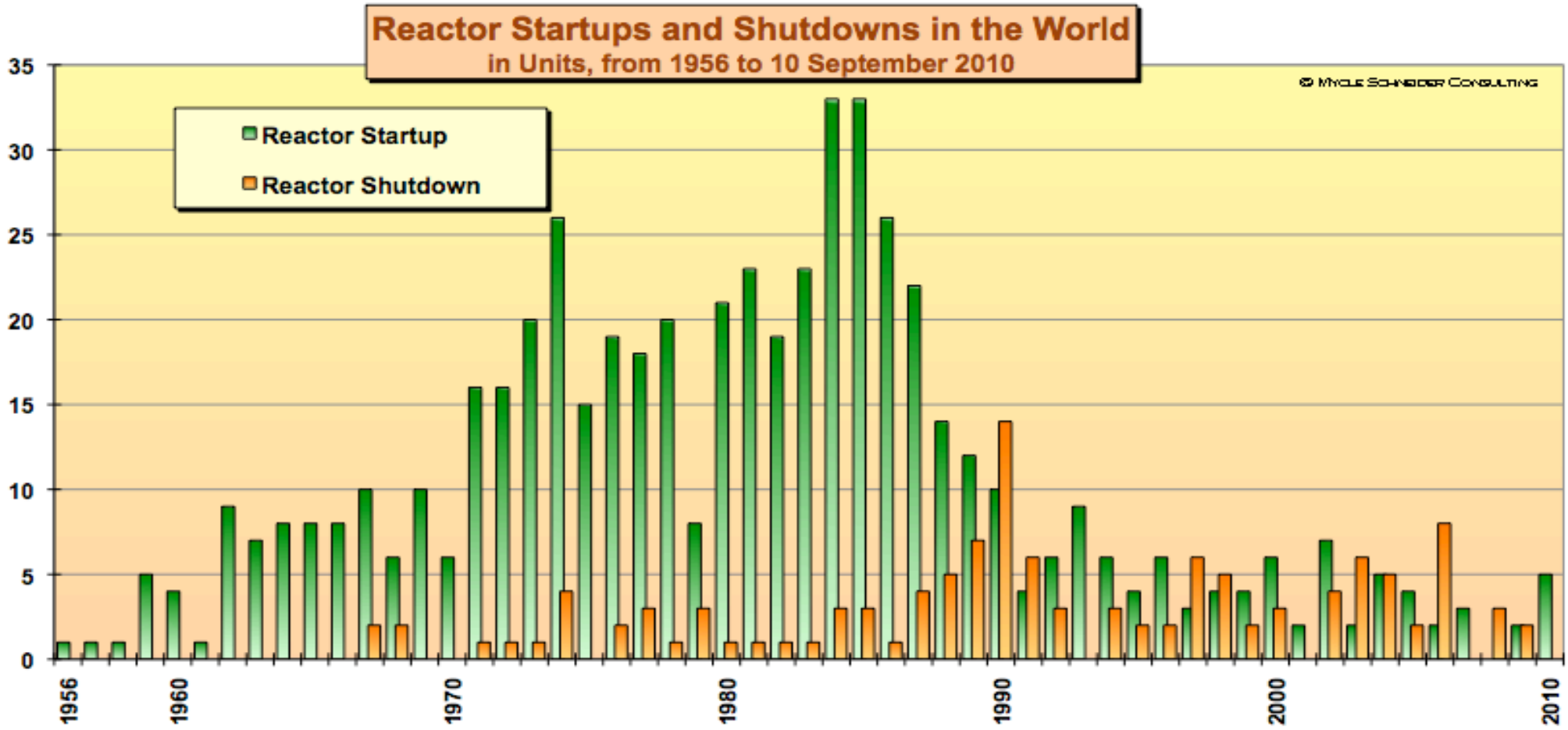
« Nuclear power is enjoying growing acceptance as a stable and clean source of energy that can help to mitigate the impact of climate change. »

Yukiya Amano
IAEA Director General
New York, 3 May 2010

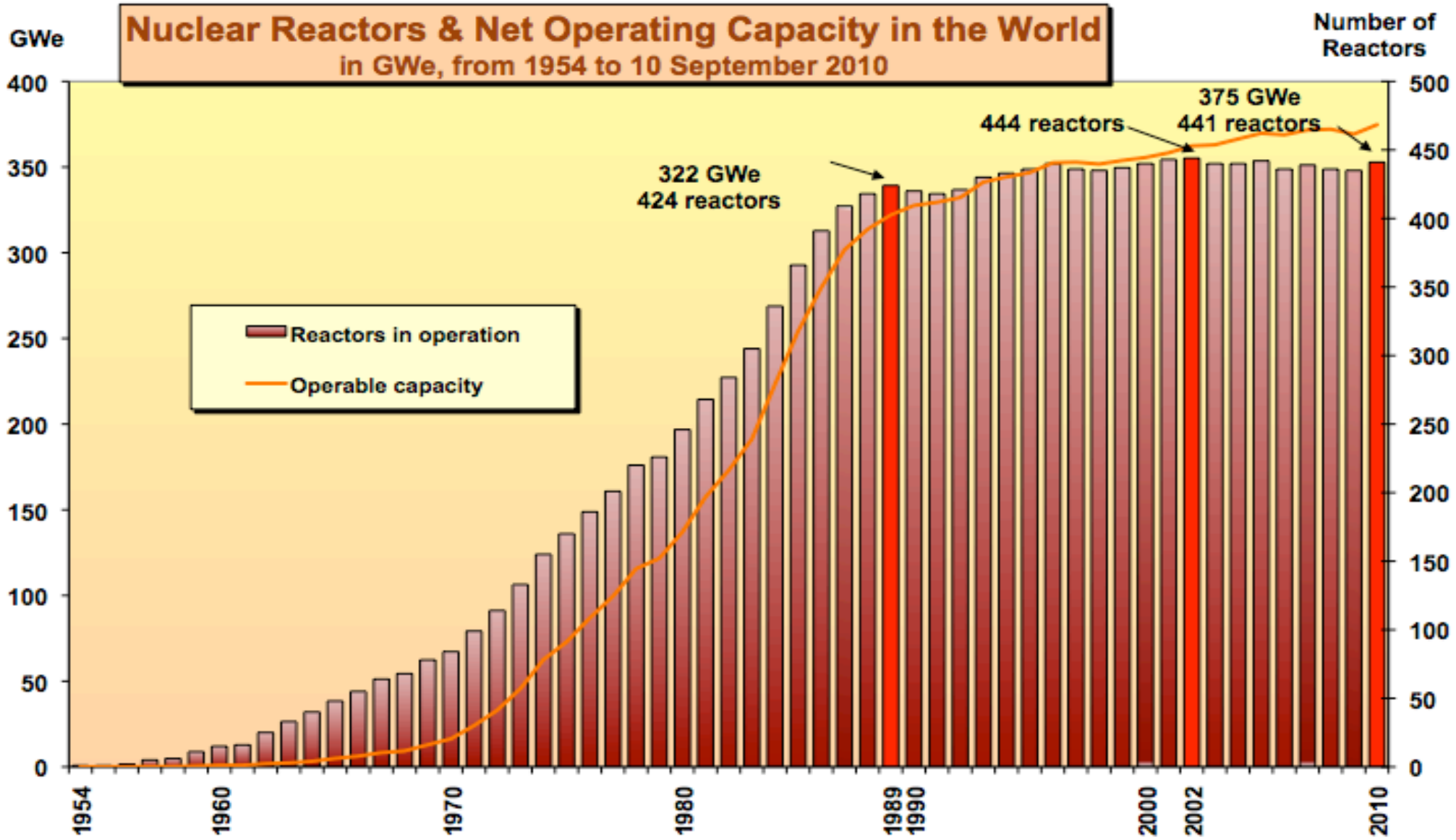
world nuclear news 5 May 2010

Another drop in nuclear generation

Annual generation of nuclear power has continued on a slight downward trend, decreasing 2% last year….

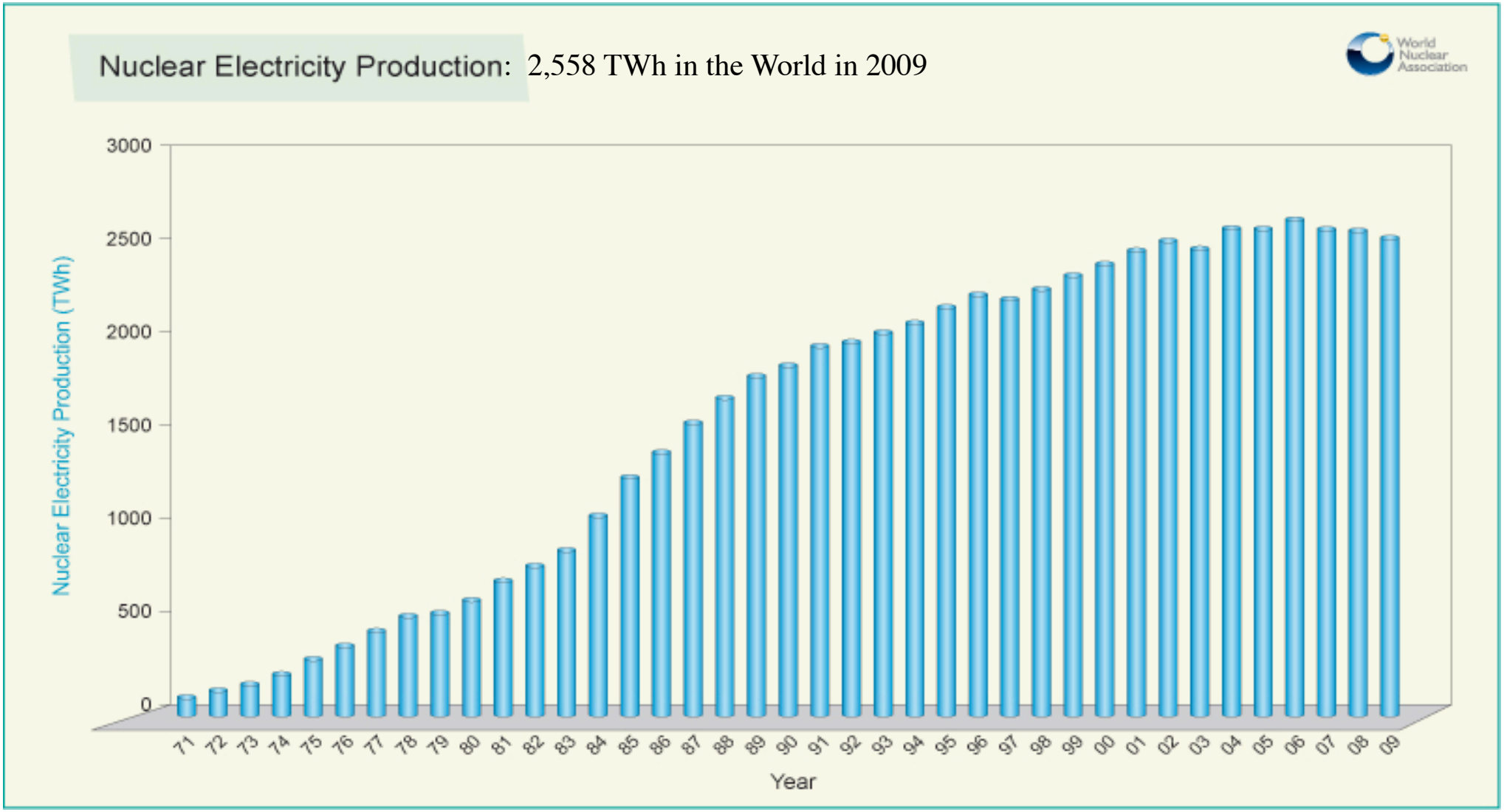


Source: IAEA-PRIS, MSC, 2010

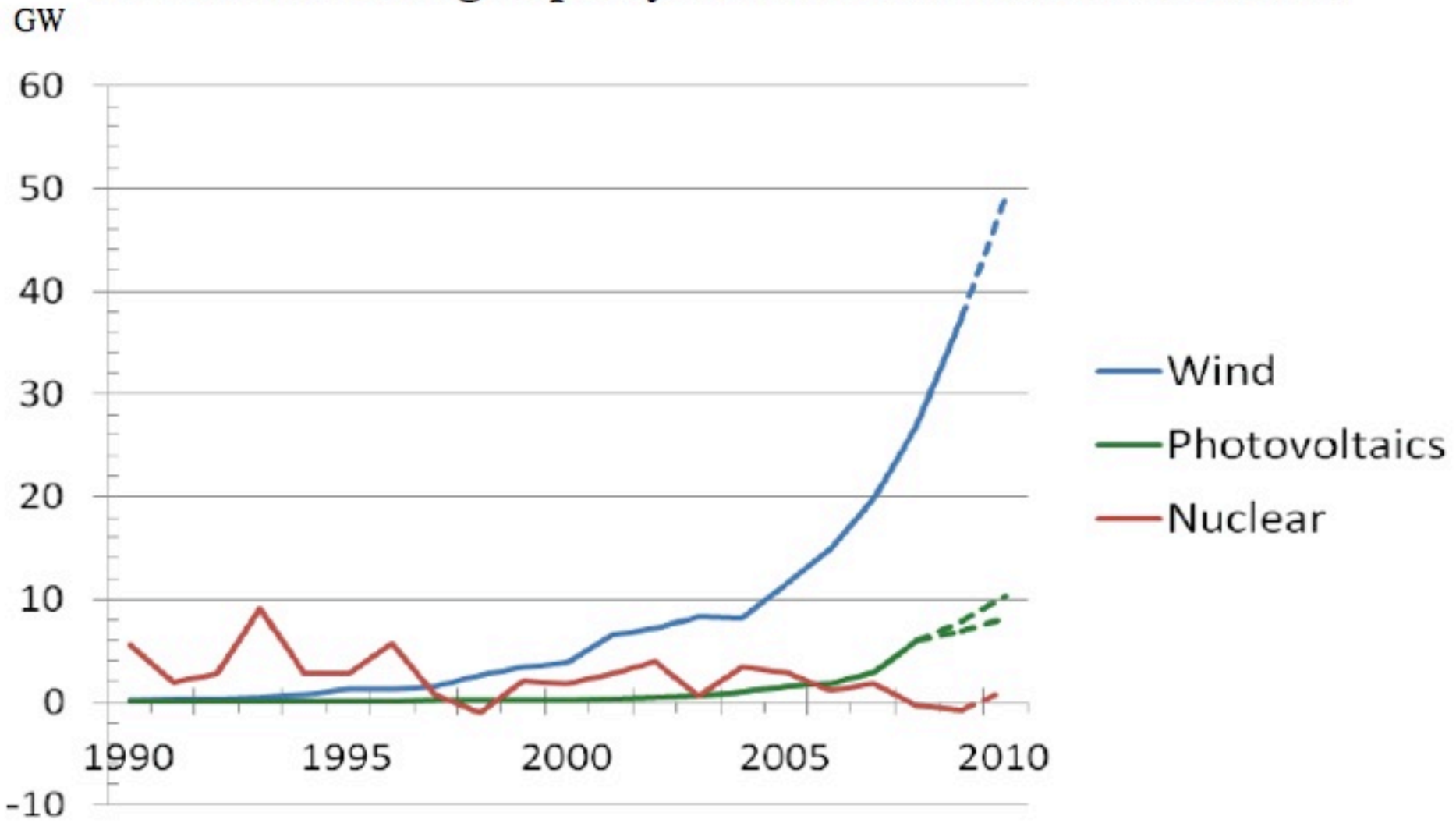


Source: IAEA-PRIS, MSC, 2010

« Another drop in nuclear generation… »

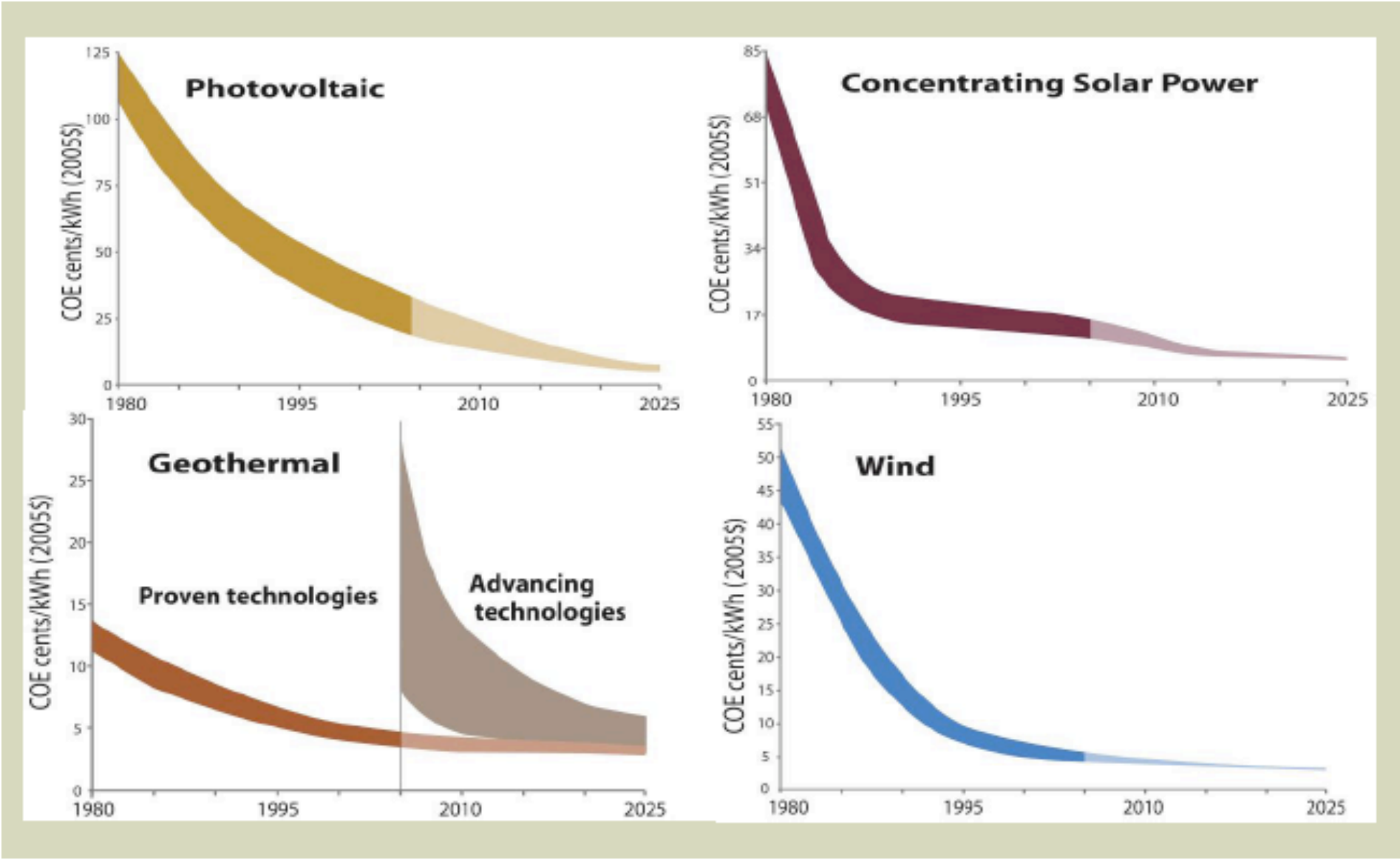


Annual Generating Capacity Additions in the World 1990-2010



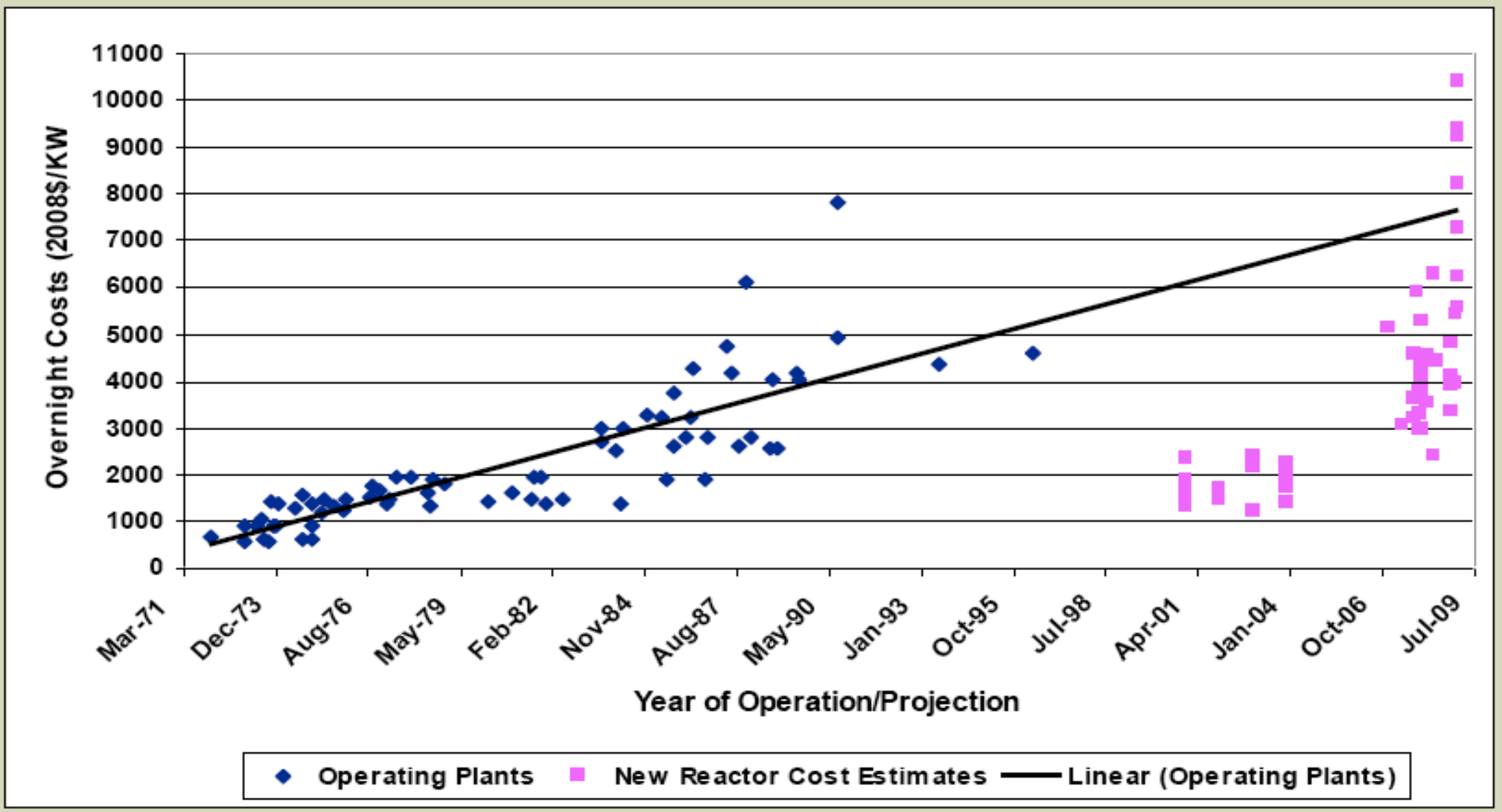
Source: Amory Lovins, RMI, personal communication, 2010

Technology Learning Curves



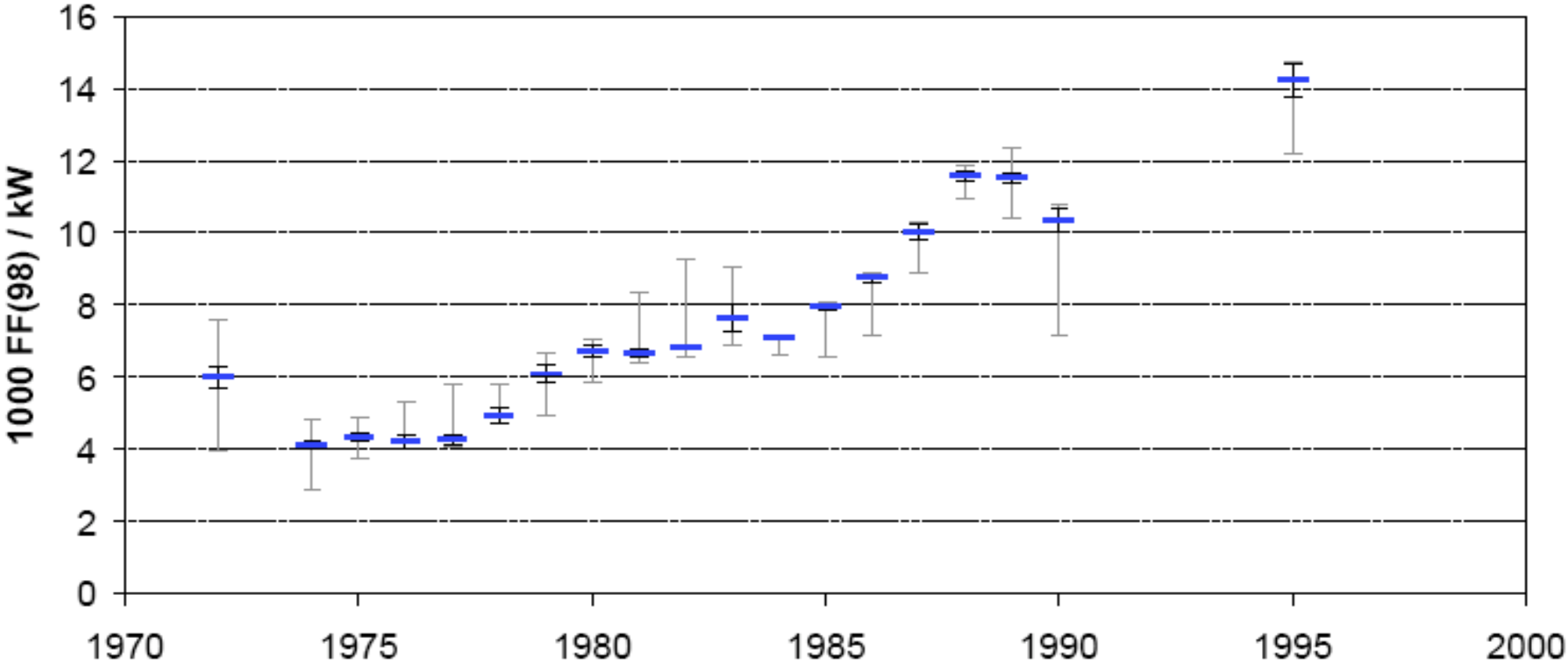
Source: Cooper 2010

Negative Learning Curve US Nuclear Reactors



Source: Cooper 2010

« Negative Learning Curve » of French PWRs



Source: Arnulf Grübler, «An assessment of the costs of the French nuclear PWR program 1970–2000 », 6 October 2009

Excessive Lead Times/Cost Overruns: Example Olkiluoto-3, Finland

1998-1999	TVO submits environmental impact assessment report.
2005	First concrete in August.
2006	Project running 18 months late.
2007	Project running 24 months late.
2008	Project running at least 36 months late.
2010	Project running at least 42 months late
2013	Start-up?

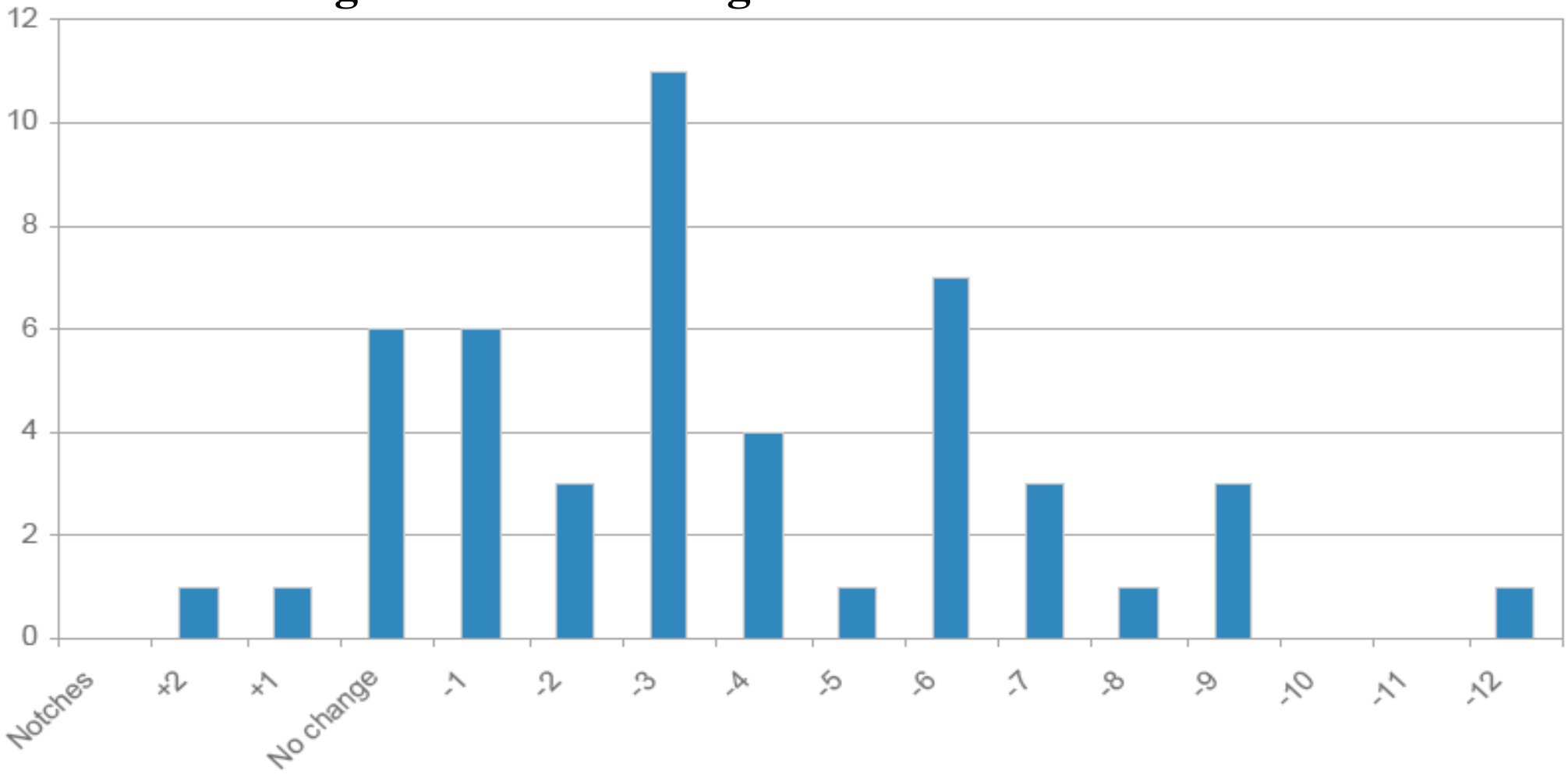
Lead Time: at least 14-15 years since EIA

Official Price: ca. €3 Billion (Guaranteed Fix Price)

Cost Overrun 5 Years after Construction Start: +€2.7 Billion (+90%)

Sources: Various, compiled by MSC

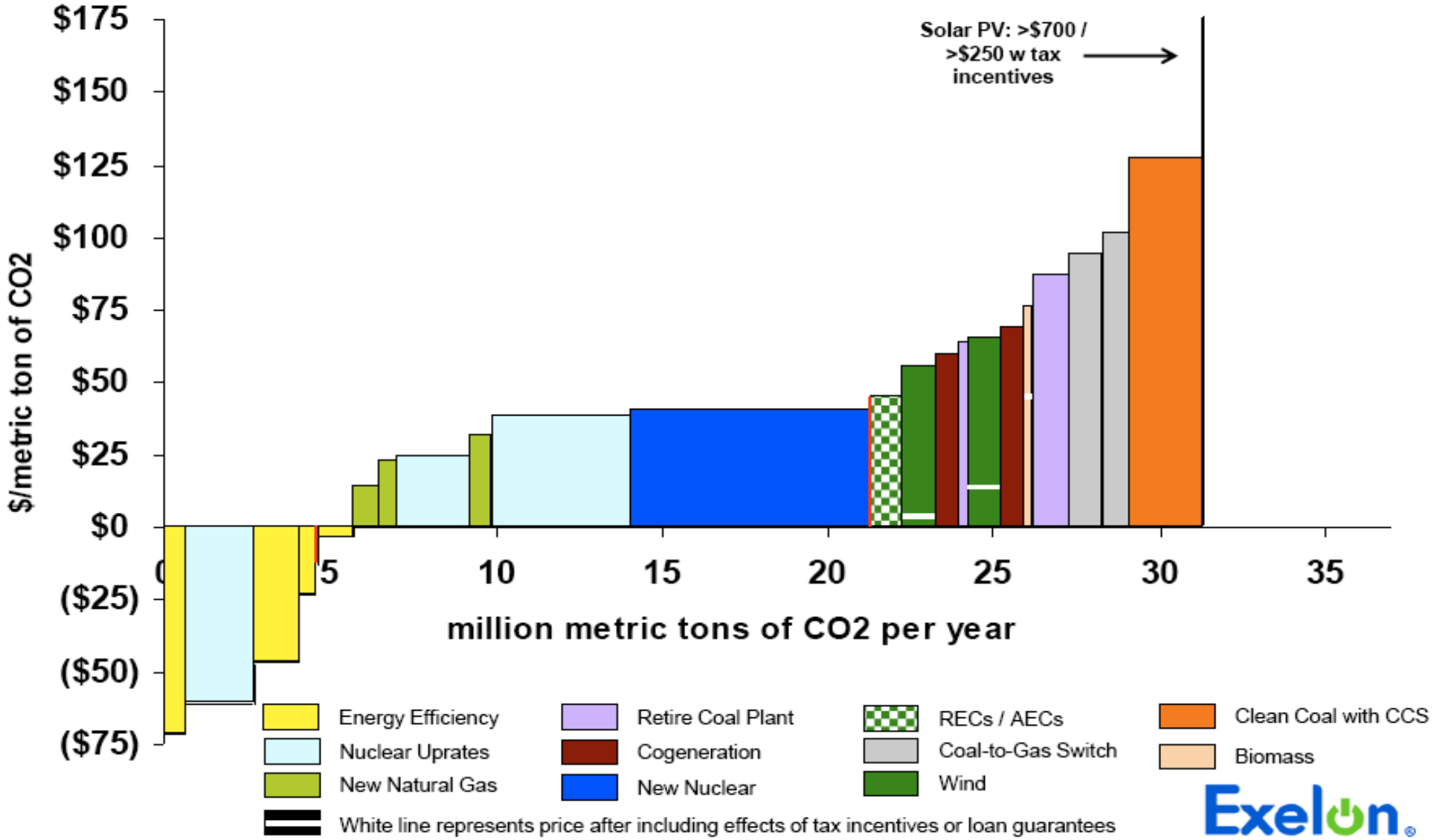
Changes in Credit Rating of 48 US Nuclear Utilities



"Moody's is considering applying a more negative view for issuers that are actively pursuing new nuclear generation."

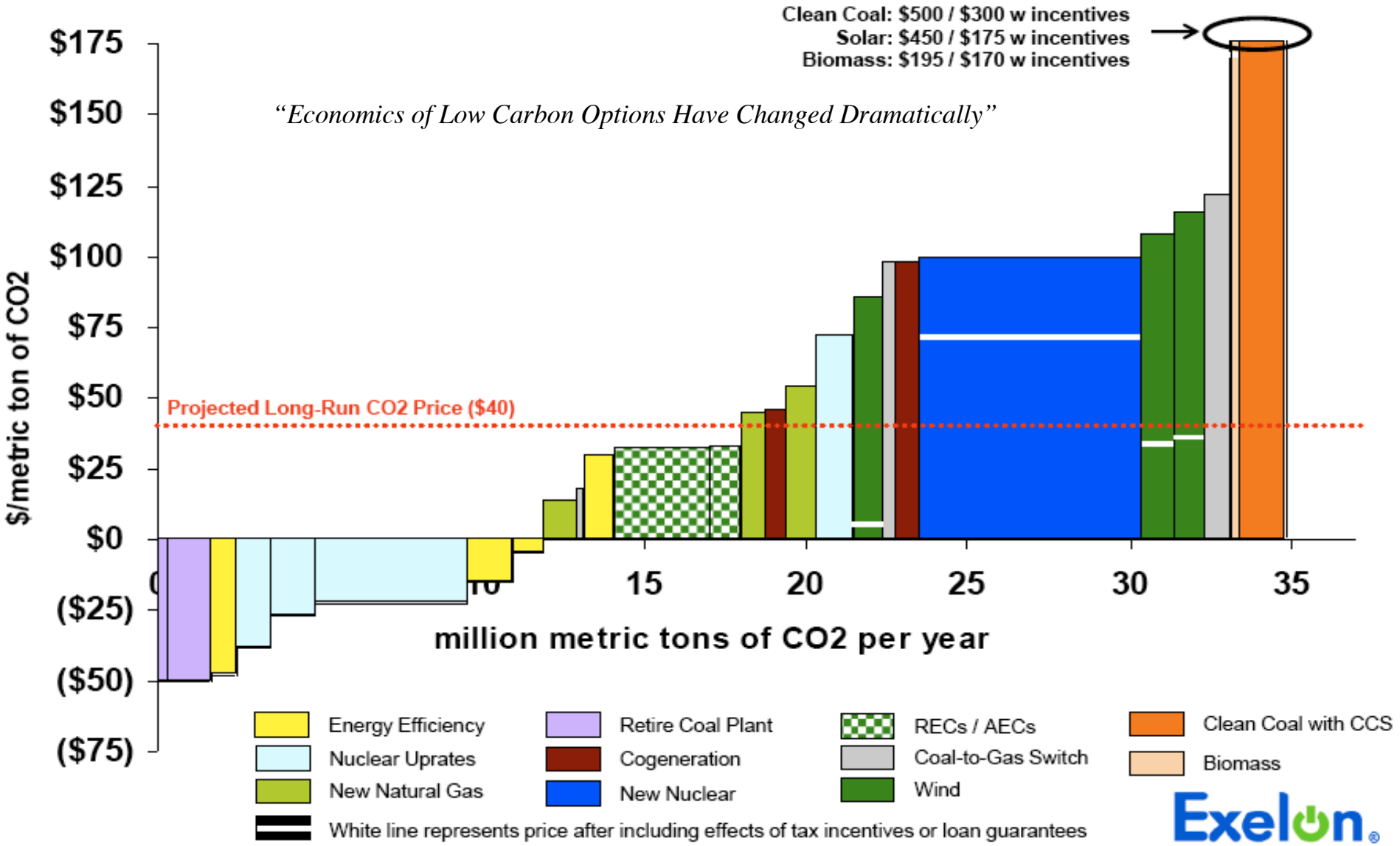
Source: Moody's, "New Nuclear Generation: Ratings Pressure Increasing", 2009

Exelon's View of Carbon Abatement Options in 2008



Source: John Rowe, Exelon

Exelon's View of Carbon Abatement Options in 2010



Source: John Rowe, Exelon

The Washington Post

Constellation Energy shelves plan for Calvert Cliffs reactor

By Steven Mufson
Saturday, October 9, 2010; 12:14 AM

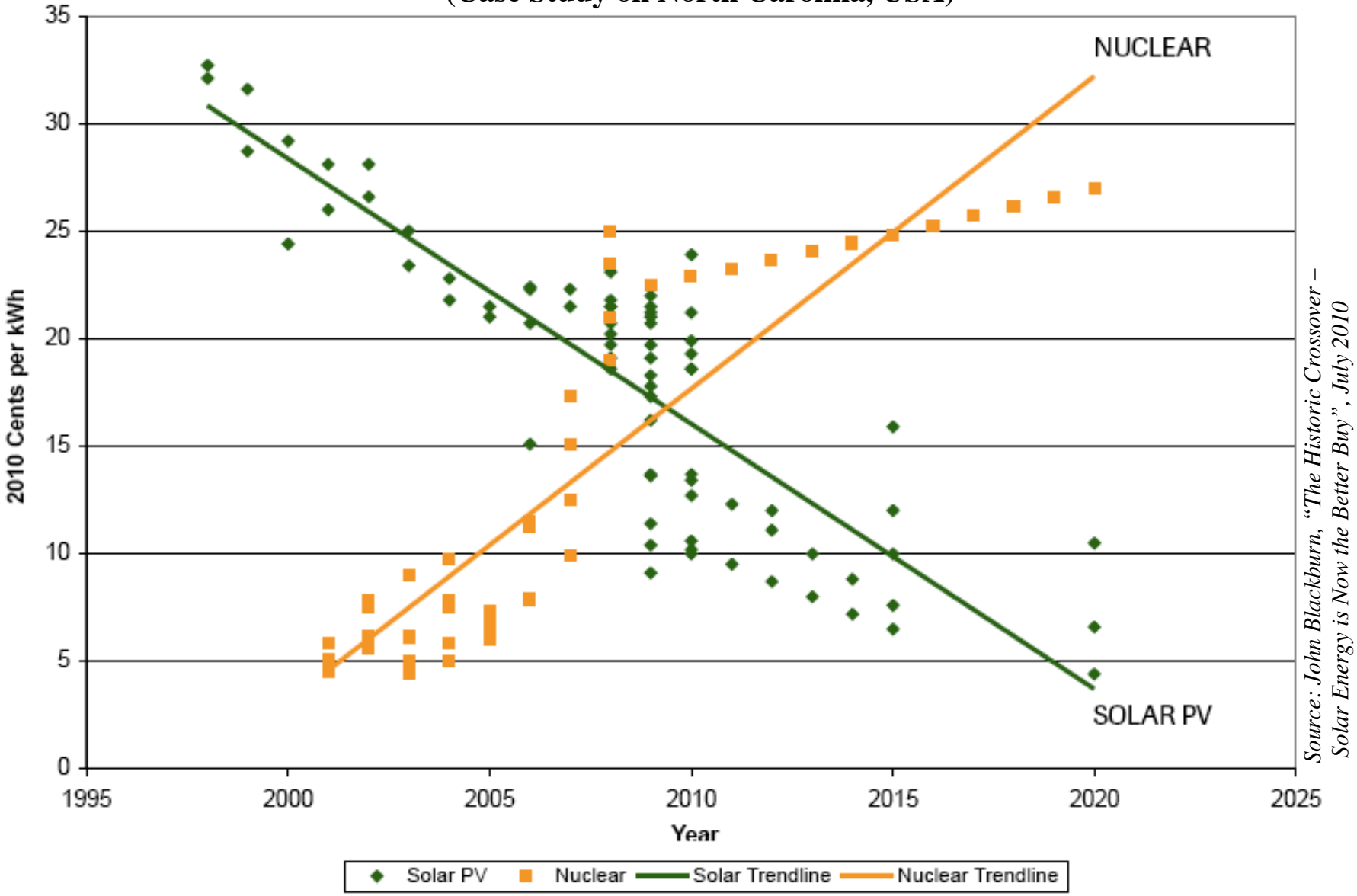
Constellation Energy has shelved its proposal to build a new reactor at its Calvert Cliffs nuclear power plant, Obama administration officials said Friday, even though the administration had decided to award the project a $7.5 billion loan guarantee.

Senior administration officials said Constellation's decision was "a surprise," but a Constellation Energy spokesman Larry McDonnell said that the administration's loan guarantee terms were "unworkable" and that Constellation had told the Energy Department "we can't move forward."

The decision by Constellation deals a blow to the idea of a U.S. nuclear renaissance. Constellation and French power company Electricite de France are partners in Unistar, a joint venture that had intended to make the new Calvert Cliffs reactor the first of a fleet of identical units around the country. They filed the loan guarantee application in July 2007.

Historic Generation Cost Crossover in 2010: Solar PV / New Nuclear

(Case Study on North Carolina, USA)



Source: John Blackburn, "The Historic Crossover – Solar Energy is Now the Better Buy", July 2010

« Is the Public Ahead of the Utilities? »

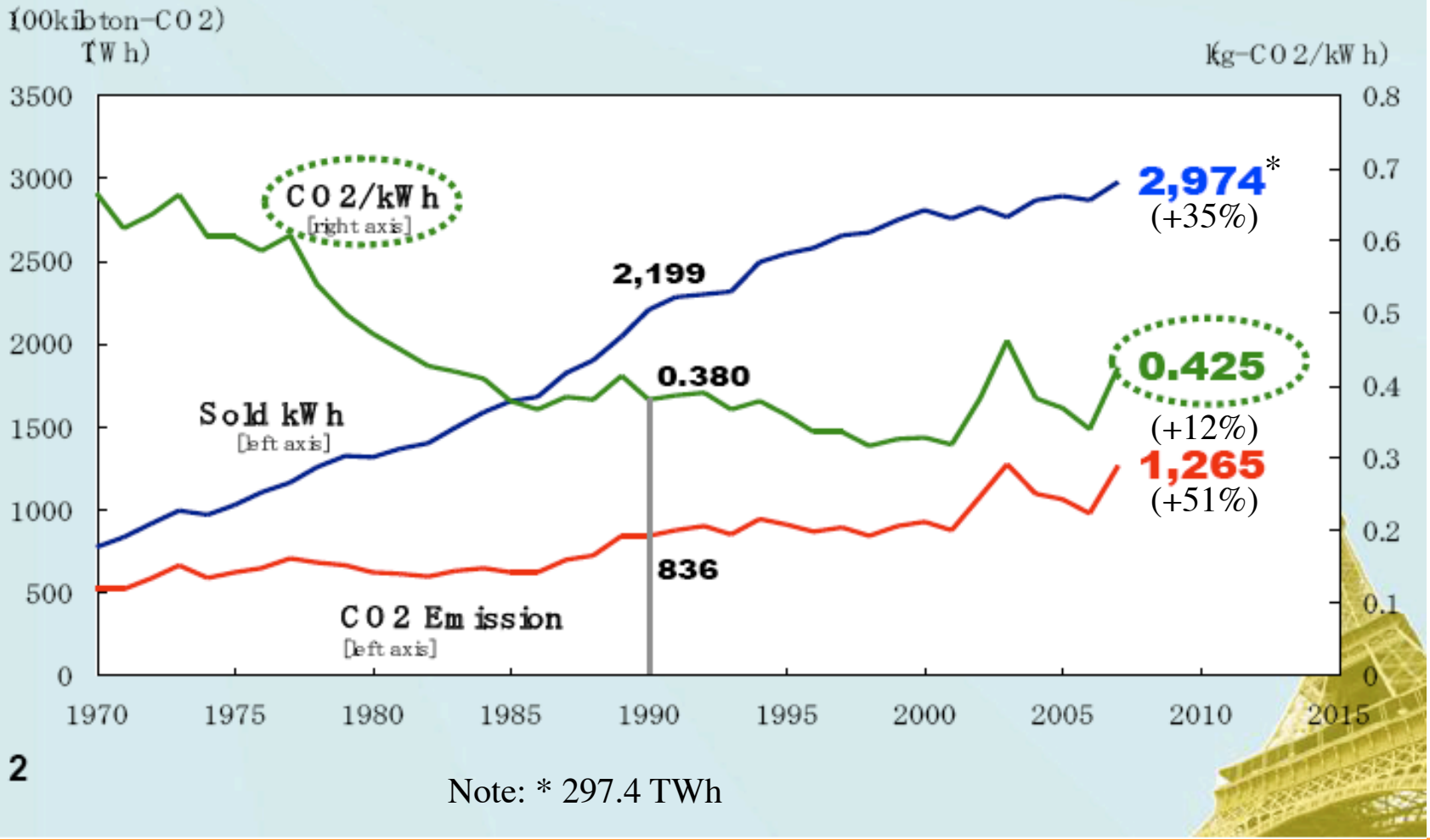
Prof. John Blackburn

"The Historic Crossover – Solar Energy is Now the Better Buy", July 2010

ee GLOBAL 2009 ENERGY EFFICIENCY GLOBAL FORUM & EXPOSITION

Supply Side

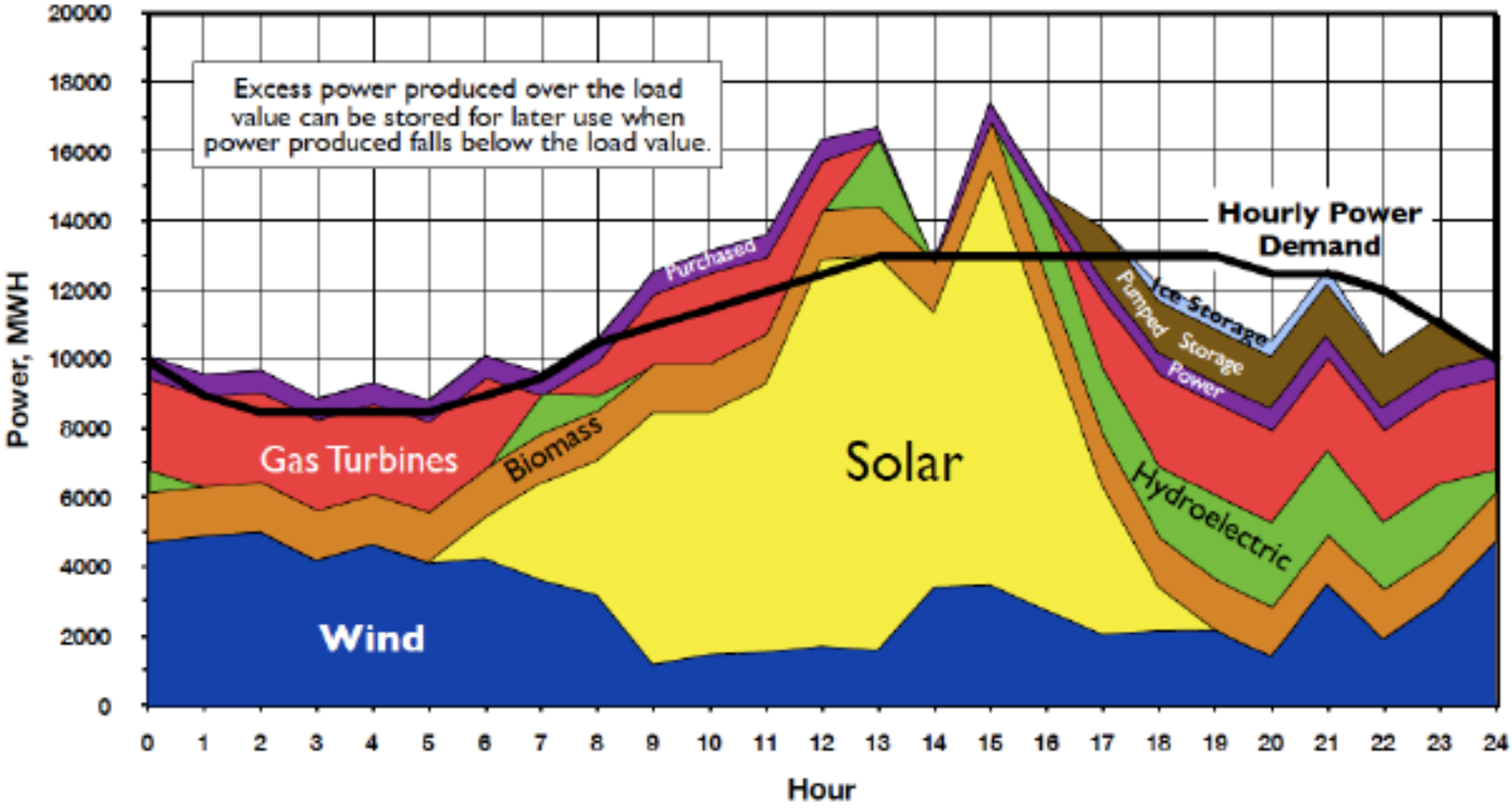
Trend of Carbon Emission from TEPCO



Note: * 297.4 TWh

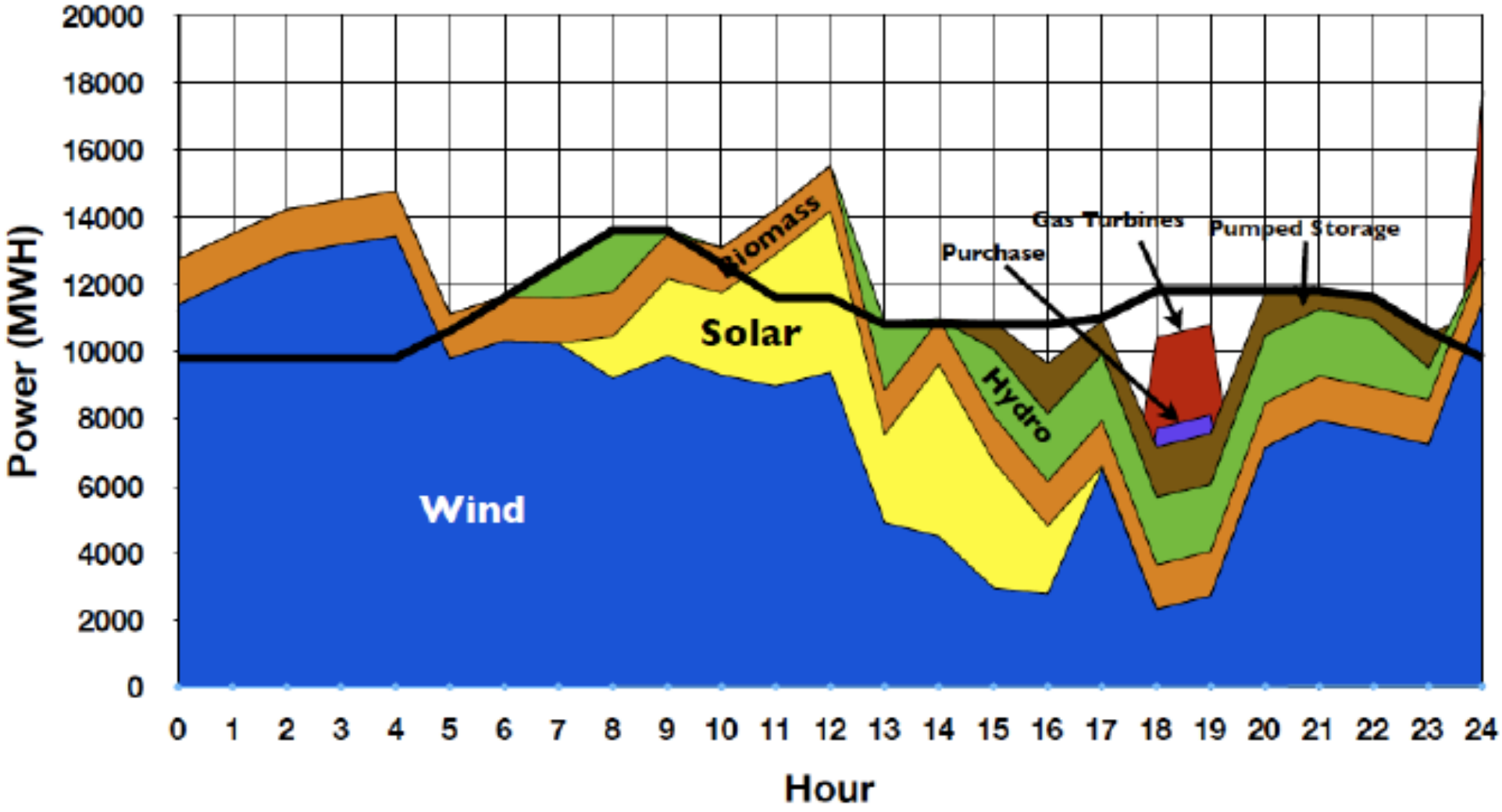
Source: TEPCO 2009

Hourly Power Generation and Load for a sample day in July



Source: John Blackburn, "Matching Utility Loads with Solar and Wind Power in North Carolina Dealing with Intermittent Electricity Sources", March 2010

Hourly Power Generation and Load for a sample day in January



Source: John Blackburn, "Matching Utility Loads with Solar and Wind Power in North Carolina Dealing with Intermittent Electricity Sources", March 2010

Conclusions of Blackburn Study on North-Carolina

• System with annual sales of 91 TWh (1/3 of TEPCO) can be run with 76% of total generation coming from solar and wind sources
+2,000 megawatts of biomass generation or cogeneration,
+2,500 megawatts of hydroelectric capacity, and
+1,500 megawatts of pumped storage.

• If ice storage (in the summer), load control, and access to vehicle batteries, purchases and auxiliary generation are needed for 6% of electricity loads.

• Only for 17 hours out of 2,952 hours examined generation falls short.

• Permits the utility systems ***"to operate with a complement of backup generation capacity which is smaller than the backup facilities commonly used in the present systems and their huge centralized coal or nuclear baseload plants."***

The Grid or the Missing Link

Urgently Needed:

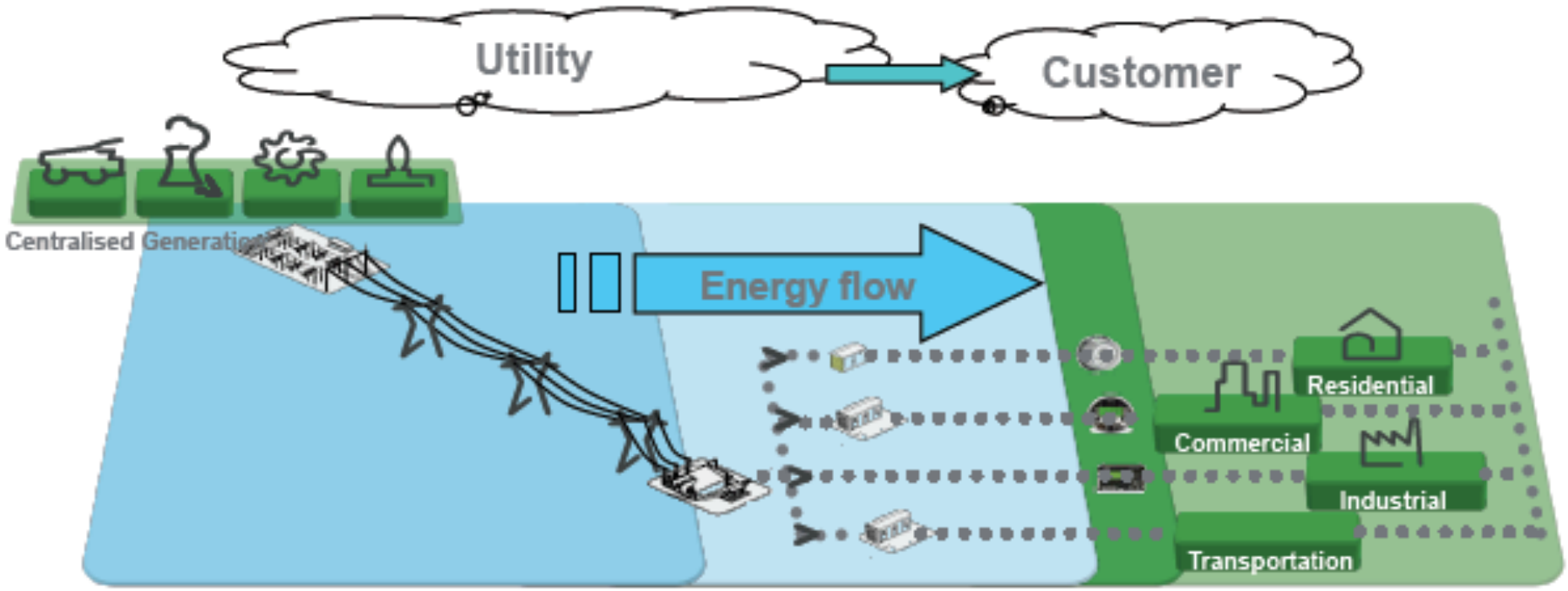
- Systemic analysis of optimized transport and distribution networks;

- Assessments of technical and social potentials/issues of decentralized approaches (micro-grids, smart grids, grid cluster, VPPs...)

- Evaluation of competing/conflicting options (big vs. small)

The Traditional Electricity Grid

- Central production adapting to demand variation
- Top-down energy flow
- Production / consumption balance done by integrated utility companies
- Rather passive users



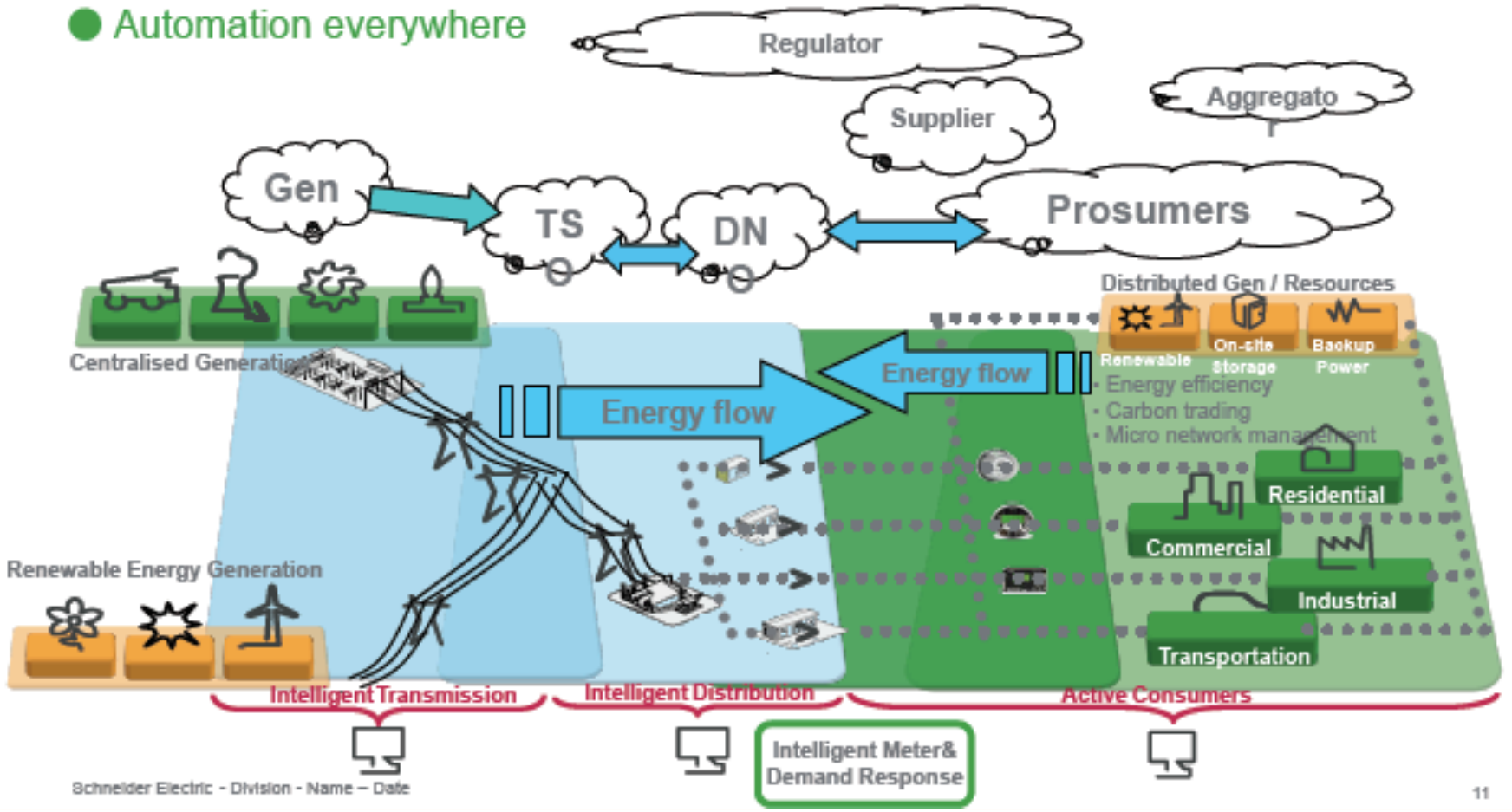
Source: Sanjay Verma, Manila, June 2010

The Smarter Grid with New Requirements

- New roles and contribution (Prosumers ….)
- Behavioural changes
- Best use of communication technologies
- Real time & visibility
- Automation everywhere

But also

- Energy Efficiency
- Renewable decentralized sources
- Energy storage



Source: Sanjay Verma, Manila, June 2010

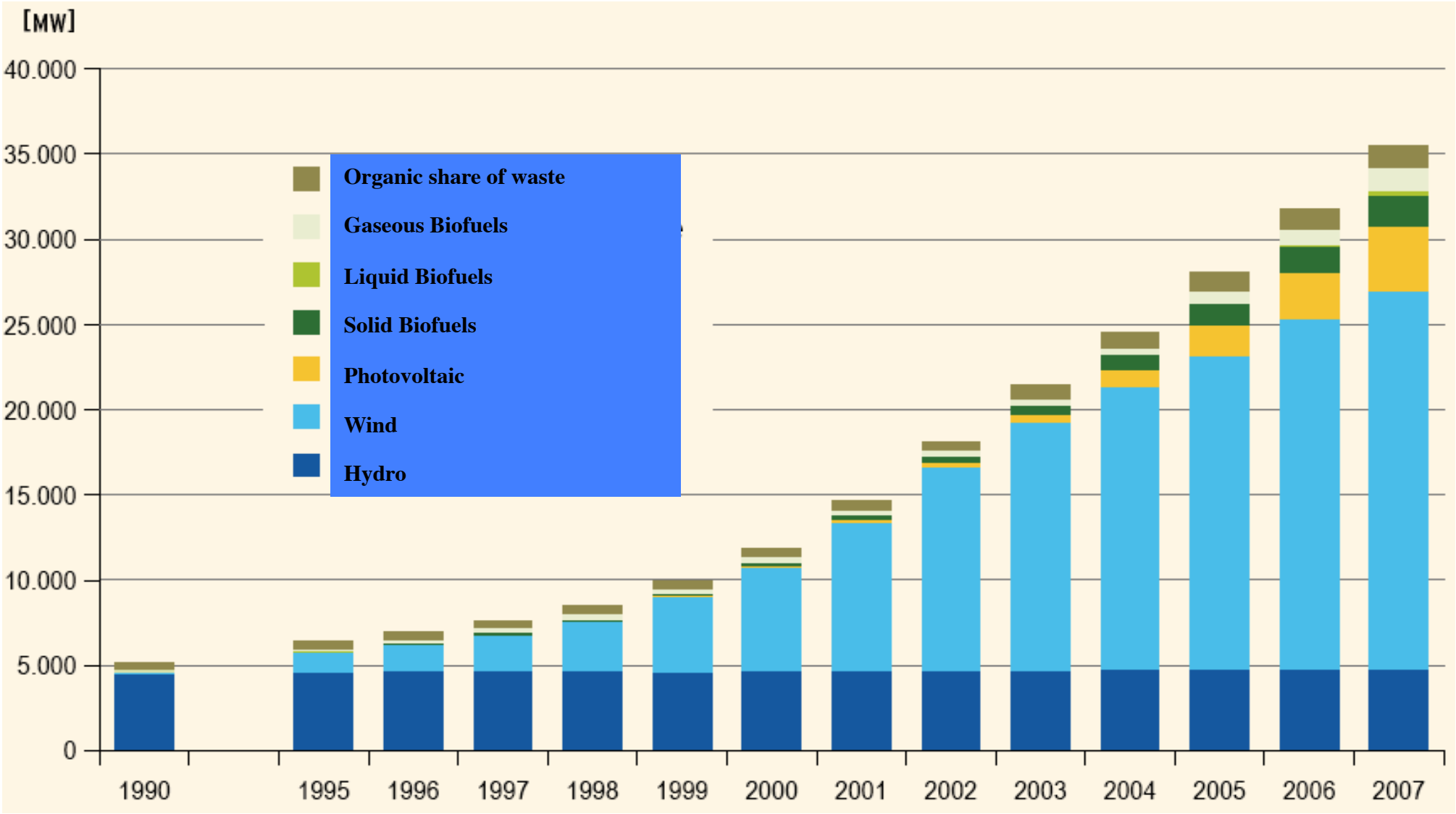
Energy Policy in Germany

A Systemic Analysis

MYCLE SCHNEIDER CONSULTING mycle@orange.fr

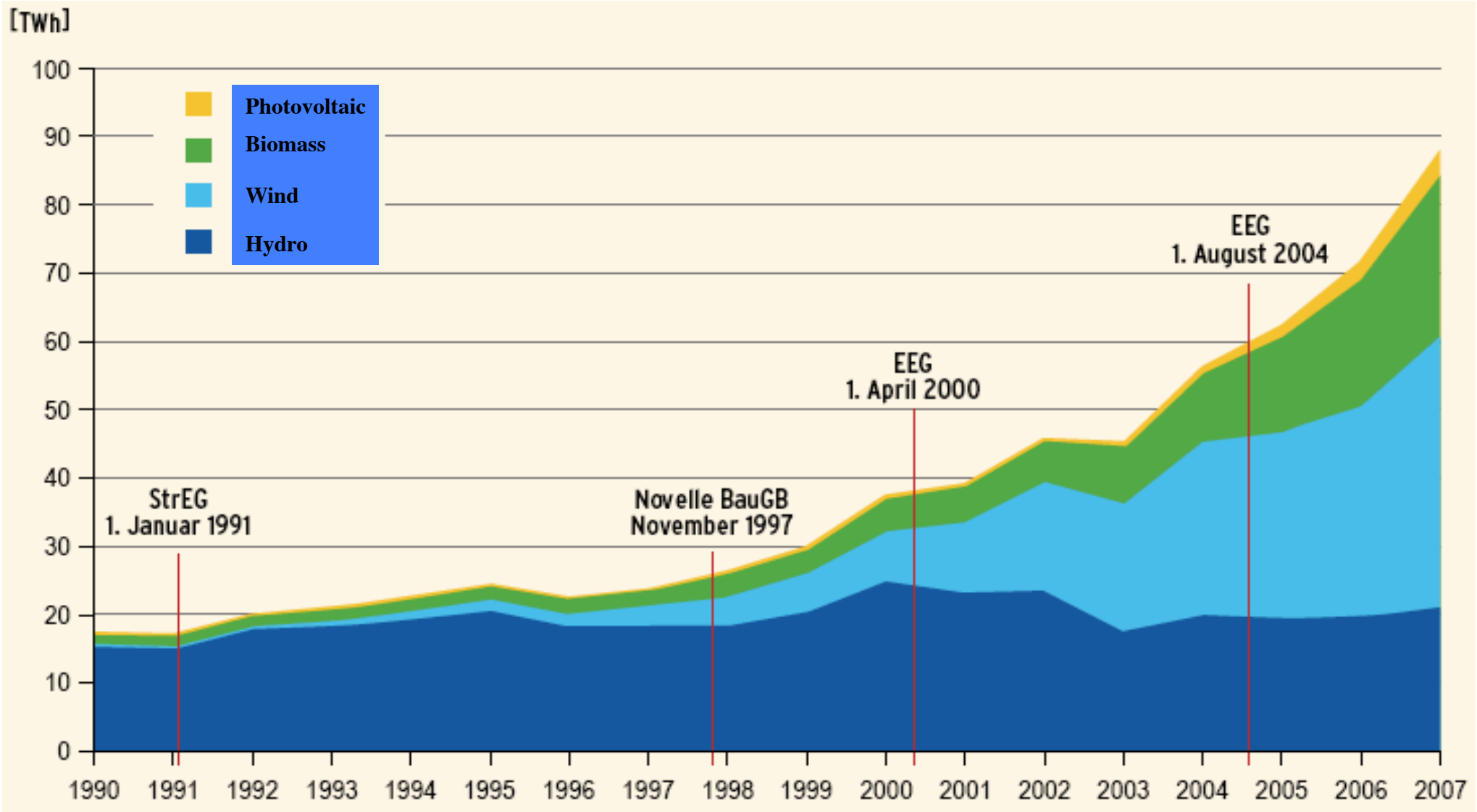
Tokyo, 13 October 2010

Renewable Electricity Generating Cap. in Germany 1990-2007 (in MW)



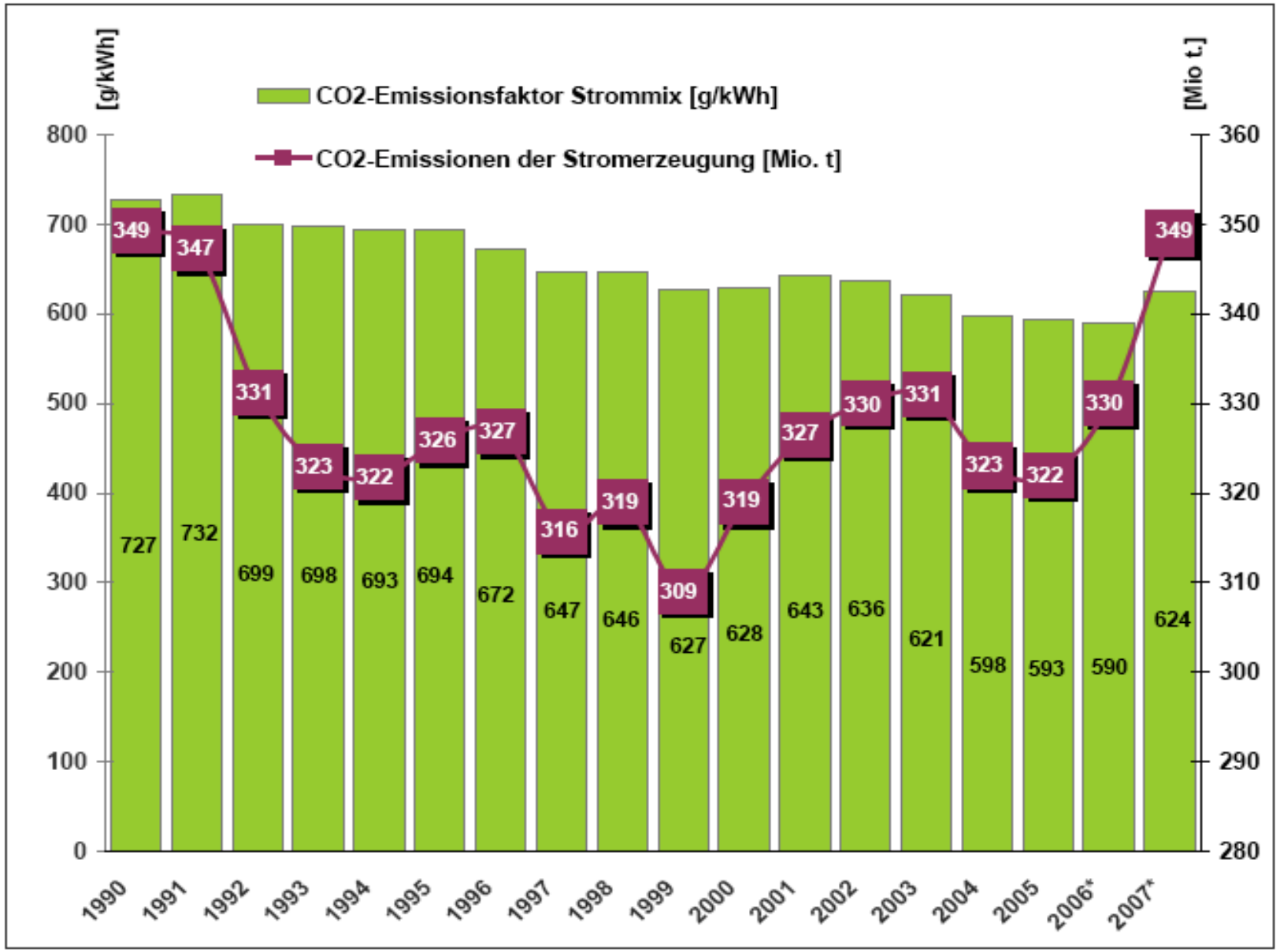
Source: BMU, "Erneuerbare Energien in Deutschland 1990-2007", 2010

Electricity Generation by Renewables in Germany 1990-2007 (in TWh)



Source: BMU, "Erneuerbare Energien in Deutschland 1990-2007", 2010

CO2-Emissions of the Electricity Generation in Germany 1990-2007



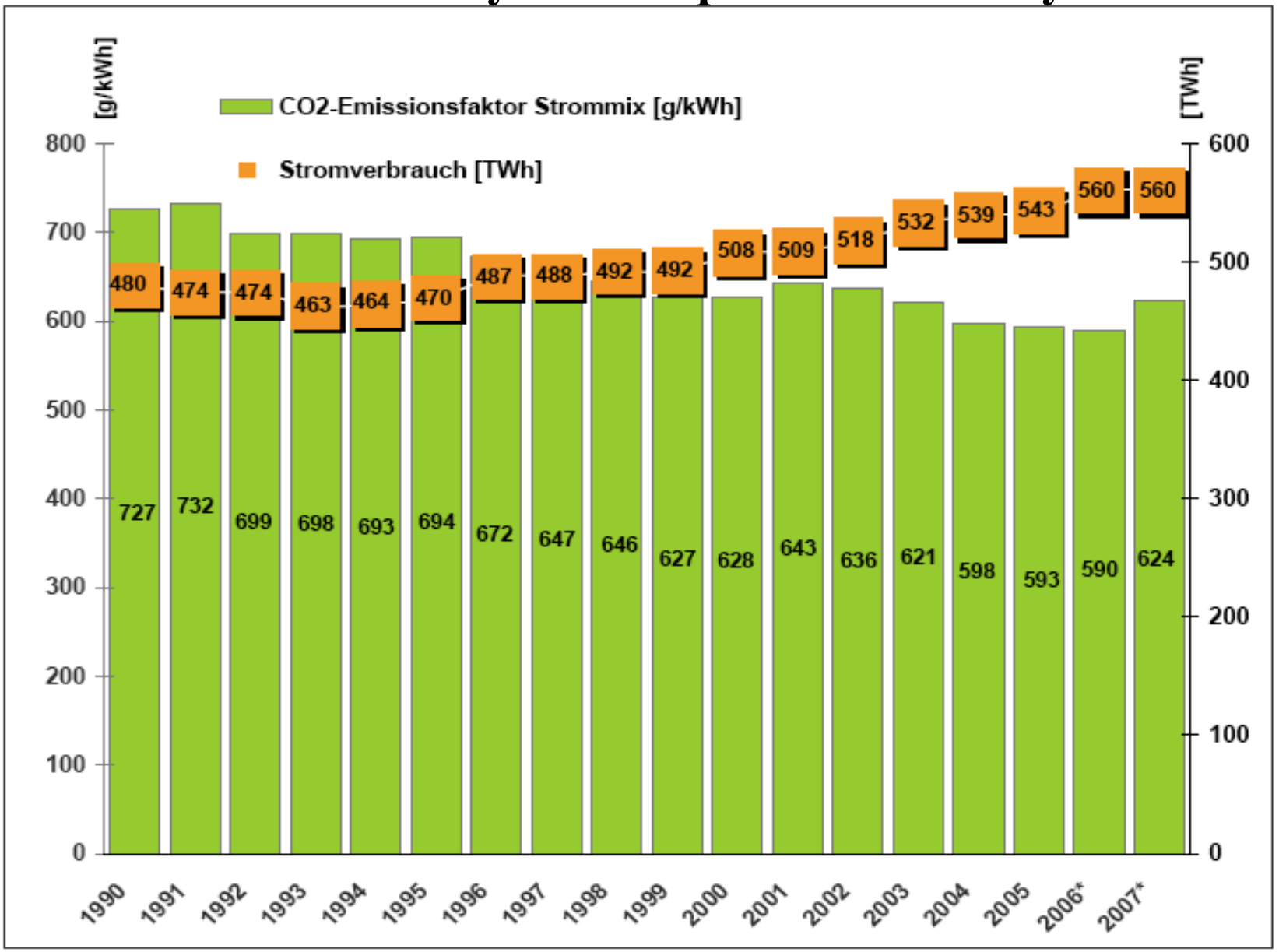
Source: Umweltbundesamt, 2009

Renewable Energy in Electricity Generation in Germany

	1990	2007
Share (in %)	3	14
Production (in TWh)	17	88
Wind Capacity (in MW)	68	22,000
PV Capacity (in MW)	2	3,800
CO2 (in million tonnes)	349	349

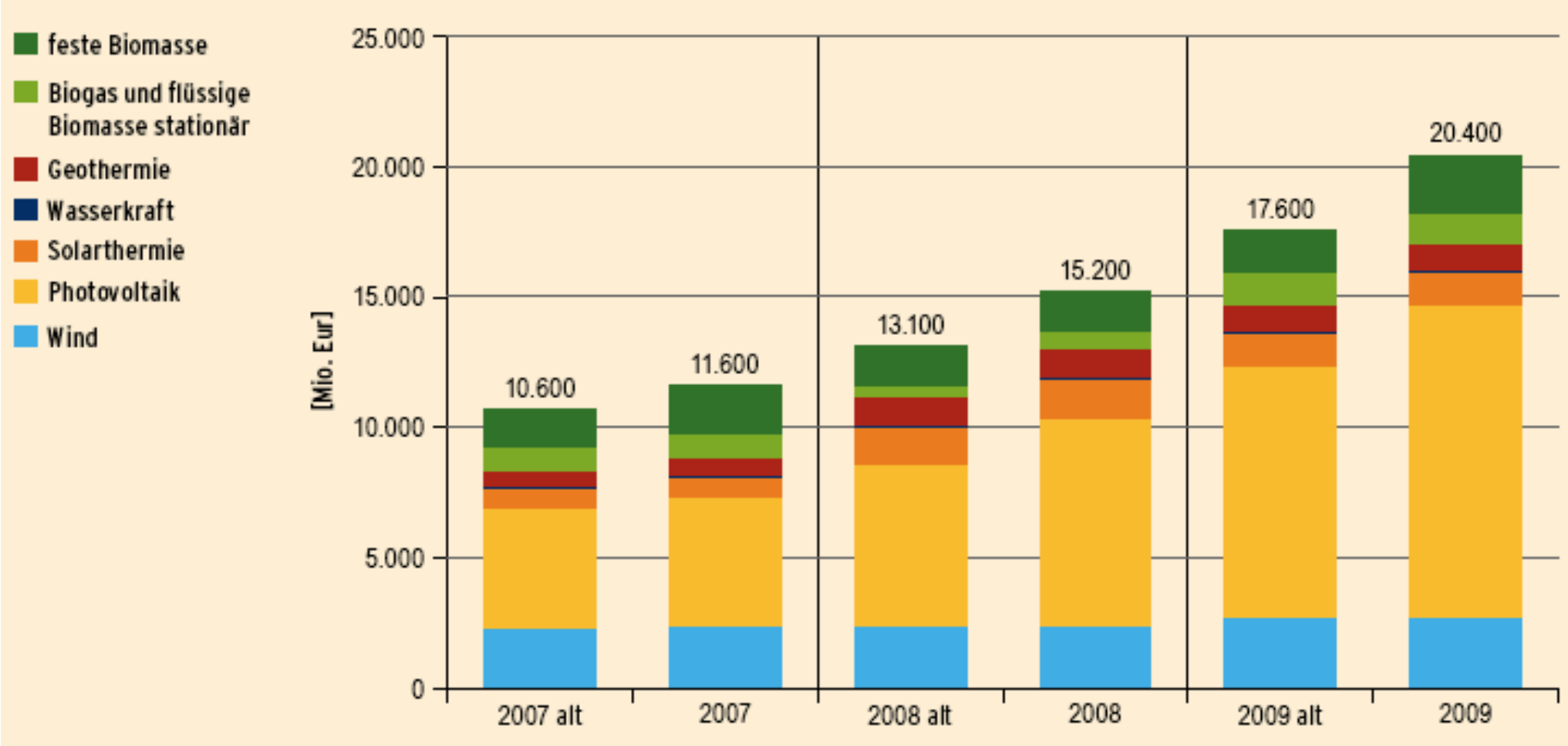
Source: BMU 2009

CO2-Emissions and Electricity Consumption in Germany 1990-2007



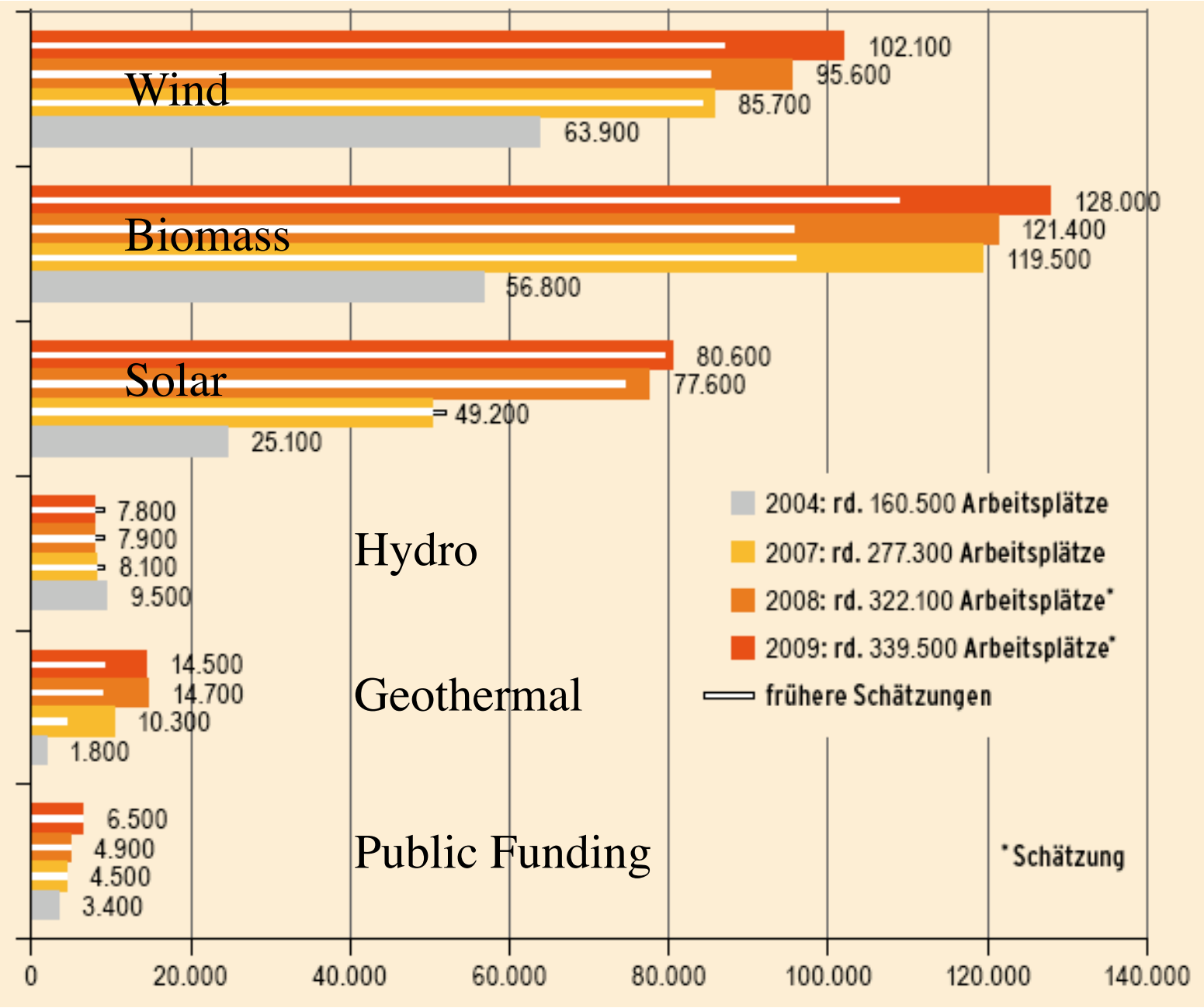
Source: Umweltbundesamt, 2009

Investment in Renewables Doubles between 2007 and 2009



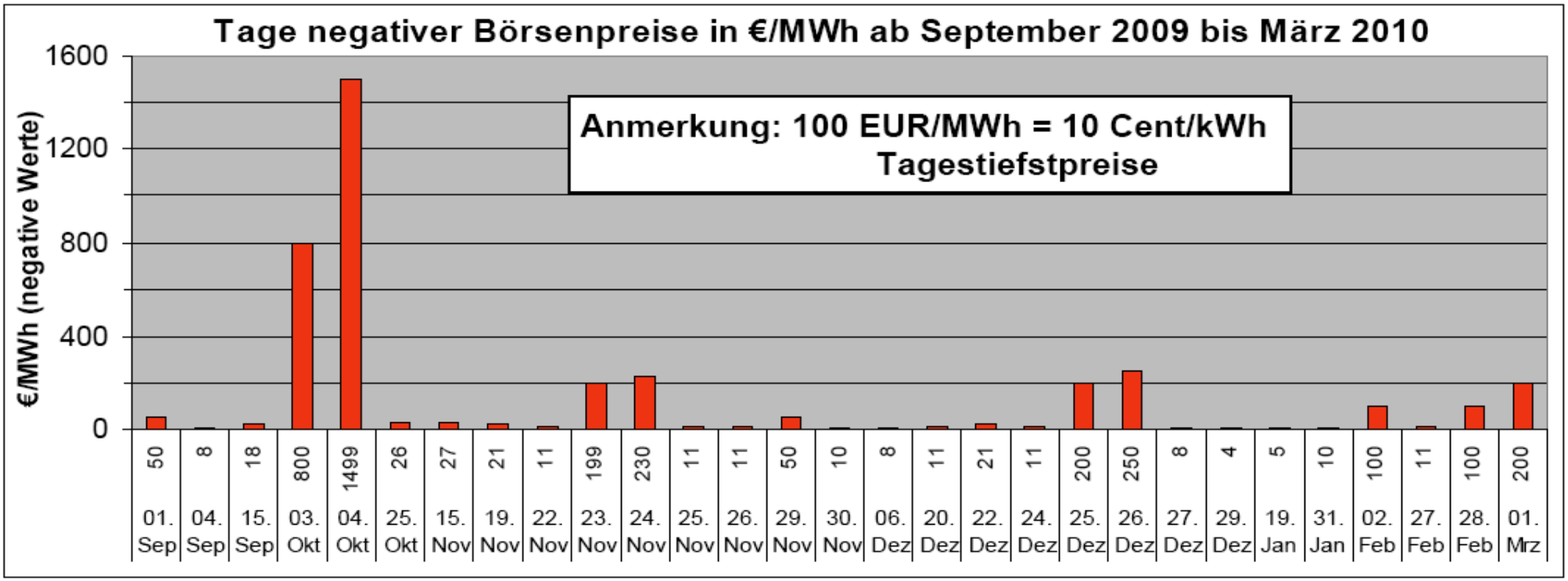
Source: BMU, "Erneuerbar beschäftigt!", September 2010

Jobs in the Renewable Energy Sector in Germany 2004-2009



Source: BMU, "Erneuerbar beschäftigt!", September 2010

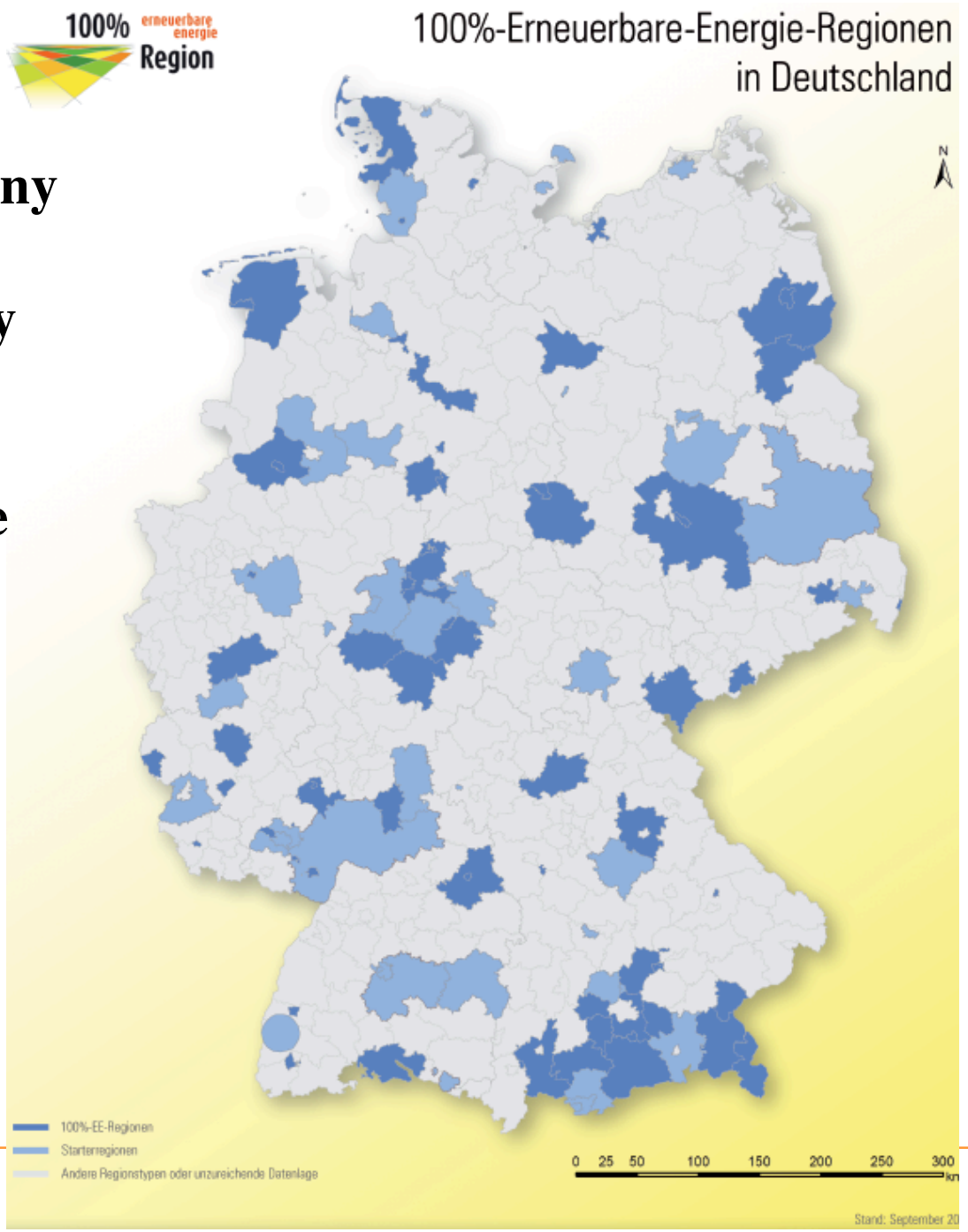
Negative Electricity Prices at the German Power Exchange

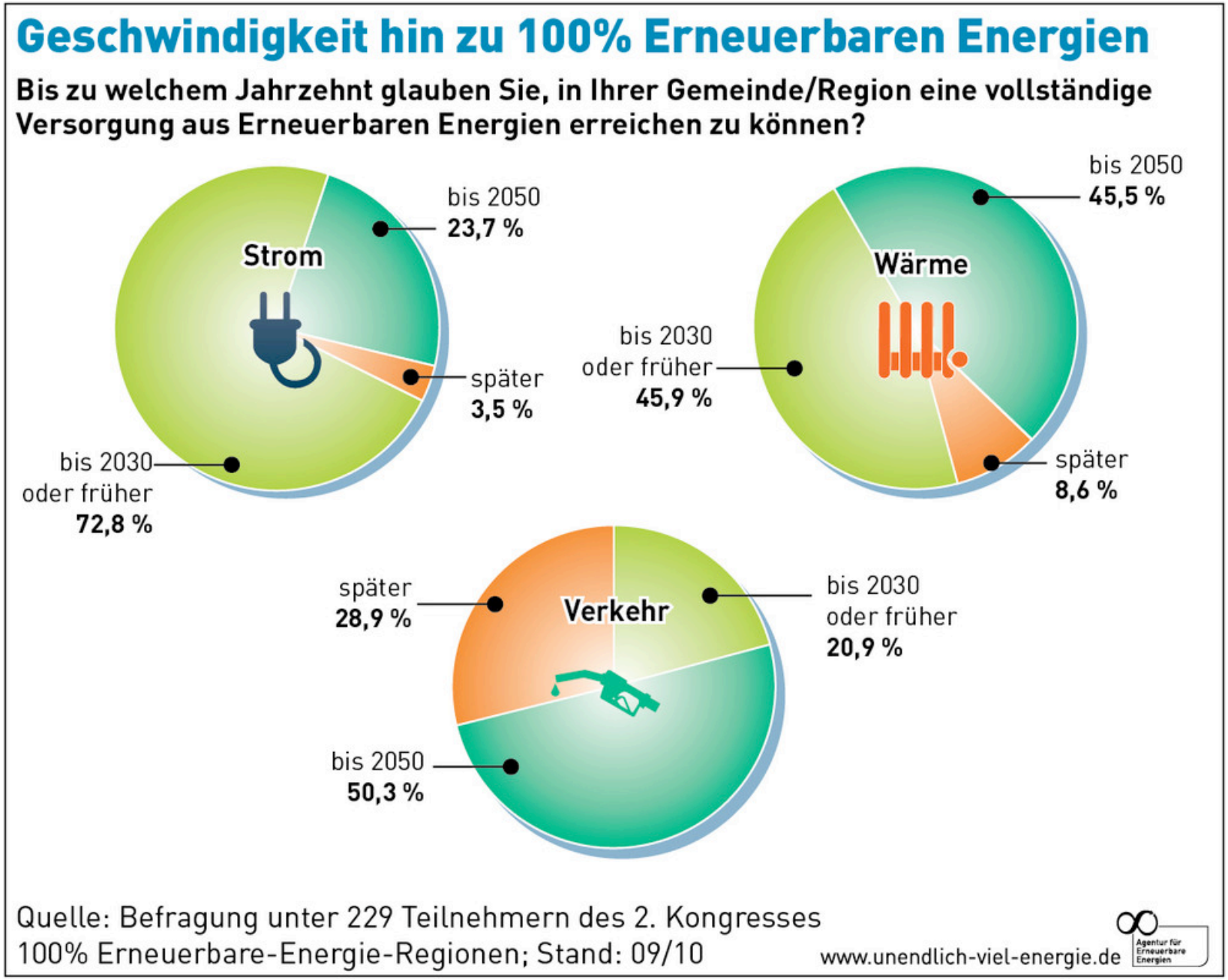


Sources: H. Alt, "Warum negative Strompreise an der Strombörse?", FH-Aachen, March 2010

Regions in Germany With 100% Renewable Energy or Target:

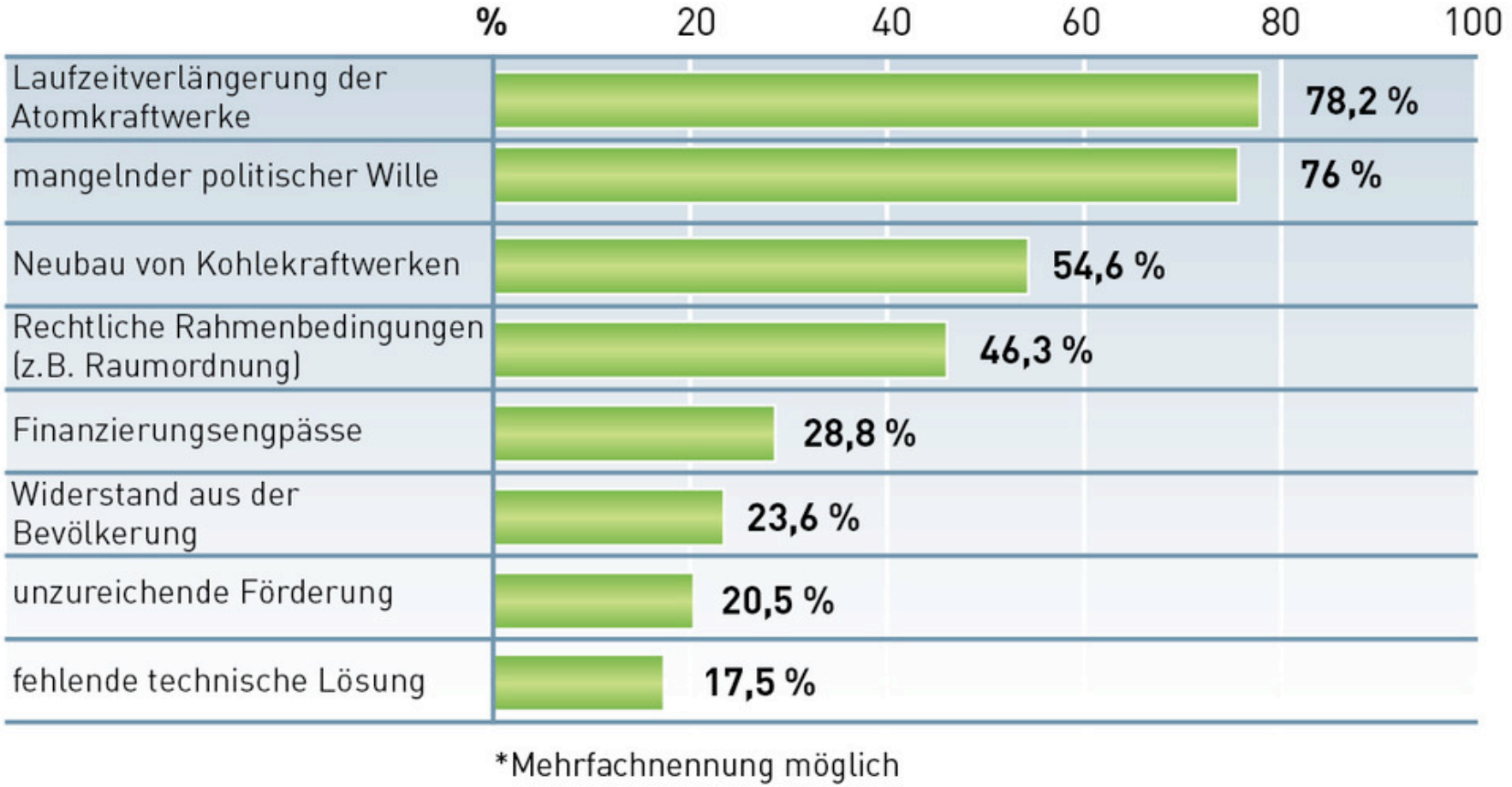
- **52% of surface**
- **35 million people**




Geschwindigkeit hin zu 100% Erneuerbaren Energien
Bis zu welchem Jahrzehnt glauben Sie, in Ihrer Gemeinde/Region eine vollständige Versorgung aus Erneuerbaren Energien erreichen zu können?
Strom
bis 2050
23,7 %
später
3,5 %
bis 2030
oder früher
72,8 %
Wärme
bis 2050
45,5 %
bis 2030
oder früher
45,9 %
später
8,6 %
Verkehr
später
28,9 %
bis 2030
oder früher
20,9 %
bis 2050
50,3 %
Quelle: Befragung unter 229 Teilnehmern des 2. Kongresses
100% Erneuerbare-Energie-Regionen; Stand: 09/10
www.unendlich-viel-energie.de
Agentur für Erneuerbare Energien

Hemmnisse für den Ausbau von Erneuerbaren Energien

Welches sind aus Ihrer Sicht aktuell die größten Hemmnisse für den weiteren Ausbau Erneuerbarer Energien?*



*Mehrfachnennung möglich

Quelle: Befragung unter 229 Teilnehmern des 2. Kongresses 100% Erneuerbare-Energie-Regionen; Stand: 09/10

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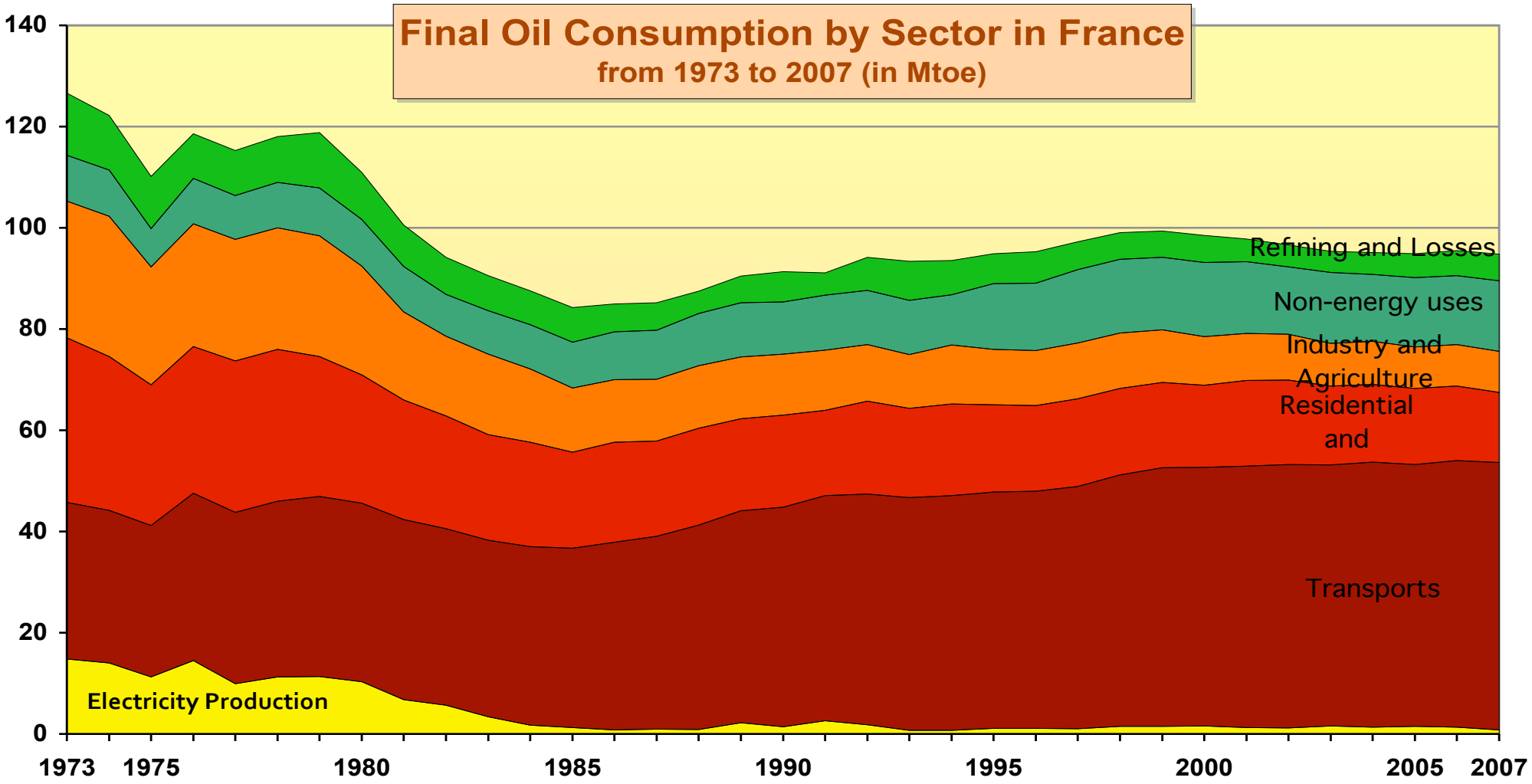
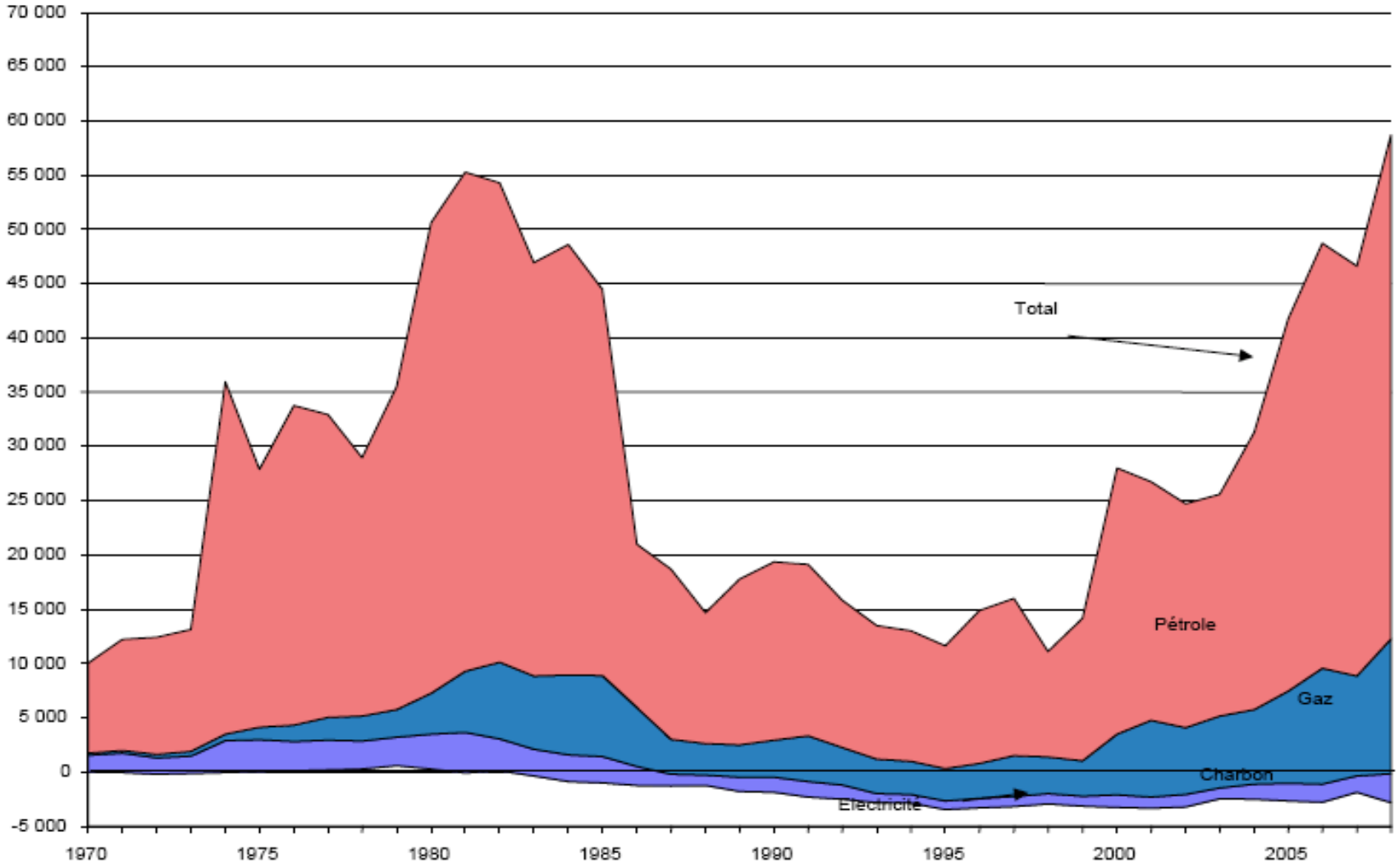


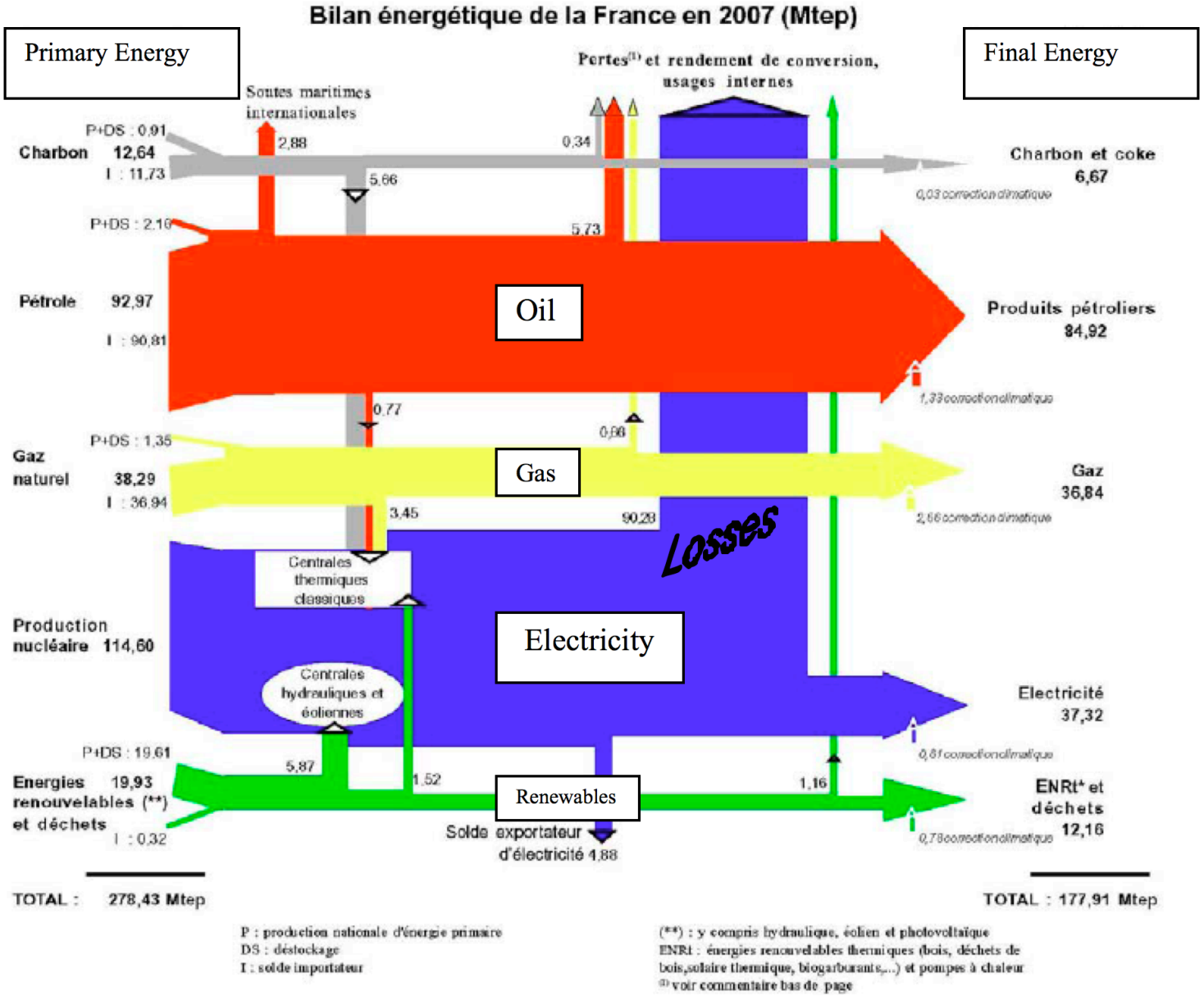
Sources: Observatoire de l'Énergie, 1992 ; DGEMP, 1998-2007

The French National Energy Bill 1970-2008 (in billion €$_{2008}$)



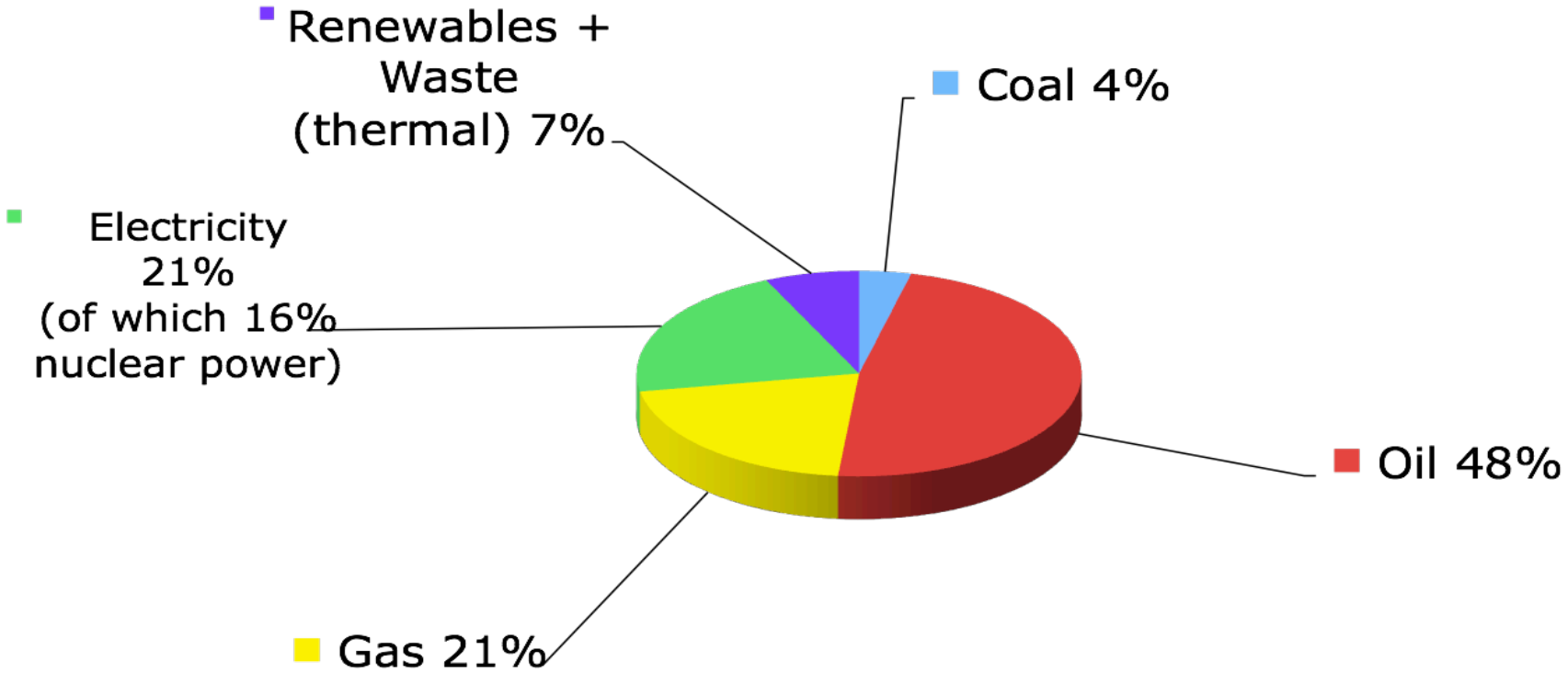
Source: CGDD-Bilan énergétique de la France, May 2009

French Energy Flowsheet 2007 (in Mtoe)



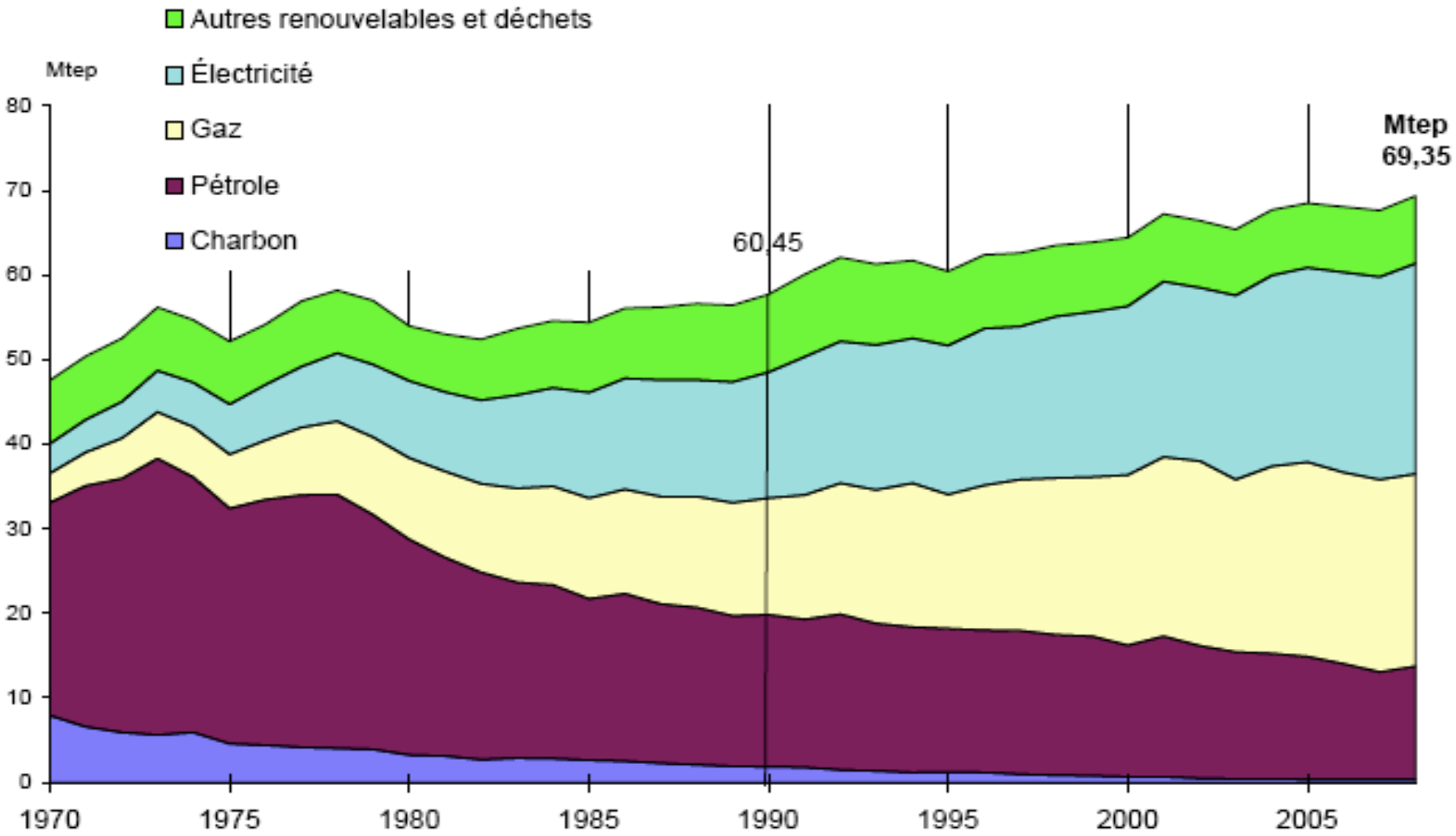
Source: Observatoire de l'énergie, L'énergie en France – Repères, *MEEDDAT, 2008*

Final Energy Consumption in France in 2007
73% fossil fuels, 16% nuclear

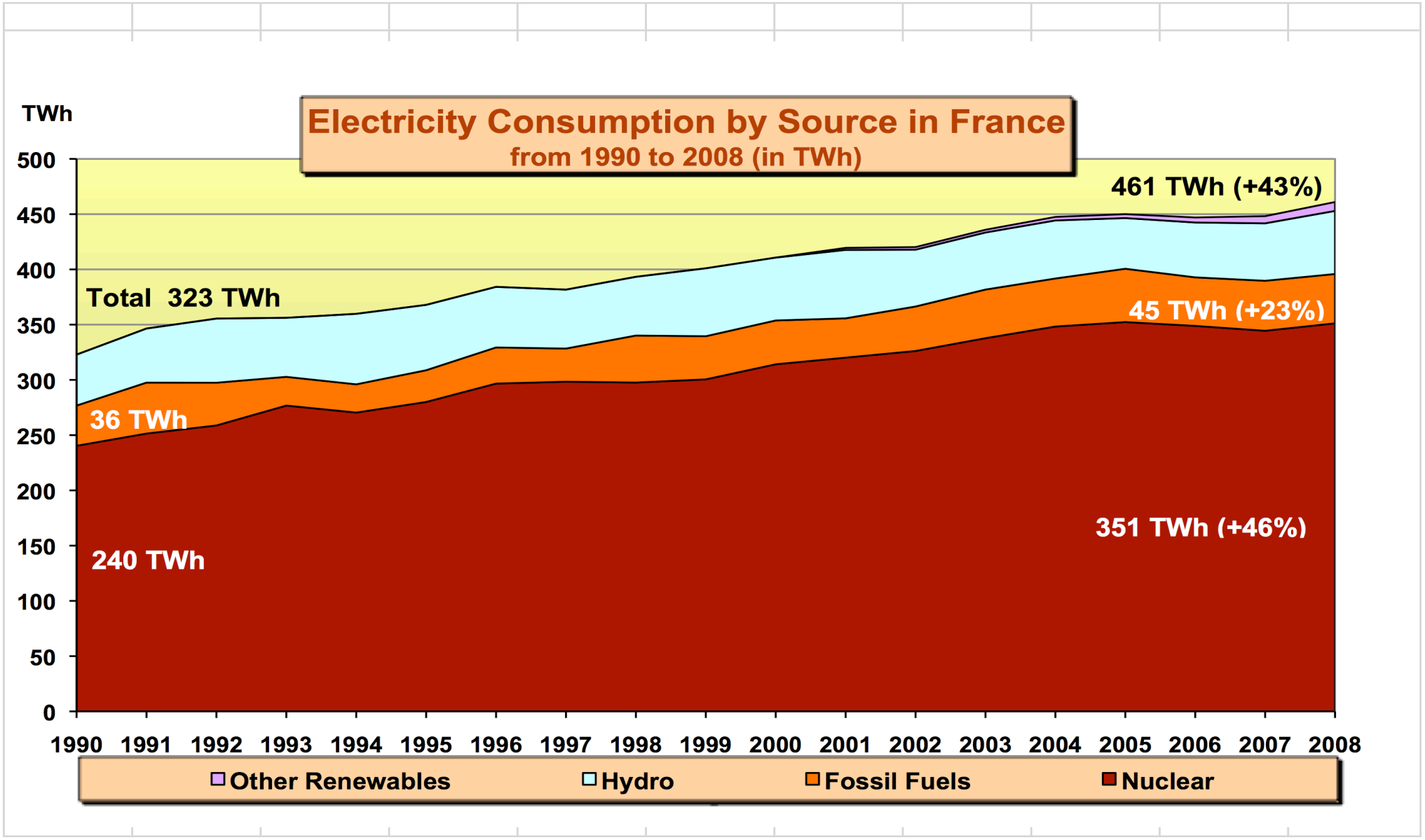


Source: French Ministry of Ecology, Energy and Sustainable Development, Bilan Energie 2007, 2008

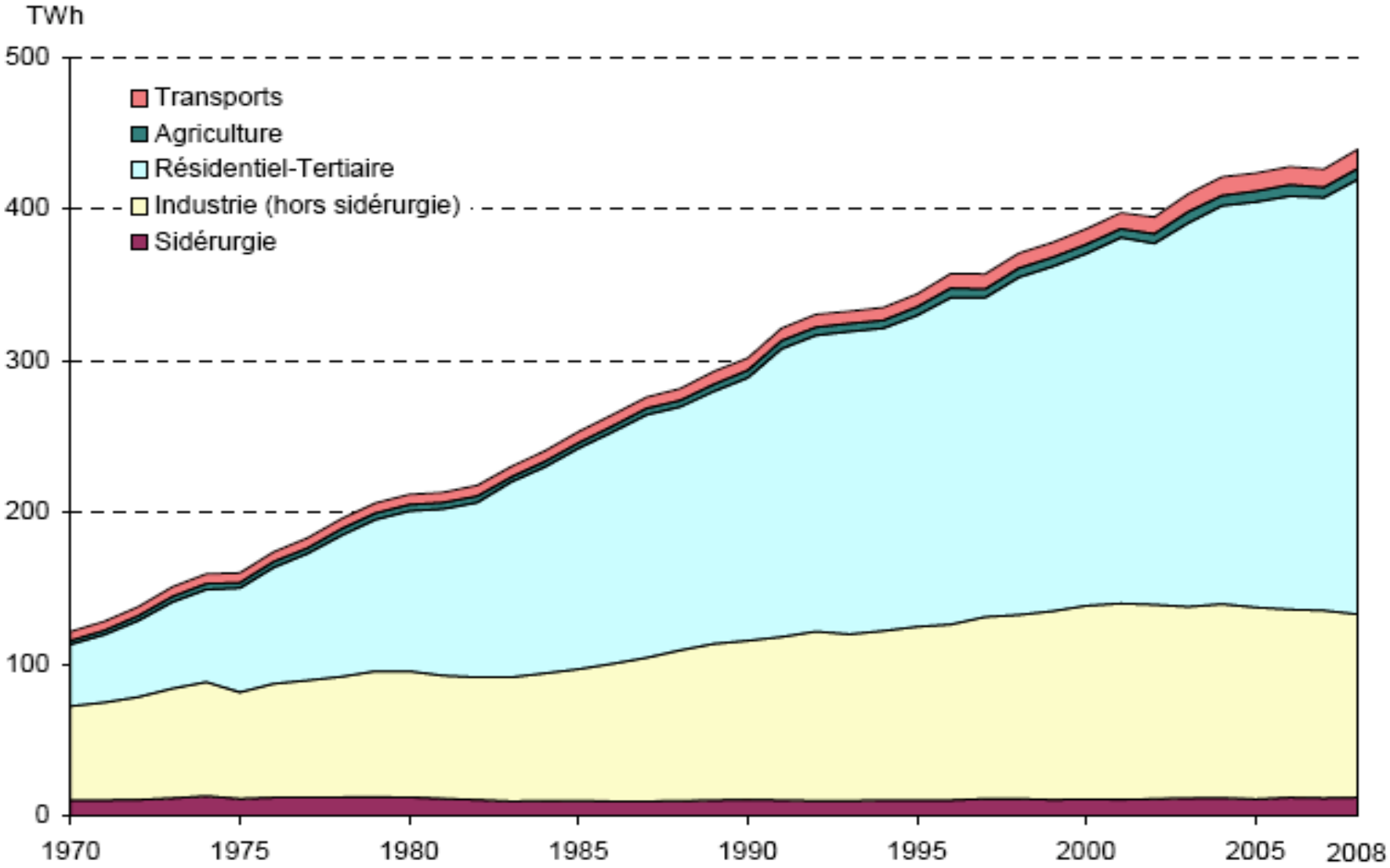
Final Energy Consumption by Source/Carrier 1970-2008 (in Mtoe)



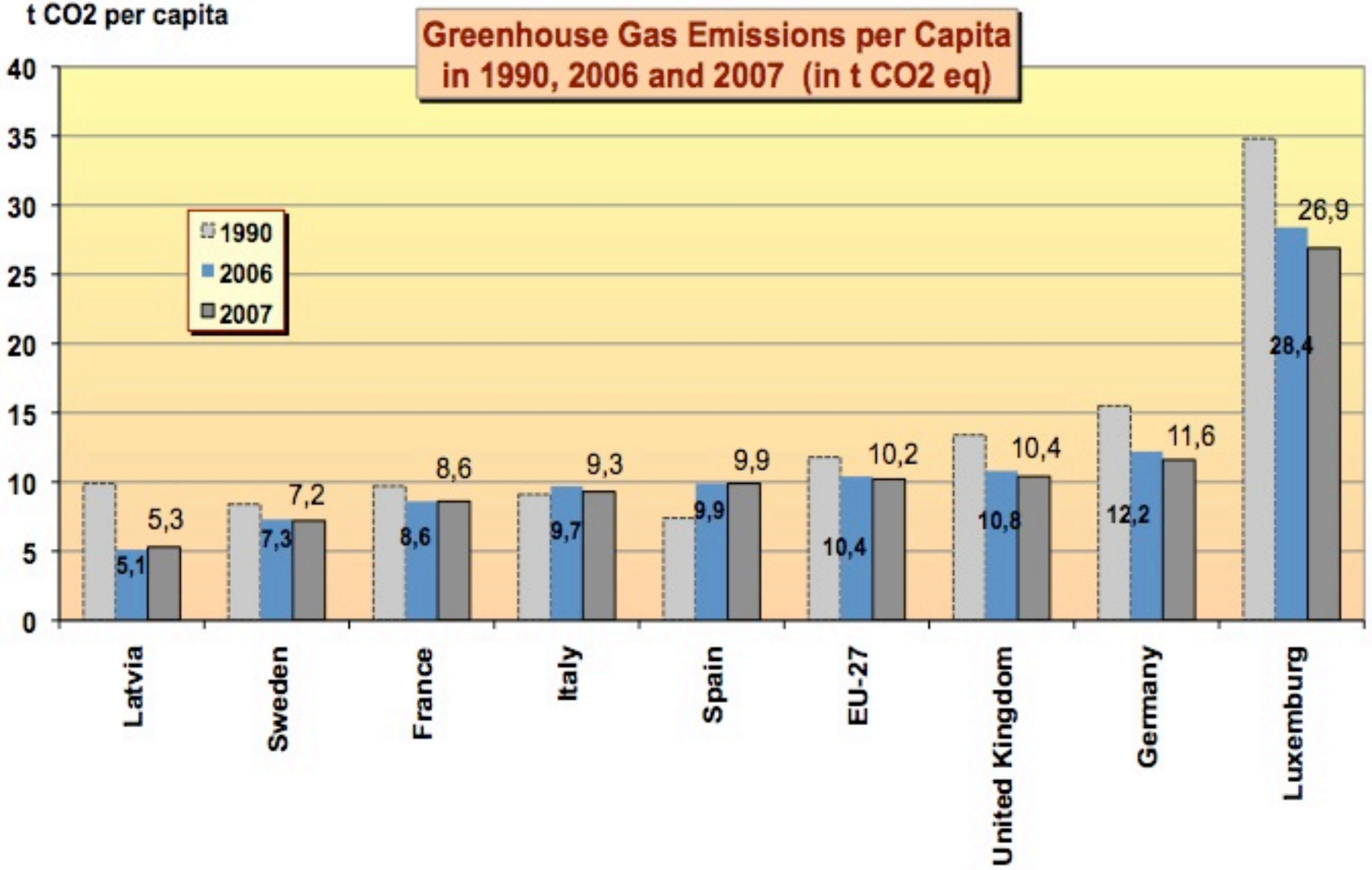
Source: CGDD-Bilan énergétique de la France, May 2009


Electricity Consumption by Source in France
from 1990 to 2008 (in TWh)
TWh
500
450
400
350
300
250
200
150
100
50
0
461 TWh (+43%)
Total 323 TWh
45 TWh (+23%)
36 TWh
351 TWh (+46%)
240 TWh
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008
Other Renewables
Hydro
Fossil Fuels
Nuclear

Electricity Consumption in France by Sector 1970-2008 (in TWh)

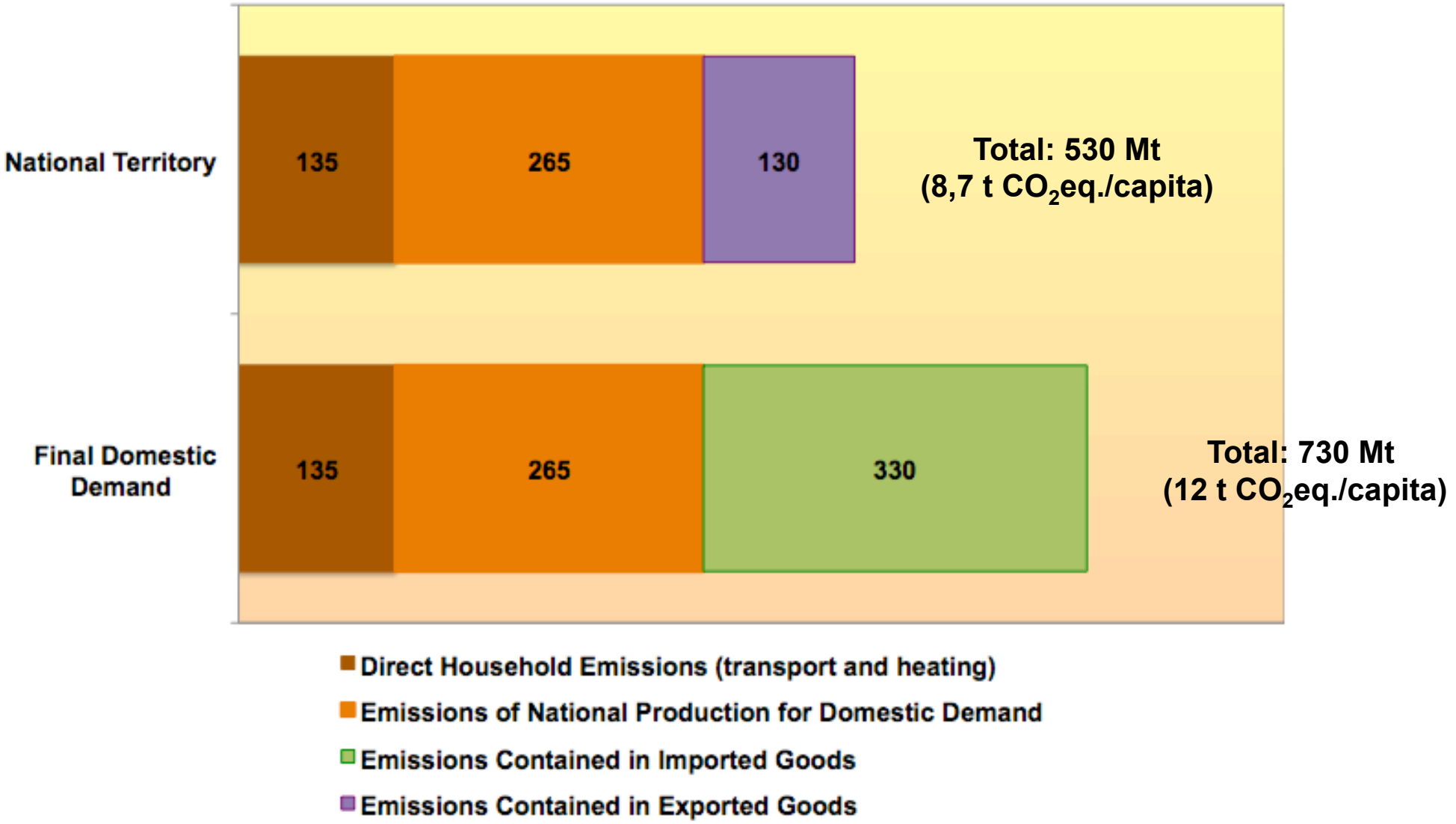


Source: CGDD-Bilan énergétique de la France, May 2009



Source: European Environment Agency 2009

Greenhouse Gas Emission France (2005)



Source: French Ministry of Ecology, 2010

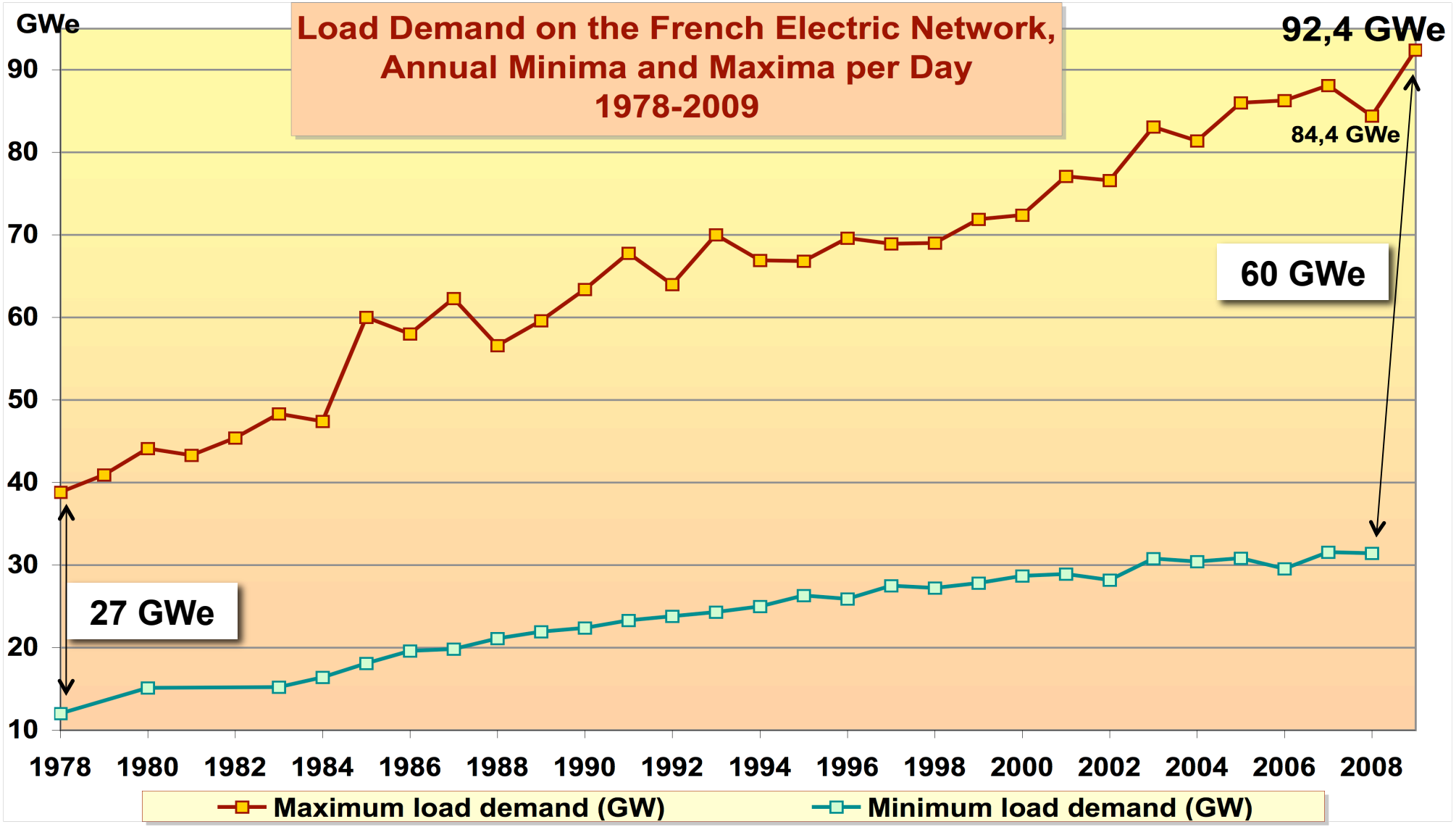
Nuclear Irrelevant To Climate Change Mitigation

"Nuclear power is unlikely to play a critical role in limiting CO_2 equivalent concentrations in the atmosphere until mid-century at the earliest…

No realistic plan foresees a reactor build rate that allows nuclear power to help stay below 550 ppme CO_2 within the next ~30-40 years."*

Robert Rosner
Director, Argonne National Laboratory
April 2009

*The term ppme CO_2 refers to parts per million equivalent CO_2 concentration of greenhouse gases in the atmosphere.



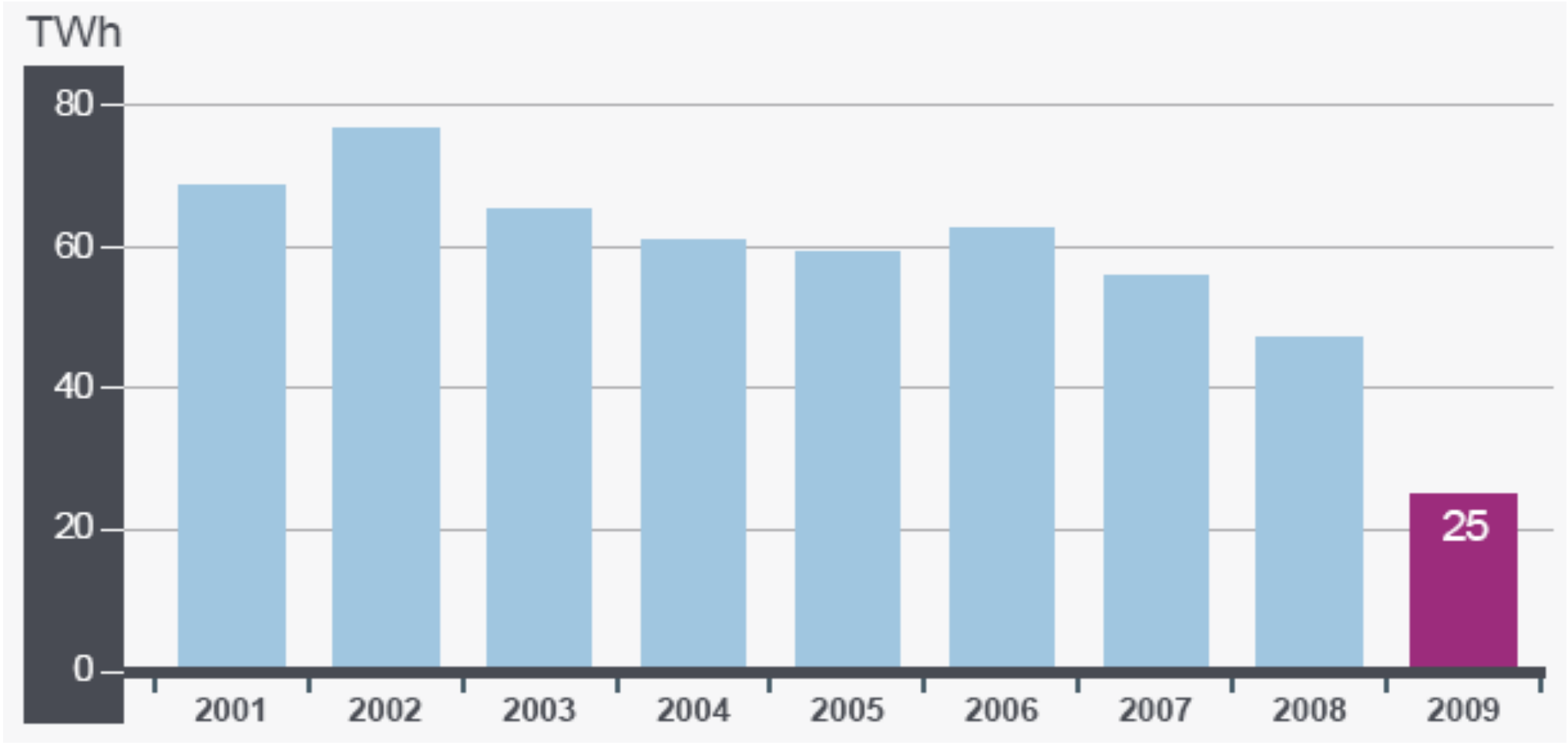
Sources: EDF (1991) ; RTE (2005) - Technical results of operation 1990, 2004; RTE 2009

EDF Restarts 30-40 Year Old Oil Fired Power Plants

Oil Plant	Capacity	Original Start-up	Mothballed	Restart
Porcheville-1	600 MW	1968	1995	2008
Porcheville-2	600 MW	1973	1998	2006
Cordemais-3	700 MW	1976	1995	2007
Aramon-1	700 MW	?	1995	2008
Total	**2600 MW**			

EDF operates its oil fired power plants between 200 h et 1500 h per year.

French Electricity Trade Balance 2001-2009

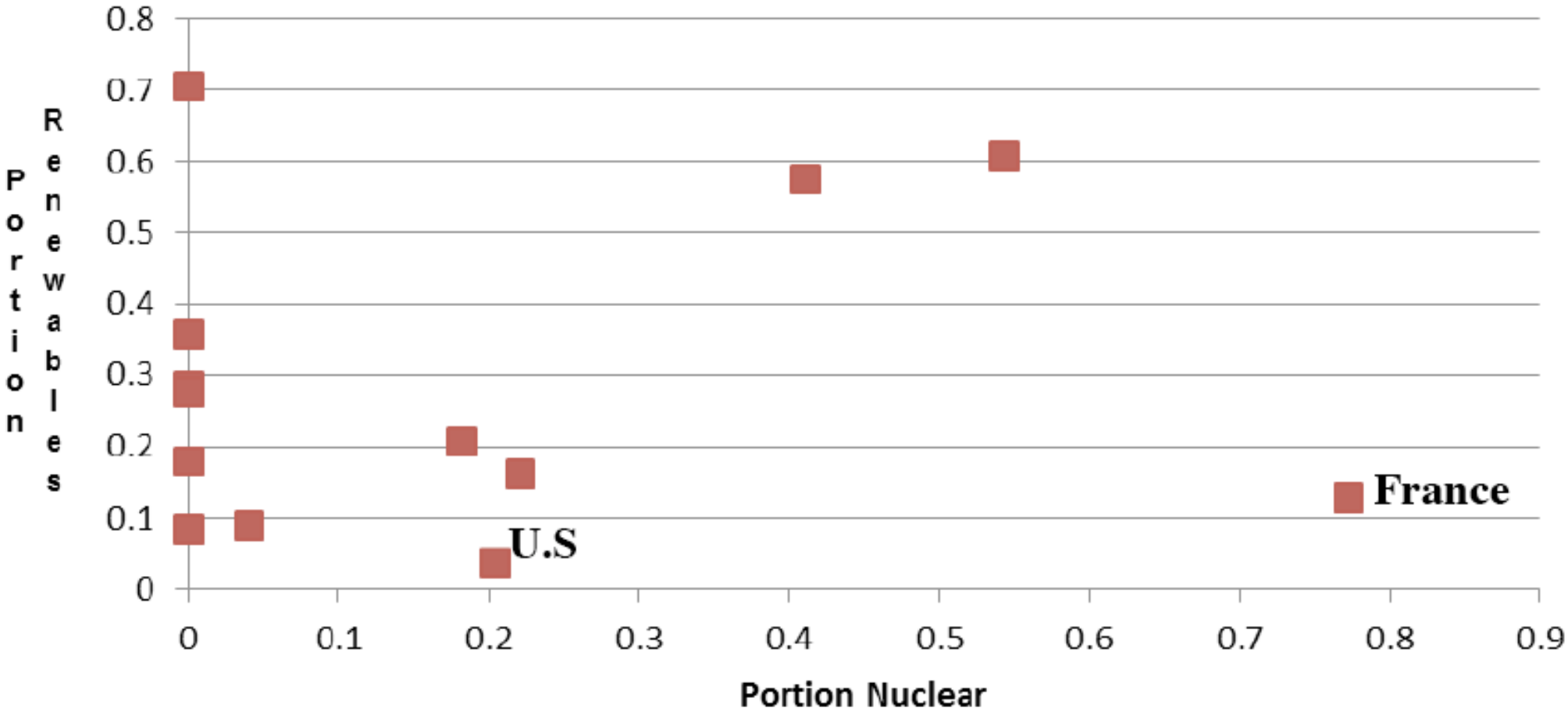


Source: RTE, Bilan Electrique 2009, 2010

Low Energy Prices → High Consumption → High Energy Bills

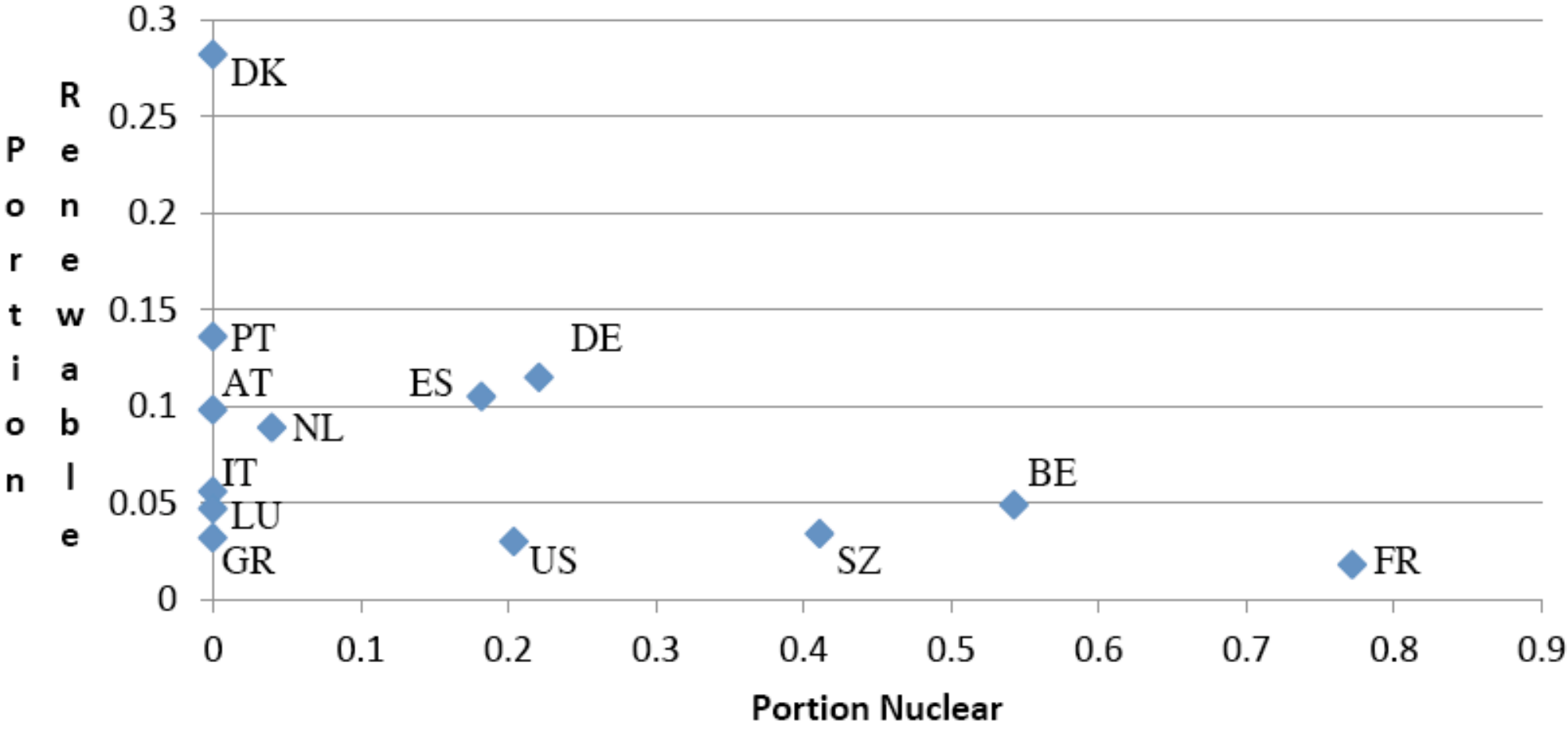
- at least 3.4 million French households (13%) spend >10% of budget on home energy
- 3 million households eligible for social tariffs (2 million electricity, 1 million gas)
- 1/5 or 2.3 million people in Paris region complain that they are cold in winter

Crowding-out Renewables: <u>All Renewables</u> vs. Nuclear Share



Source: Mark Cooper, "POLICY CHALLENGES OF NUCLEAR REACTOR CONSTRUCTION, COST ESCALATION AND CROWDING OUT ALTERNATIVES", September 2010

Crowding-out Renewables: Non-Hydro Renewables vs. Nuclear Share



Source: Mark Cooper, "POLICY CHALLENGES OF NUCLEAR REACTOR CONSTRUCTION, COST ESCALATION AND CROWDING OUT ALTERNATIVES", September 2010

Conclusions

• Nuclear power plays a limited role in the international energy sector: ≈13% of electricity, ≈5% of primary energy, ≈2% of final energy in the world. Further decline is highly likely.

• The nuclear industry has failed to deliver in the past. Large budget overruns, construction delays and excessive overall lead times. Much of this had to be covered by the tax-payer.

• Problems with recent new build projects indicate that there is no change to be expected.

• Nuclear power is irrelevant to climate change mitigation.

• Renewable energy is already economically competitive, even under unfavourable conditions.

• Renewables will not lead to lower emissions if energy efficiency does not rapidly make the step from long-term rhetoric to radical implementation.

The energy future lies in affordable, distributed, superefficient technologies, smart grids and sustainable urbanism. Nuclear policy – centralized, inflexible and generally autocratic – symbolizes the opposite.

The perpetuation of nuclear energy will massively hinder rather than favour the urgent implementation of reliable, sustainable energy policies.

In brief: implement intelligent energy services the smart way!

Thank you!

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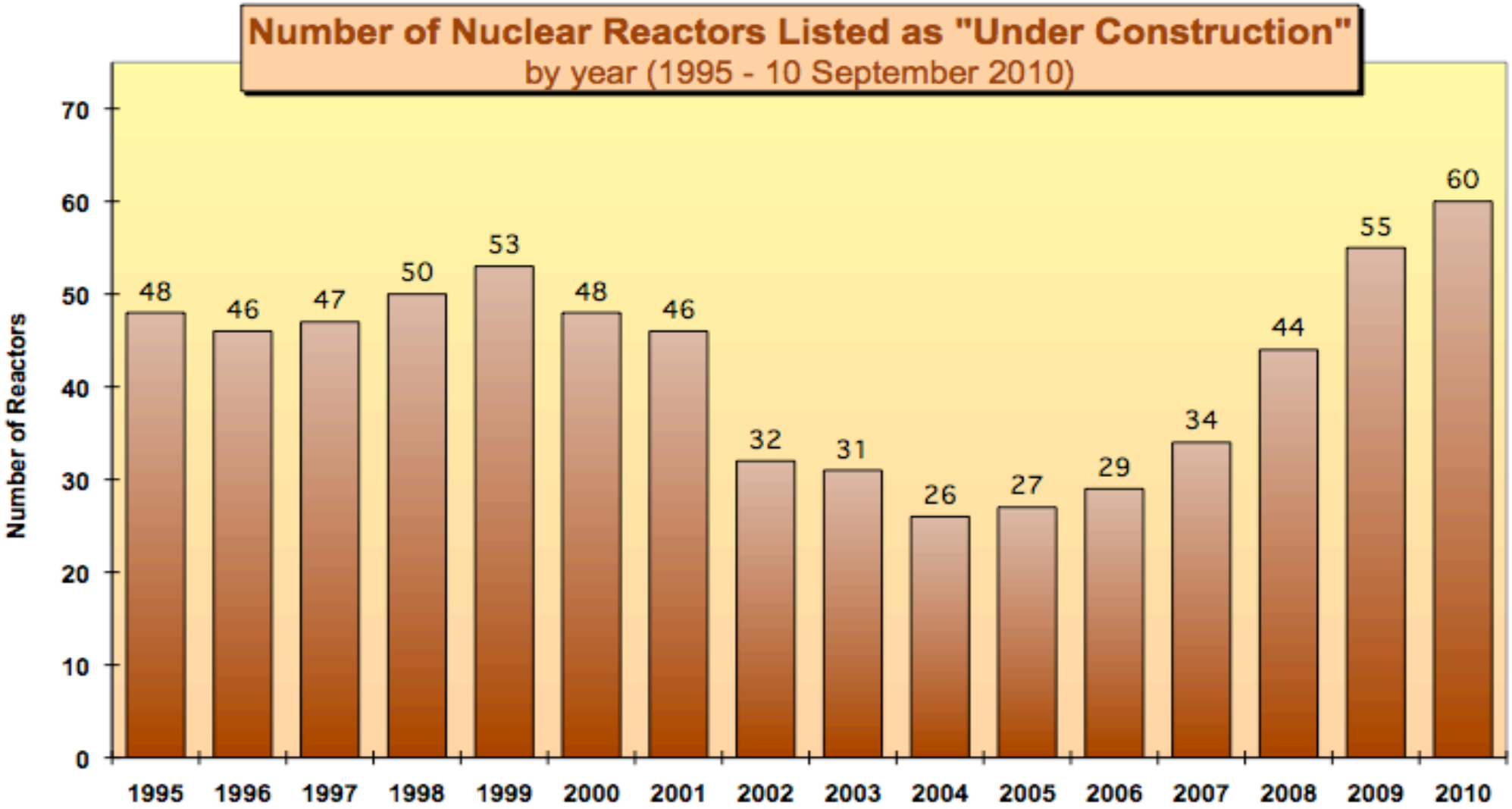
Annexes

Some Thoughts on Key Barriers and Potential Ways Out

- Common denominators of energy policy failure
  - Decisions based on demand "forecasts" and estimated supply technology potentials.
  - Overwhelming public support for alleged "silver bullet" supply side solutions.
  - Efficiency has largest potential and has failed miserably.
- Key basic assumptions for change
  - Start with an energy *service* need analysis.
  - Place human needs first – The home is the place to start.

- Boost systemic approaches to design and implement and prioritize long term over short term.
- Take energy policy out of the hands of physicists and engineers, involve social scientists and civil society to develop implementation strategies for the necessary scope, scale and speed of change.
- Develop kit-EE/RE-implementation tools that intrinsically link RE to an efficiency approach.
- Urgently undertake research into potentially conflicting infrastructure investments with adverse system effects for emerging strategies (e.g. smart grids).



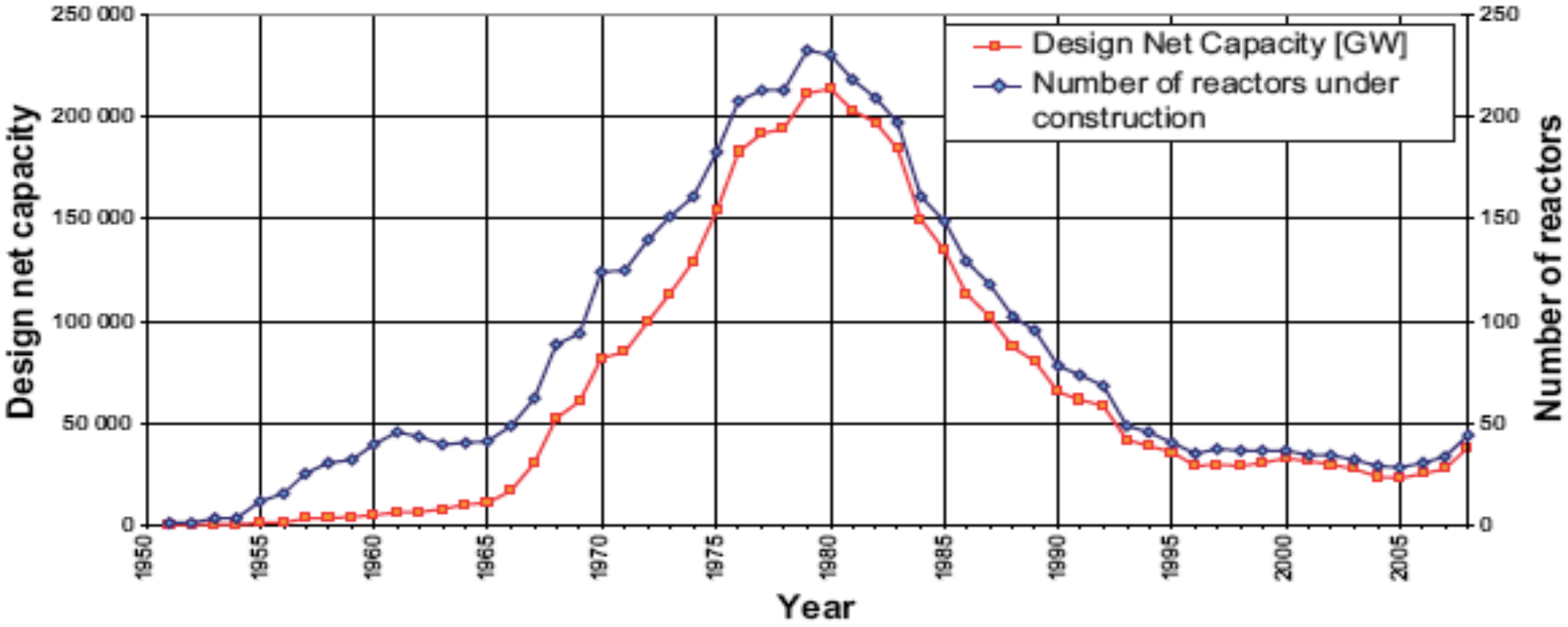
Sources: CEA, IAEA-PRIS, MSC 2010

Nuclear Reactors Listed as "Under Construction" (as of Sep. 2010)

Country	Units	MWe (net)	Construction Start	Grid Connection
China	23	23,620	2005-2010	2010-2015
Russia	11	9,153	1985-2010	2010-?
South-Korea	5	5,560	2006-2008	2010-2013
India	4	2,506	2002-2004	2009-2011
Bulgaria	2	1,906	1987	2014-2015
Japan	2	2,650	2004-2010	2011-2014
Slovakia	2	782	1985	2012-2013
Taiwan	2	2,600	1999	2011-2012
Ukraine	2	1,900	1986-1987	2015-2016
Argentina	1	692	1981	2010
Brazil	1	1,245	2010	2018
Finland	1	1,600	2005	2012
France	1	1,600	2007	2012
Iran	1	915	1975	2009
Pakistan	1	300	2005	2011/05/31
USA	1	1,165	1972	2012
Total	60	58,584		

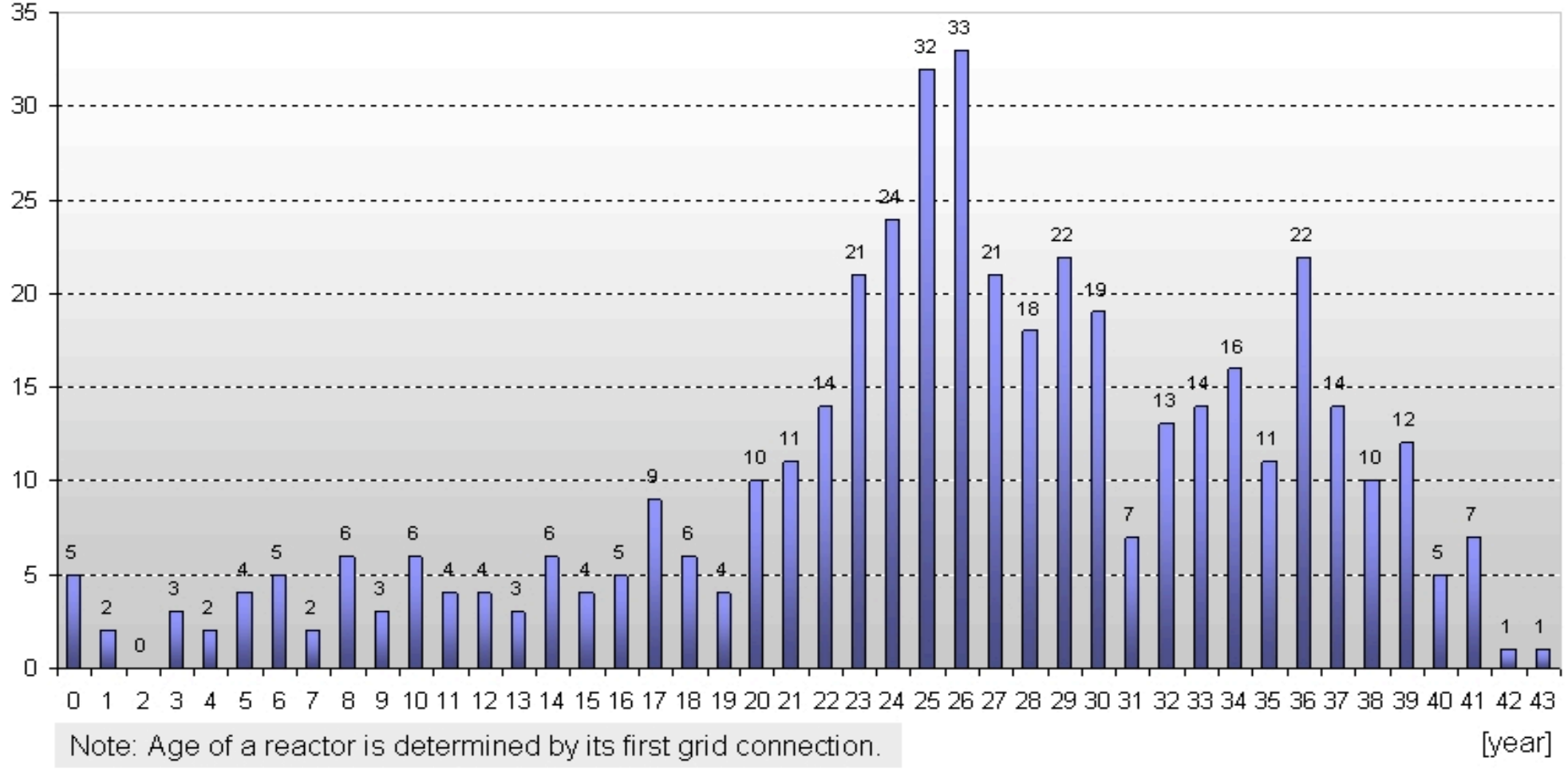
Sources: IAEA-PRIS, WNN, MSC 2010

Number of units and total nominal capacity in MW (!) 1951-2008



Source: IAEA, International Status and Prospects of Nuclear Power, 2008

Number of Operating Reactors by Age



Source: IAEA-PRIS, 2010

Chinese Fantasies

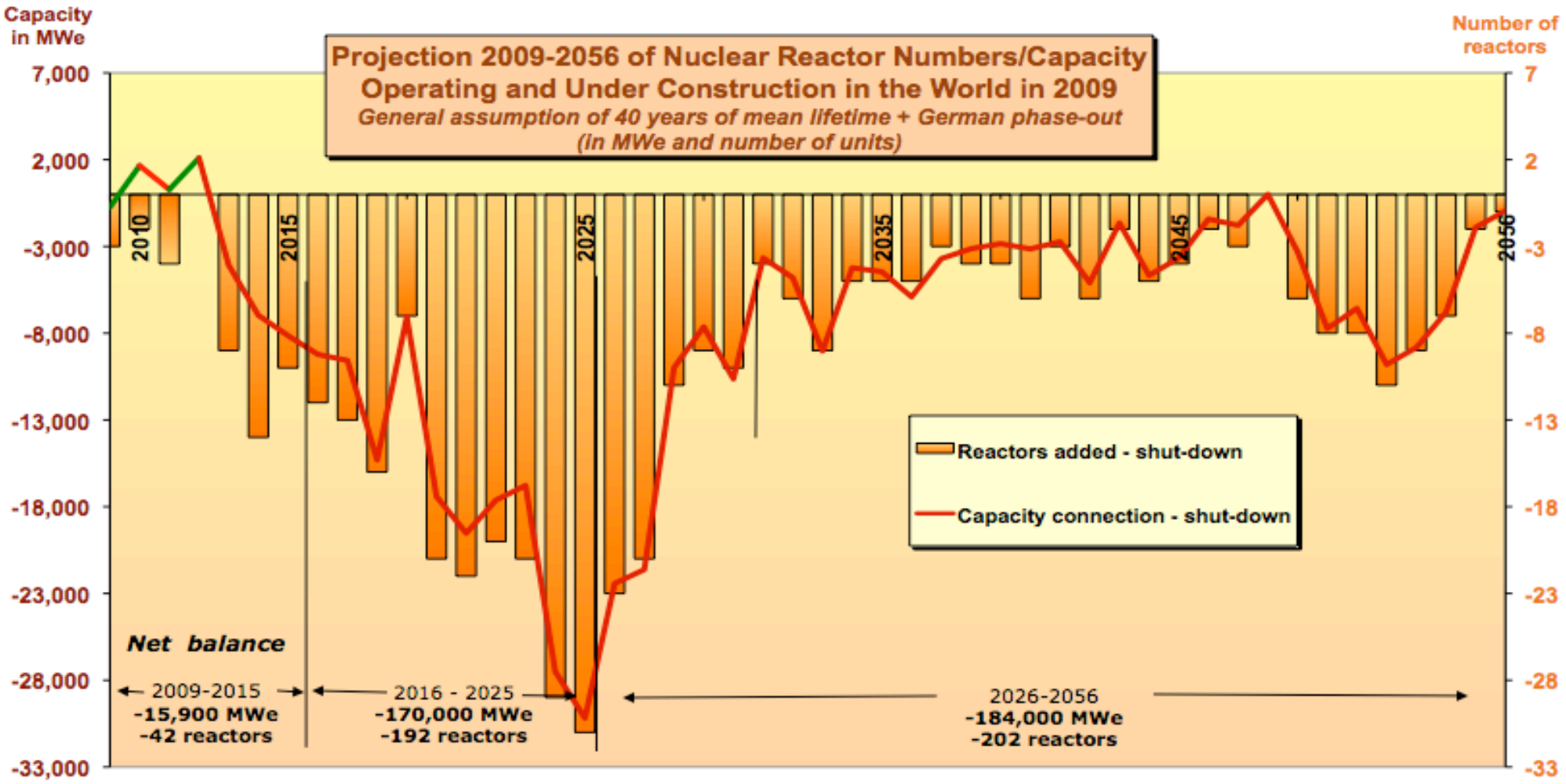
Chinese Forecasting	Capacity Planned	Capacity Installed	Share Realized
in 1985 for 2000	20,000 MW	2,168 (in 15 Years)	11%
in 1996 for 2010	20,000 MW	May 2010 8,438 (in 25 Years)	42%
in 2006 for 2020	40,000 MW to 60,000 MW	+30,000 to + 50,000? (in 10 Years?)	?

Source: Mycle Schneider Consulting

Indian Fantasies

Indian Forecasting	Capacity „planned“	Capacity installed	Share realized
in 1984 for 2000	10,000 MW	2,720 MW in ca. 15 years	27%
in 2005 for 2012	11,000 MW	7,000 MW (max) in ca. 30 years	64%
in 2005 for 2020	20,000 MW	+13,000 MW in 10 years?	?
in 2009 for 2050	470,000 MW	x 100 in 40 years?	?

Source: various, Ramana 2010



Sources: IAEA-PRIS, WNA, MSC 2009

Massive Nuclear Skills Gap

OECD Nuclear Energy Agency on Finland, Germany, South Korea, UK, USA…

"These national surveys show that employers require more engineers and scientists having a nuclear component to their education than those graduating."

Source: OECD NEA, *Nuclear Competence Building,* 2004

No Change in Sight

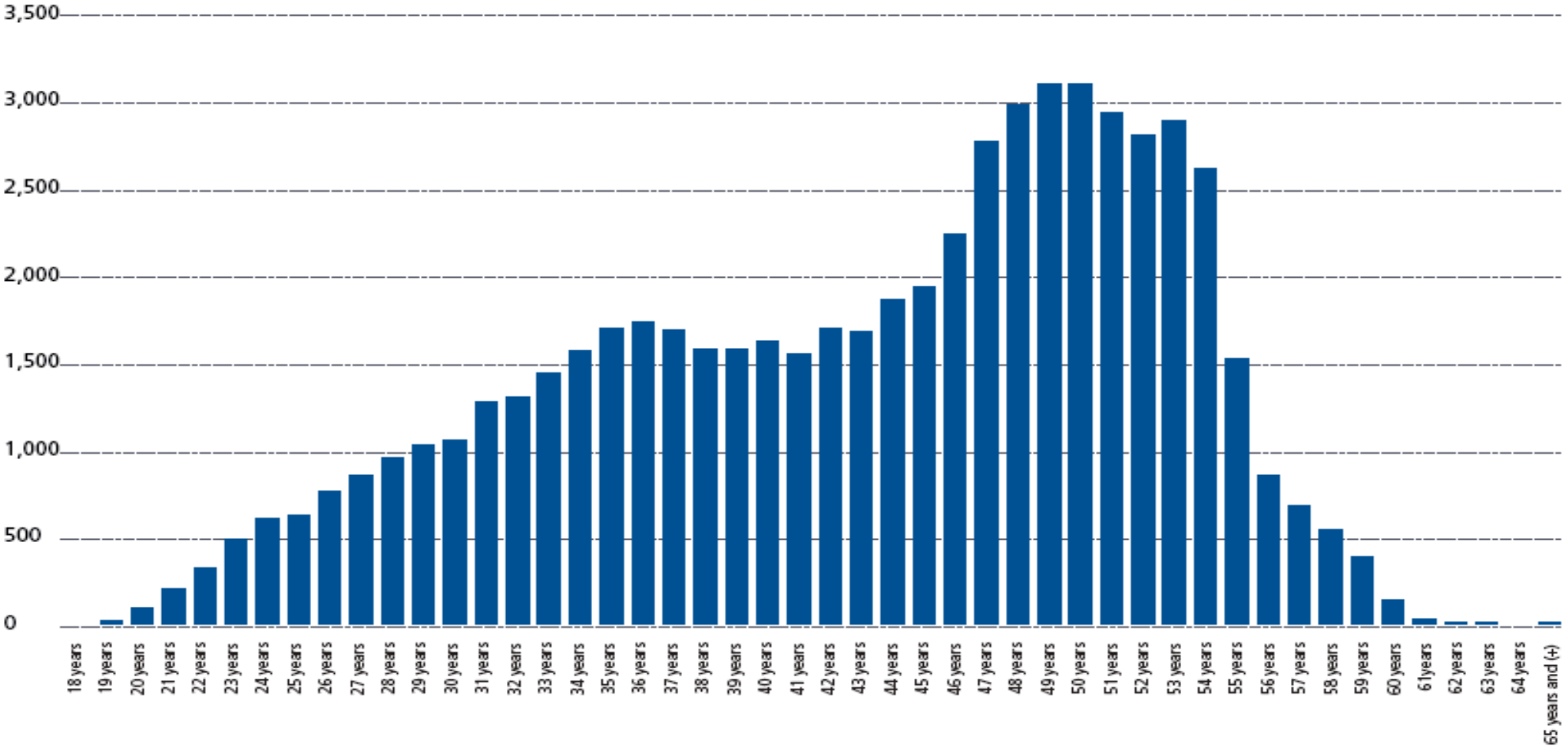
« The “aging workforce” issue is keeping countless CEOs awake at night. (…)

The U.S. Department of Labor indicates that a third of the workers in the nuclear industry are eligible to retire in the next five years. (…)

The U.S. nuclear power industry will need to attract about 26,000 new employees over the next 10 years for existing facilities. These estimates do not include additional resources necessary to support new plants. »

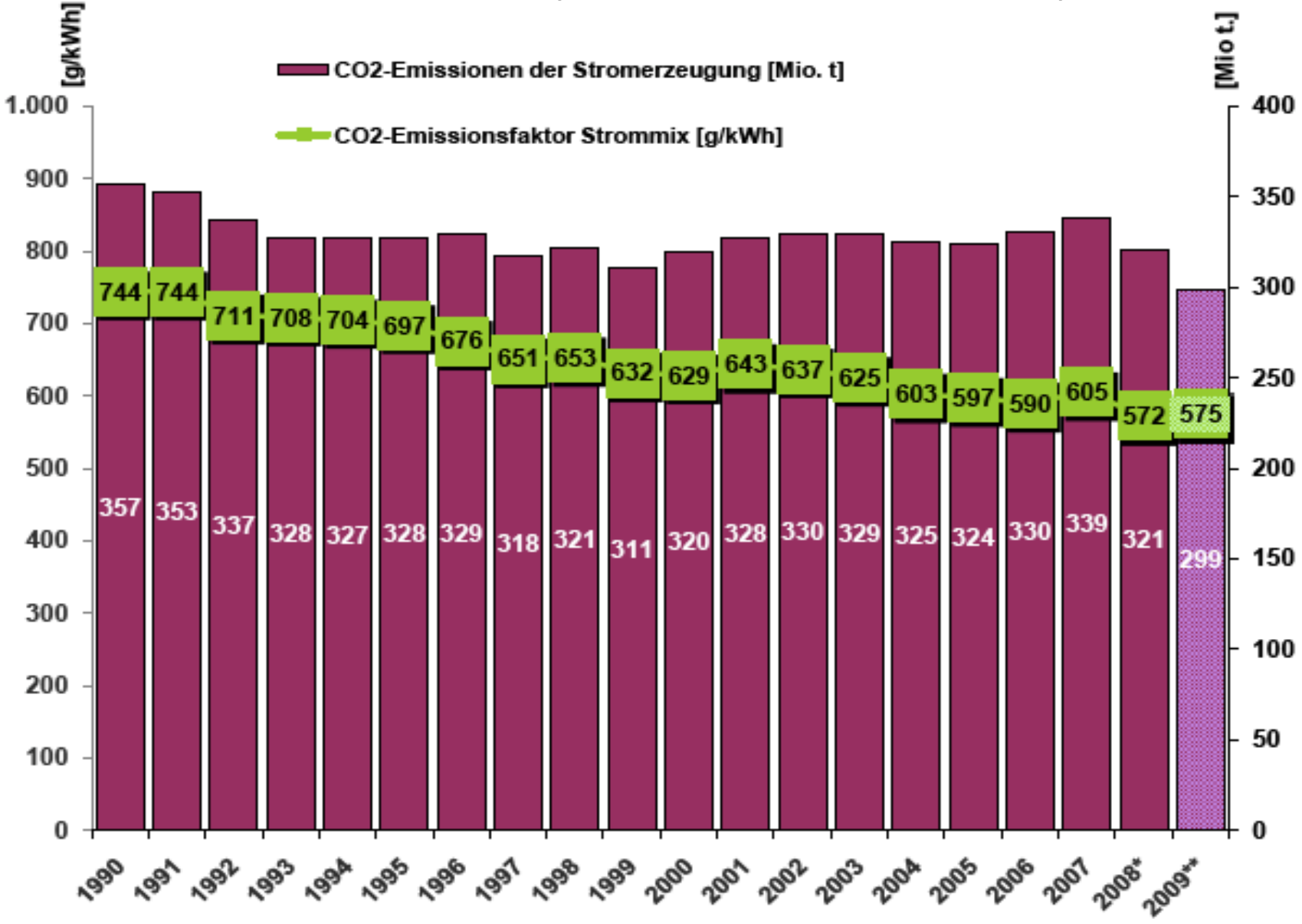
Source: Capgemini, « Preparing for the Nuclear Renaissance », March 2008

Workforce Age Structure at EDF
(as of the end of 2008)



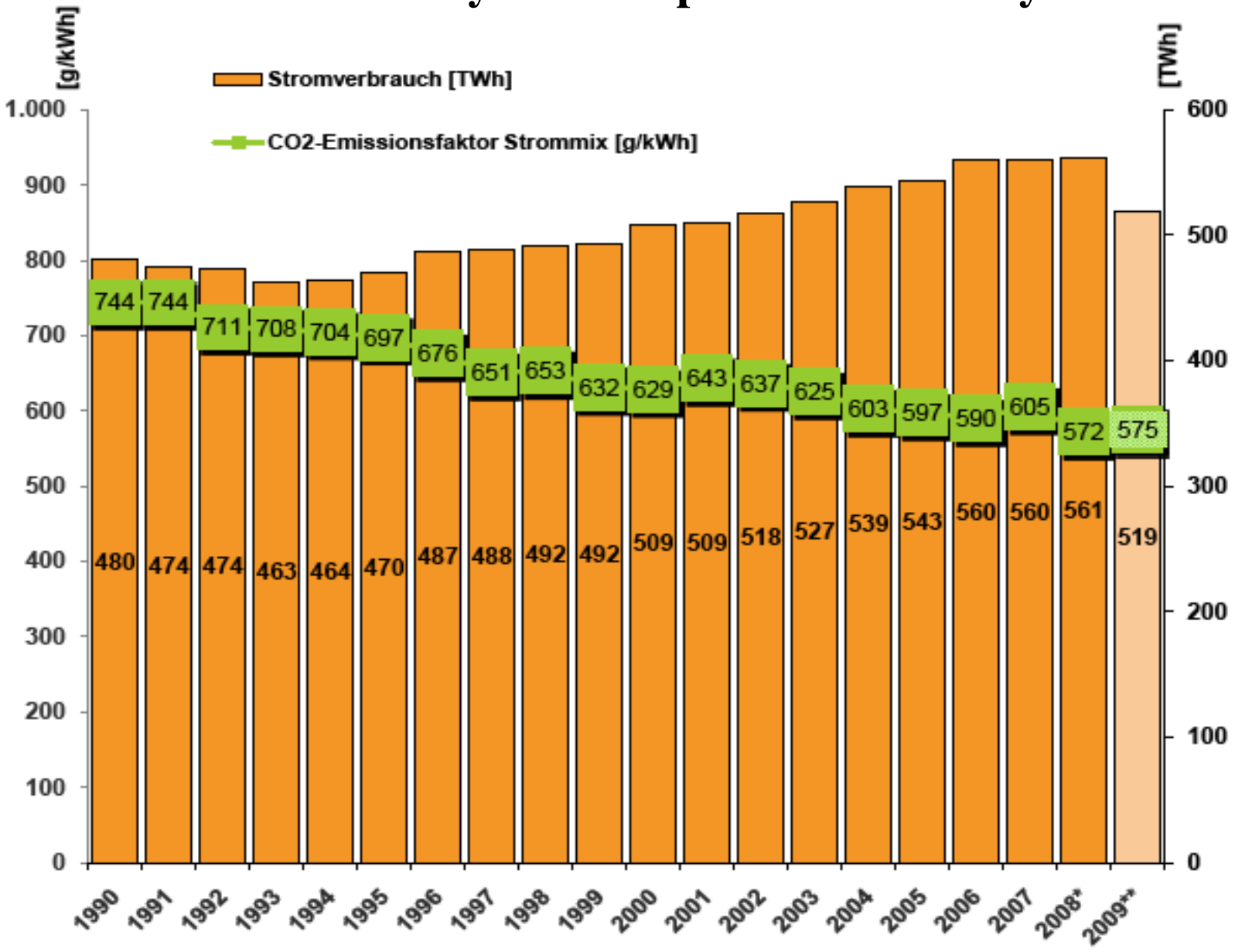
Source: RTE, Document de Référence 2008", April 2008

CO2-Emissions of the Electricity Generation in Germany 1990-2009

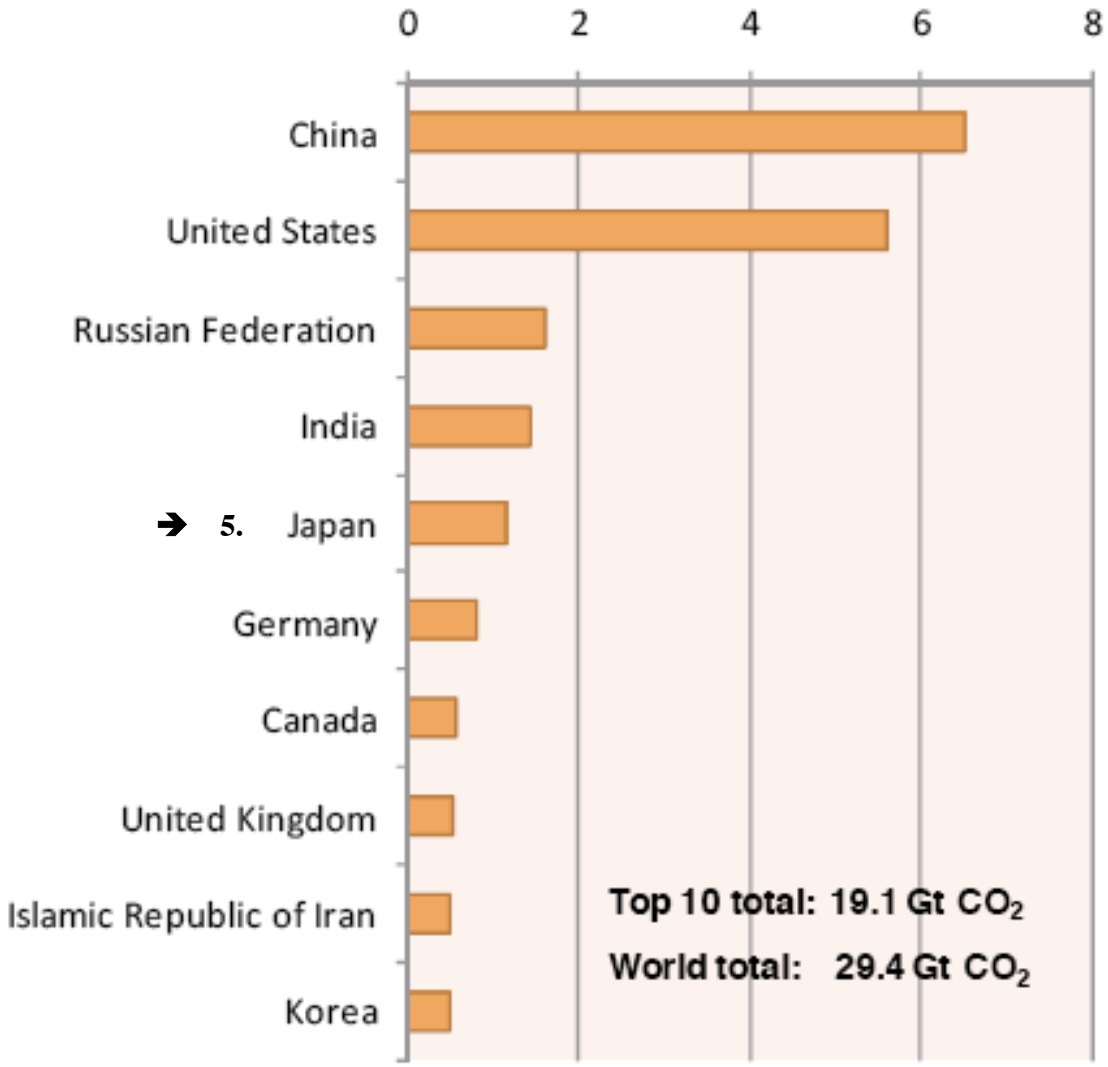


Source: Umweltbundesamt, 2010

CO2-Emissions and Electricity Consumption in Germany 1990-2009



Top 10 Emitters of CO2 in the World in 2008



Source: IEA, "CO2 Emissions from Fuel Combustion", 2010