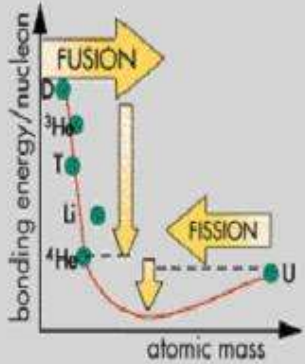




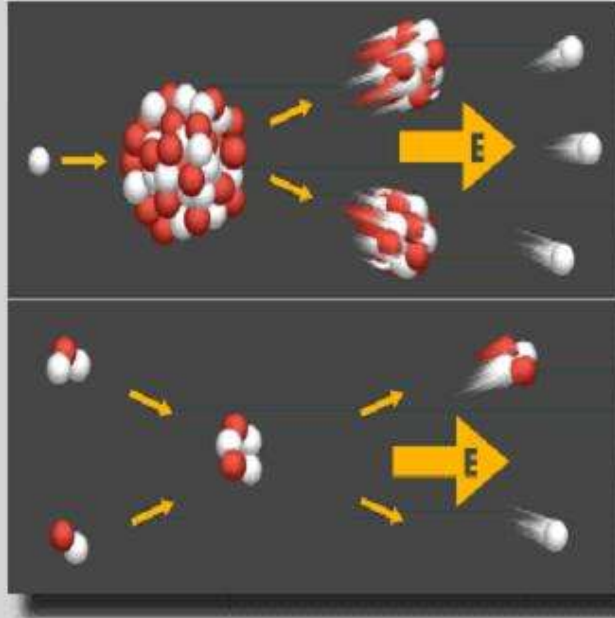
Role of nuclear in low carbon energy system

Vladimír Slugeň
Vladimir.Slugen@stuba.sk

Štiepenie-fission



Fúzia-fusion



Energy:

Fusion	3E11 J/g
Fission	8E10 J/g
Coal	3E4 J/g
Oil	4E4 J/g

Fuel for:

1 GW	CP -	3E9 kg/r
	NPP -	2E4 kg/r
	FP -	250 kg/r

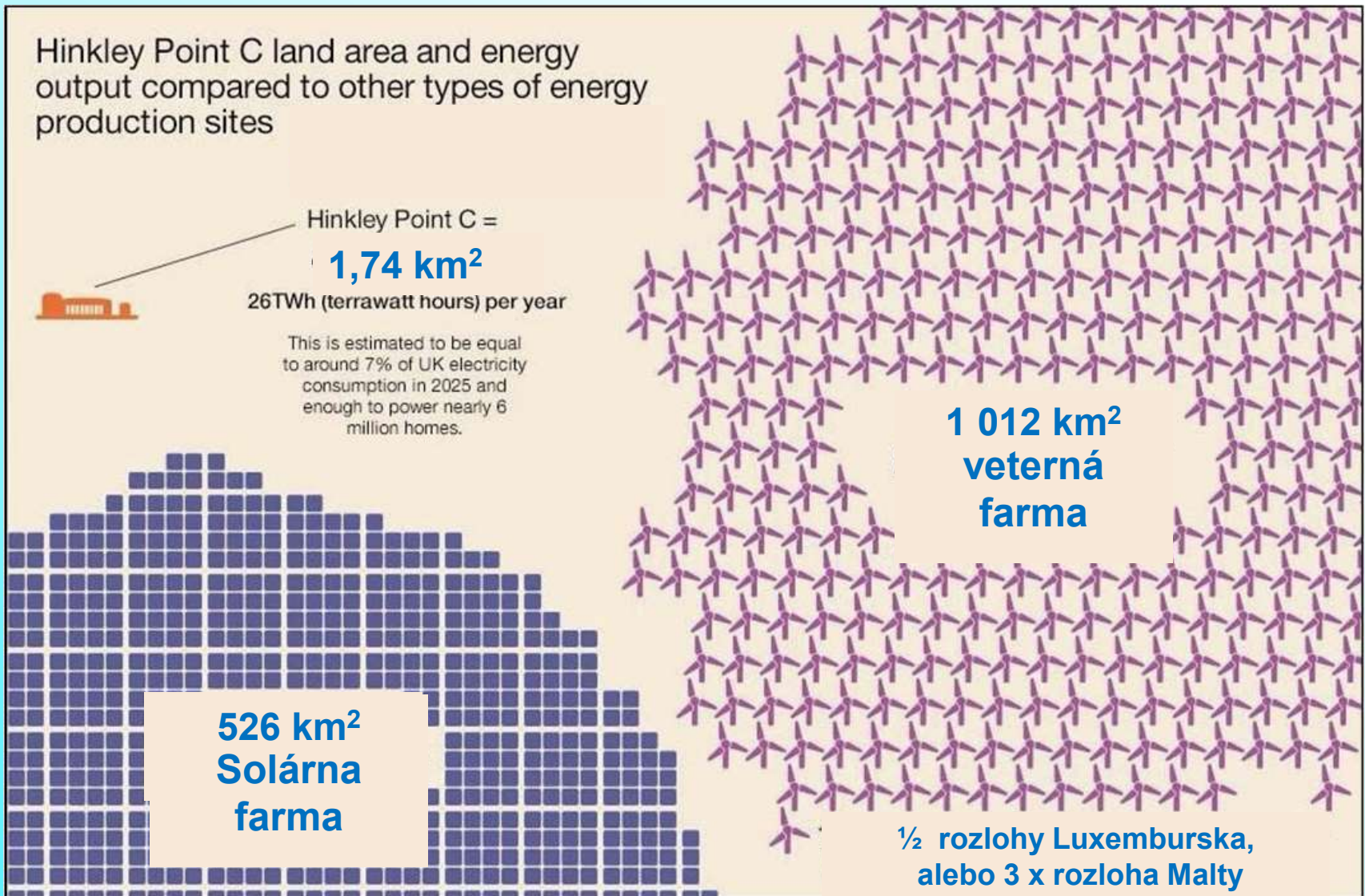
Reaction

Q [MeV]

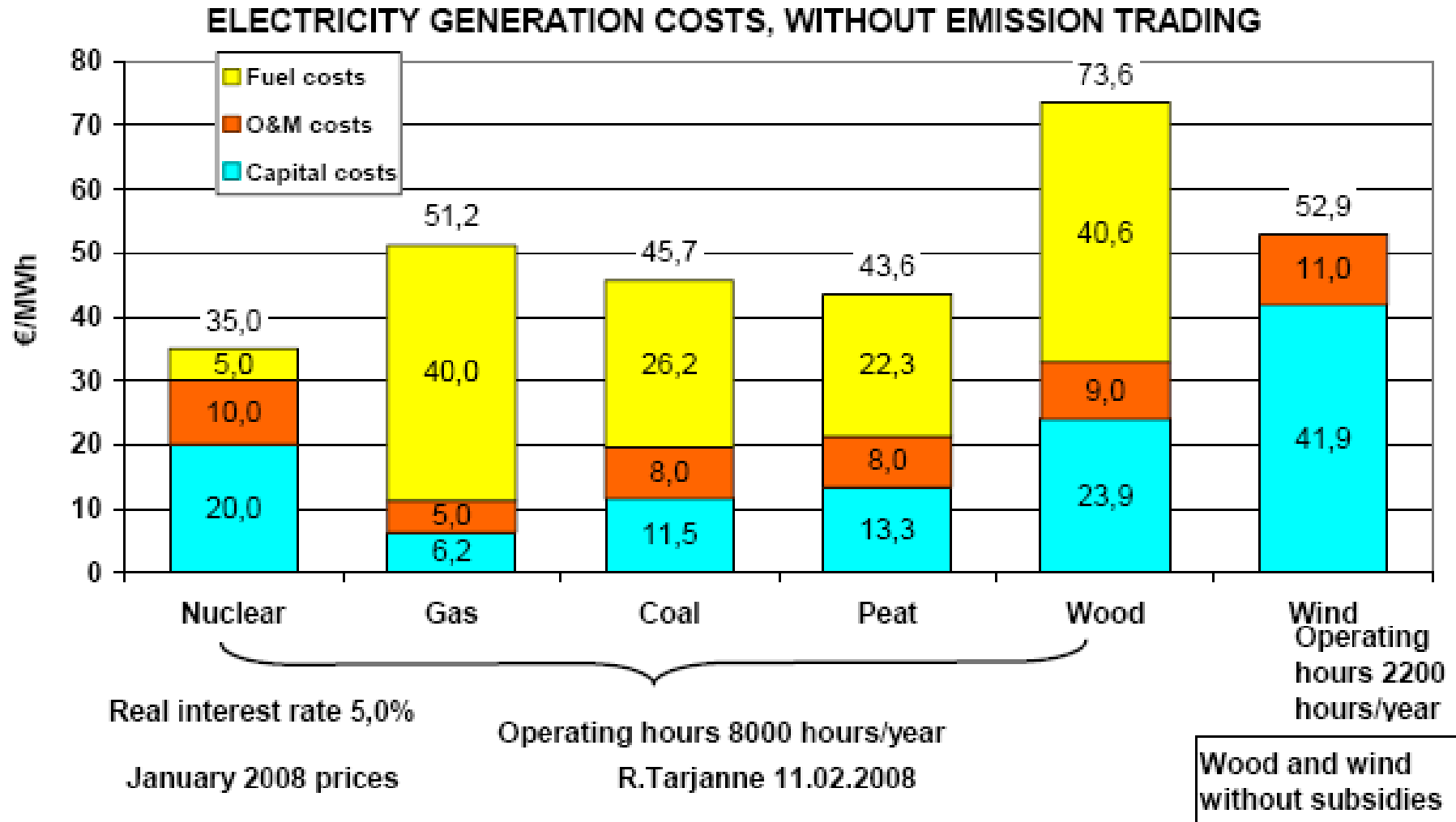
E [MeV]

TD	$T + D \rightarrow 4 \text{ He } (3,52 \text{ MeV}) + n (14,06 \text{ MeV})$	17,58	3,52
DD	$D + D \rightarrow T (1,01 \text{ MeV}) + H (3,03 \text{ MeV})$	4,04	4,04
DD	$D + D \rightarrow 3 \text{ He } (0,82 \text{ MeV}) + n (2,45 \text{ MeV})$	3,27	0,82
3 HeD	$3 \text{ He } + D \rightarrow 4 \text{ He } (3,67 \text{ MeV}) + H (14,67 \text{ MeV})$	18,34	18,34
11 BH	$11 \text{ B } + H \rightarrow 4 \text{ He } + 4 \text{ He } + 4 \text{ He } + 8.68 \text{ MeV}$	8,68	8,68

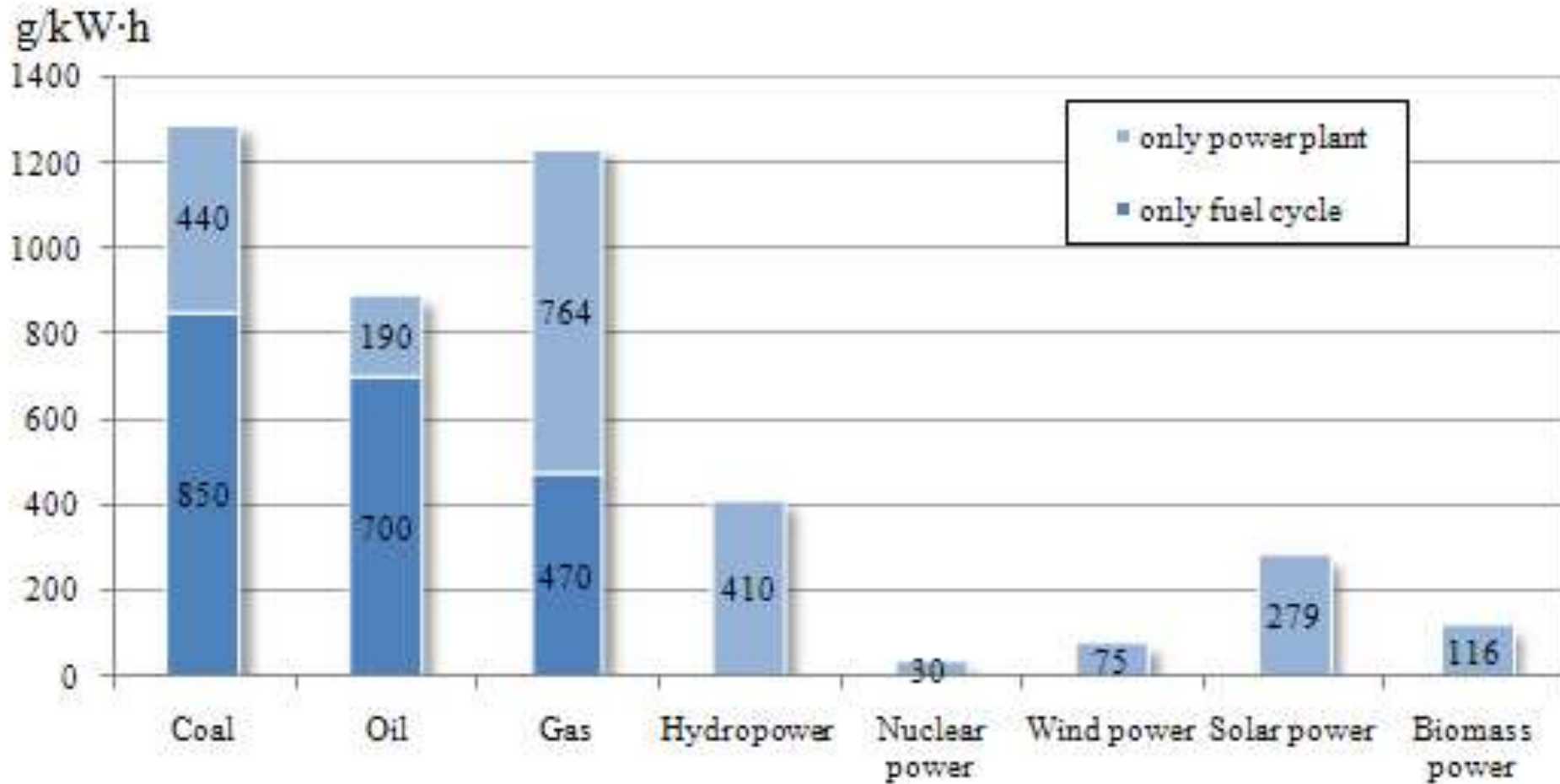
Porovnanie technológií z pohľadu nárokov na zastavanosť:



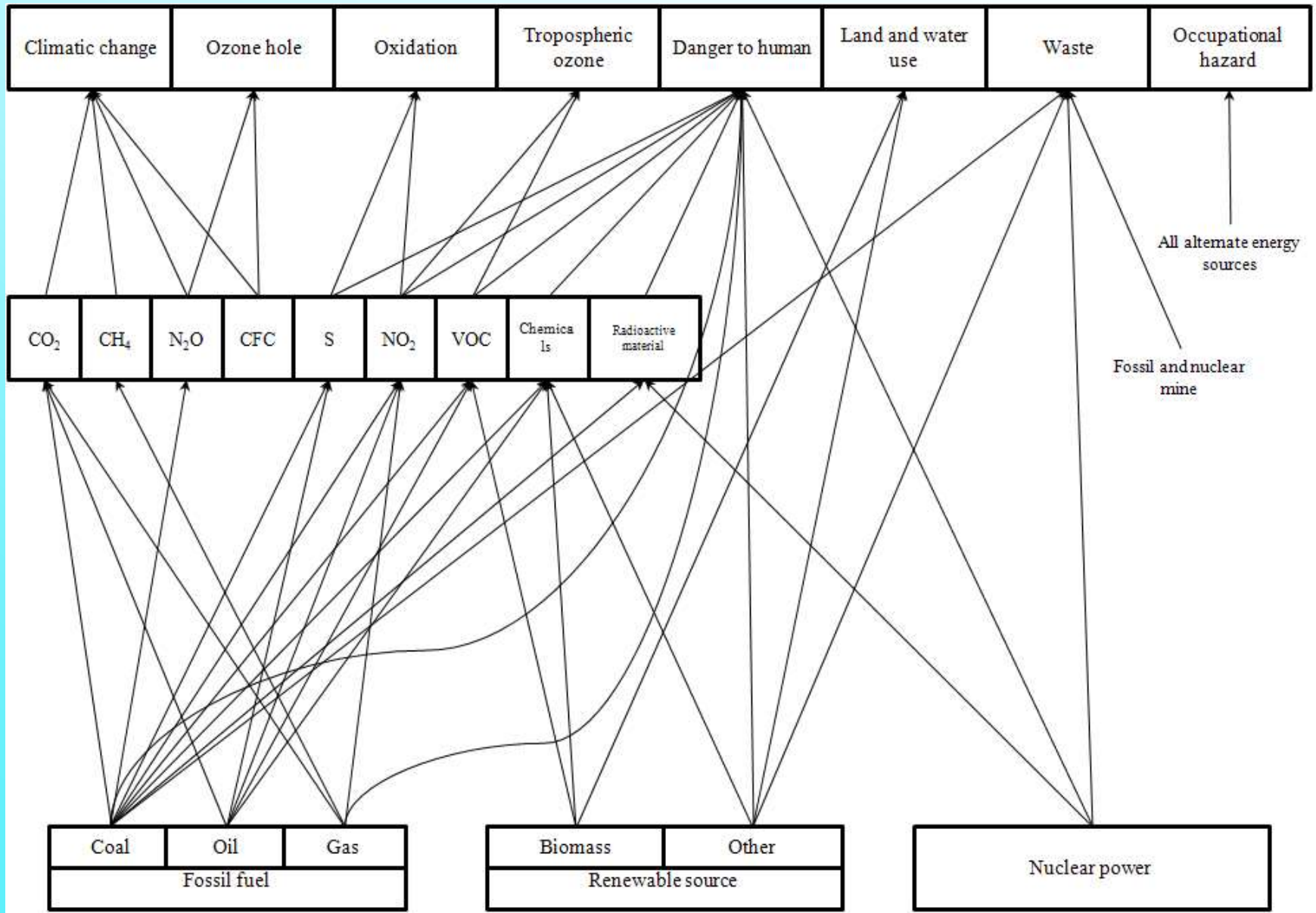
Nuclear should stay in the balanced mix of electricity sources



Specific emissions of CO₂



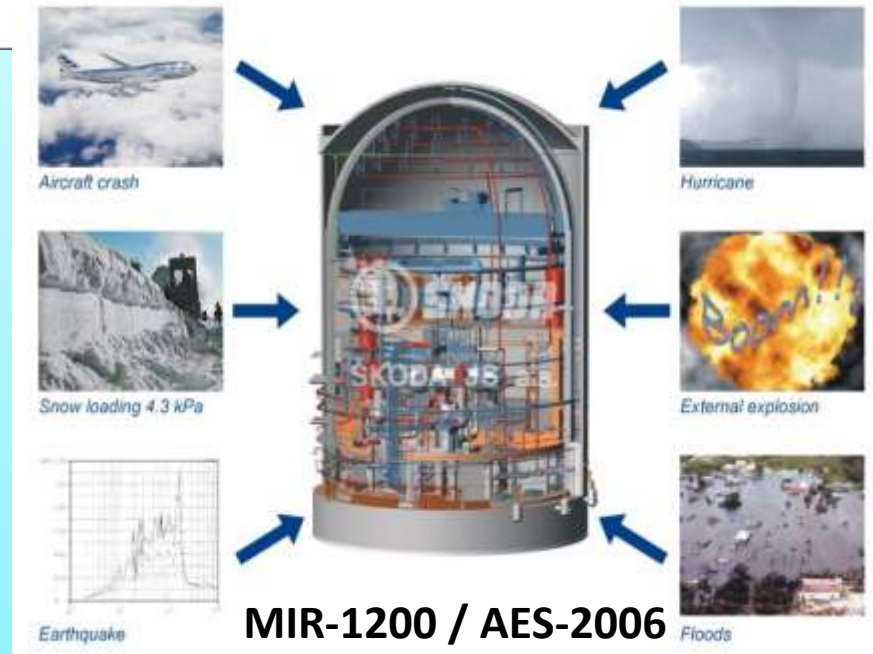
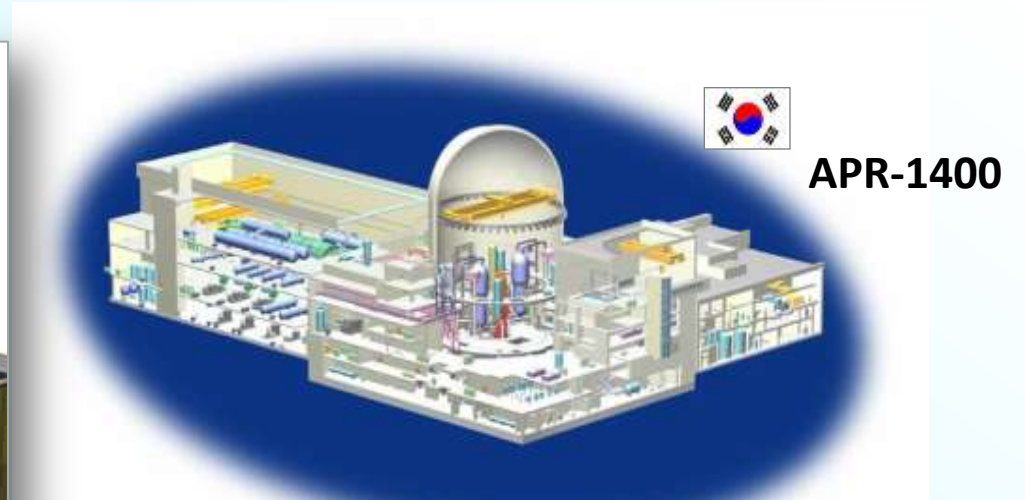
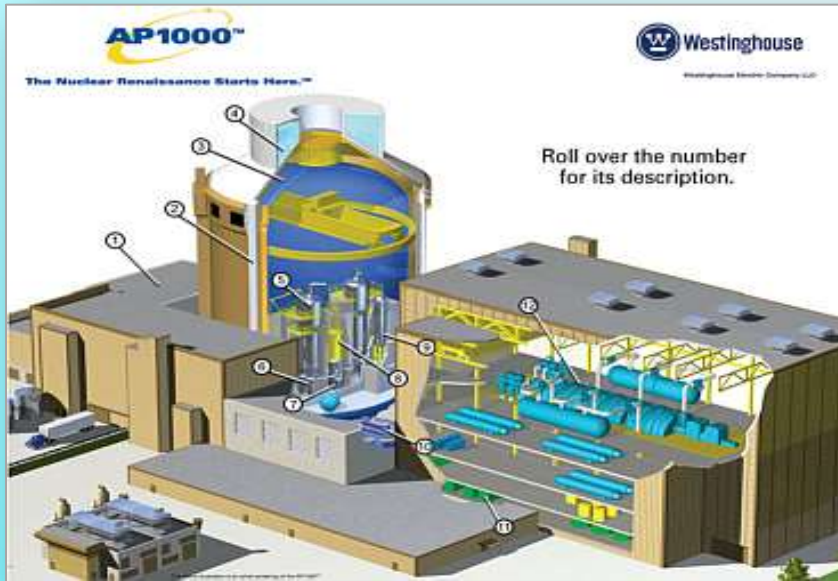
Enviro impacts of different energy production



Nuclear technology

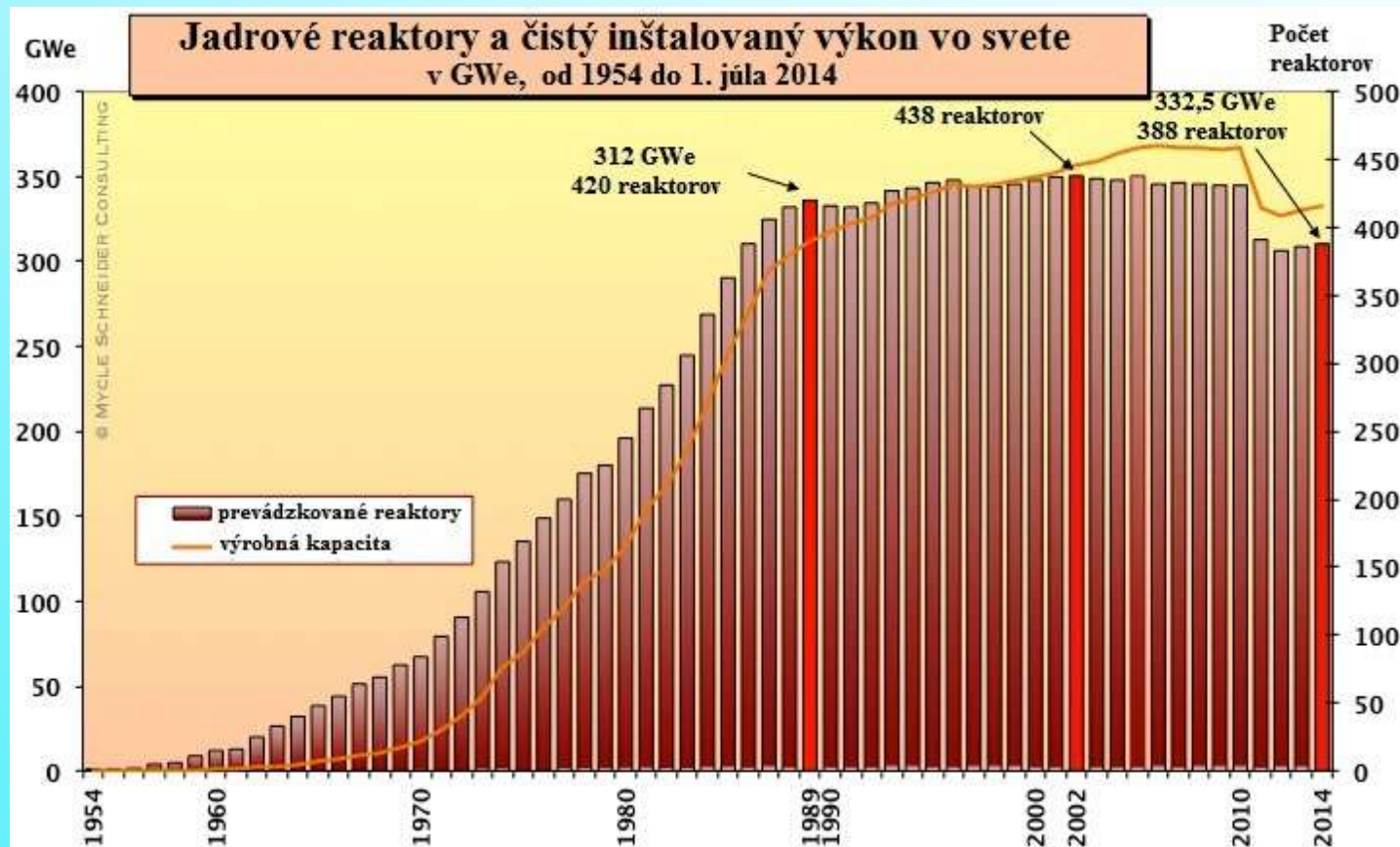


REACTORS Gen-3 (3+)



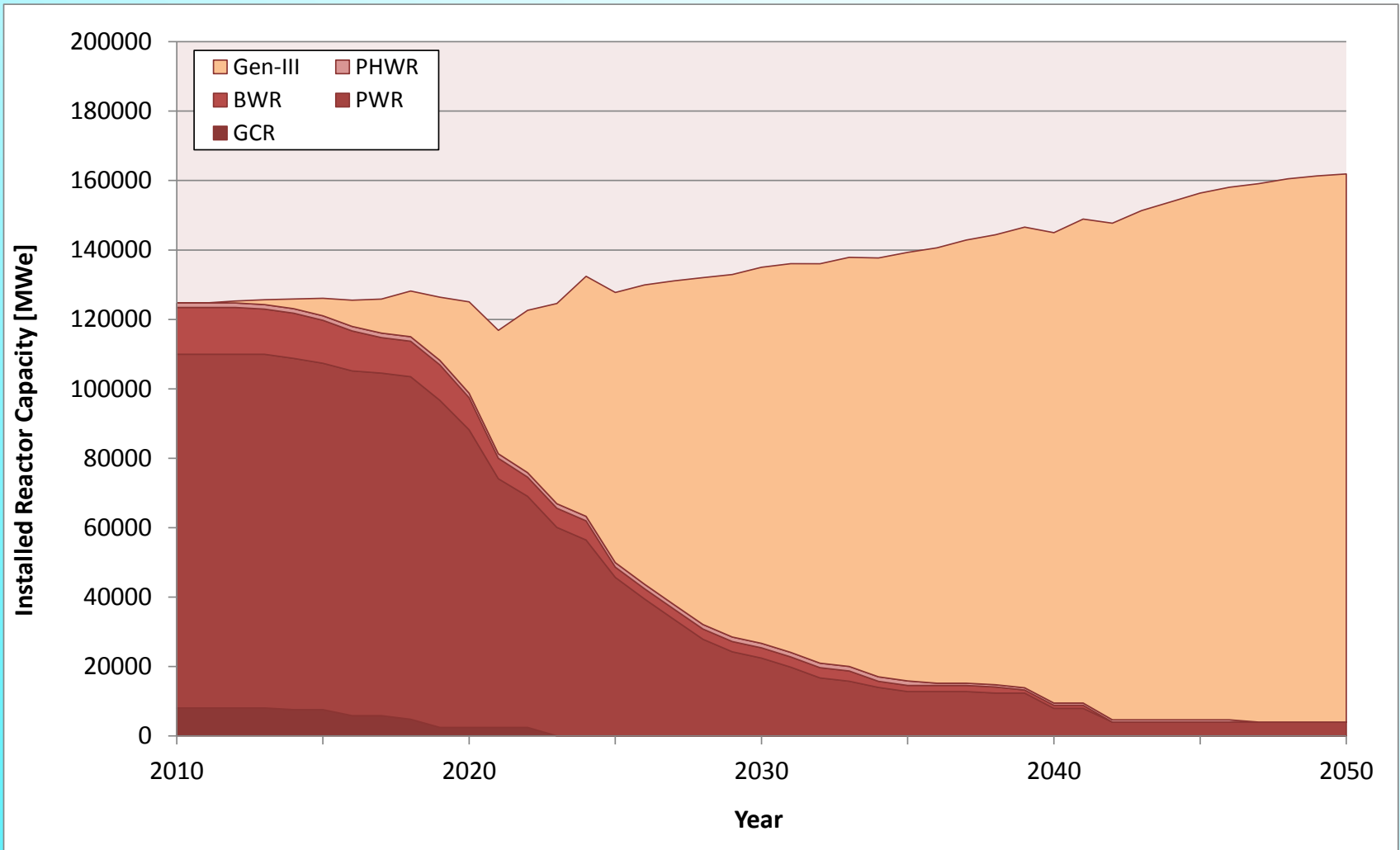
NPPs in world (2014)

- 31 countries
- 10,8 % of electricity production world-wide
- 388 reactors in operation and 67 in built

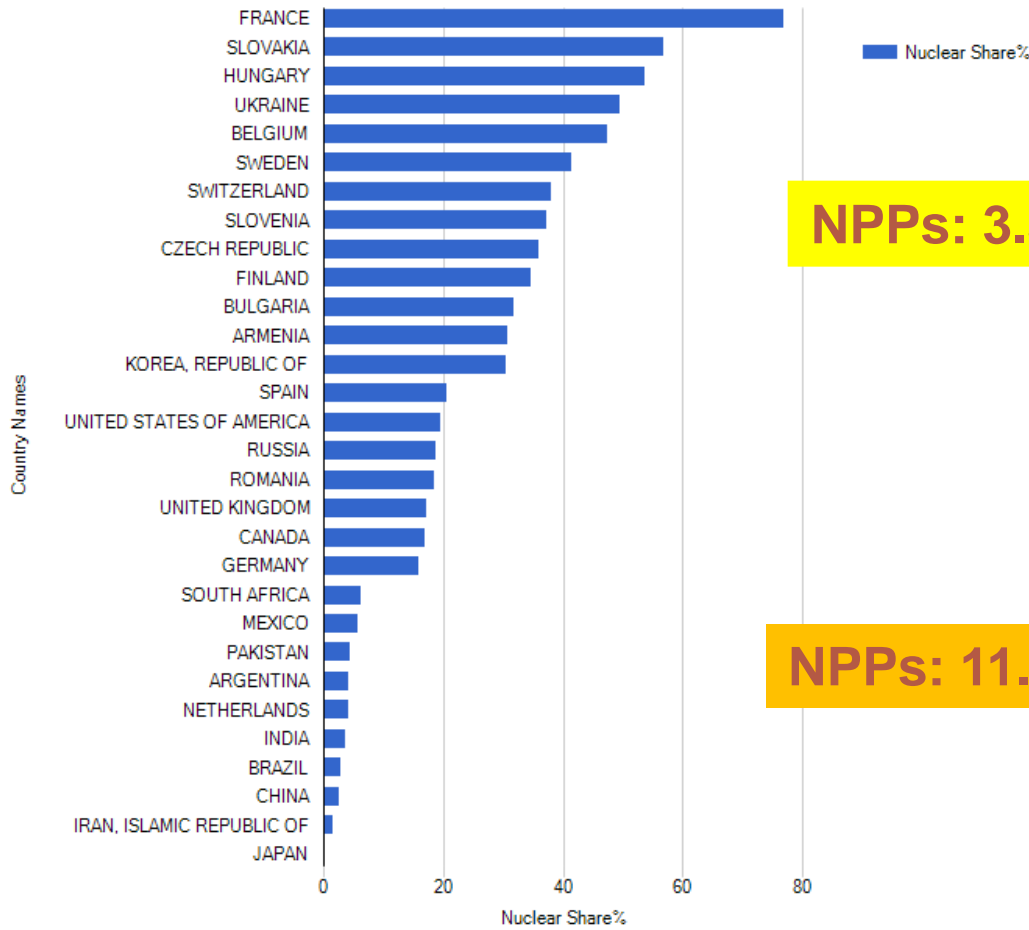


OECD/IEA Technology Roadmap

~115 reactors (1400 MWe)
~160 reactors (1000 MWe)



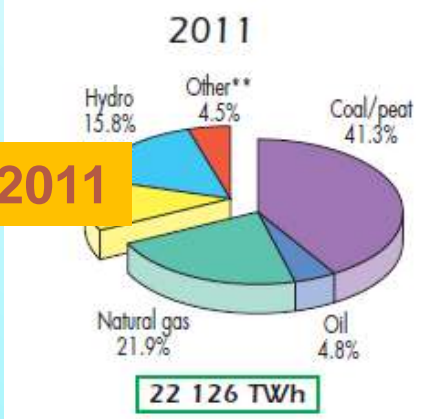
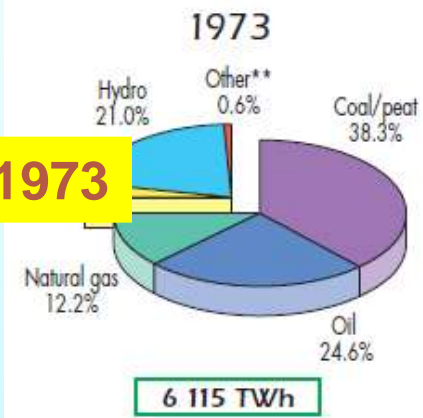
Nuclear share in electricity product.



NPPs: 3.3 % in 1973

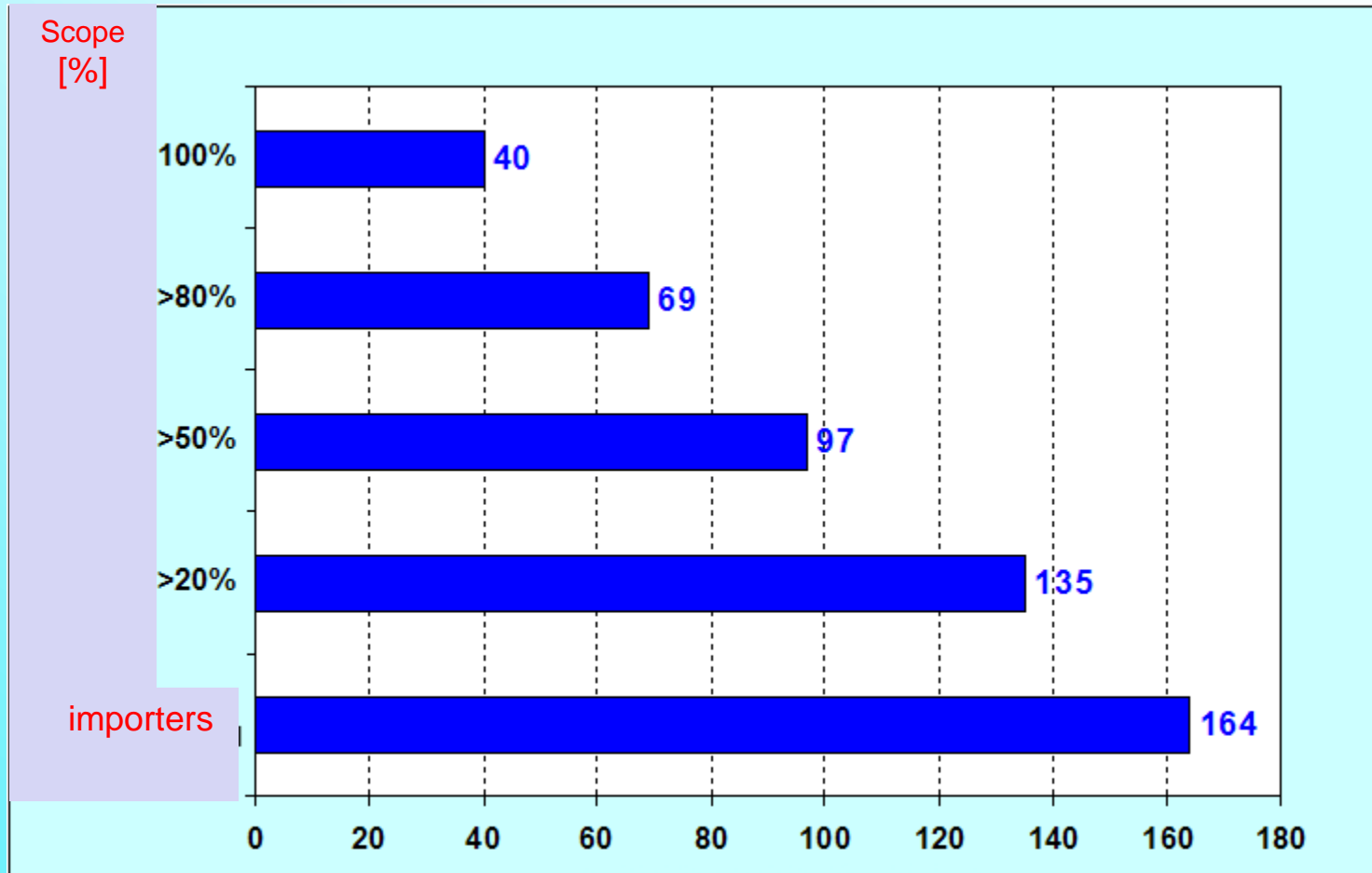
NPPs: 11.7 % in 2011

1973 and 2011 fuel shares of electricity generation*



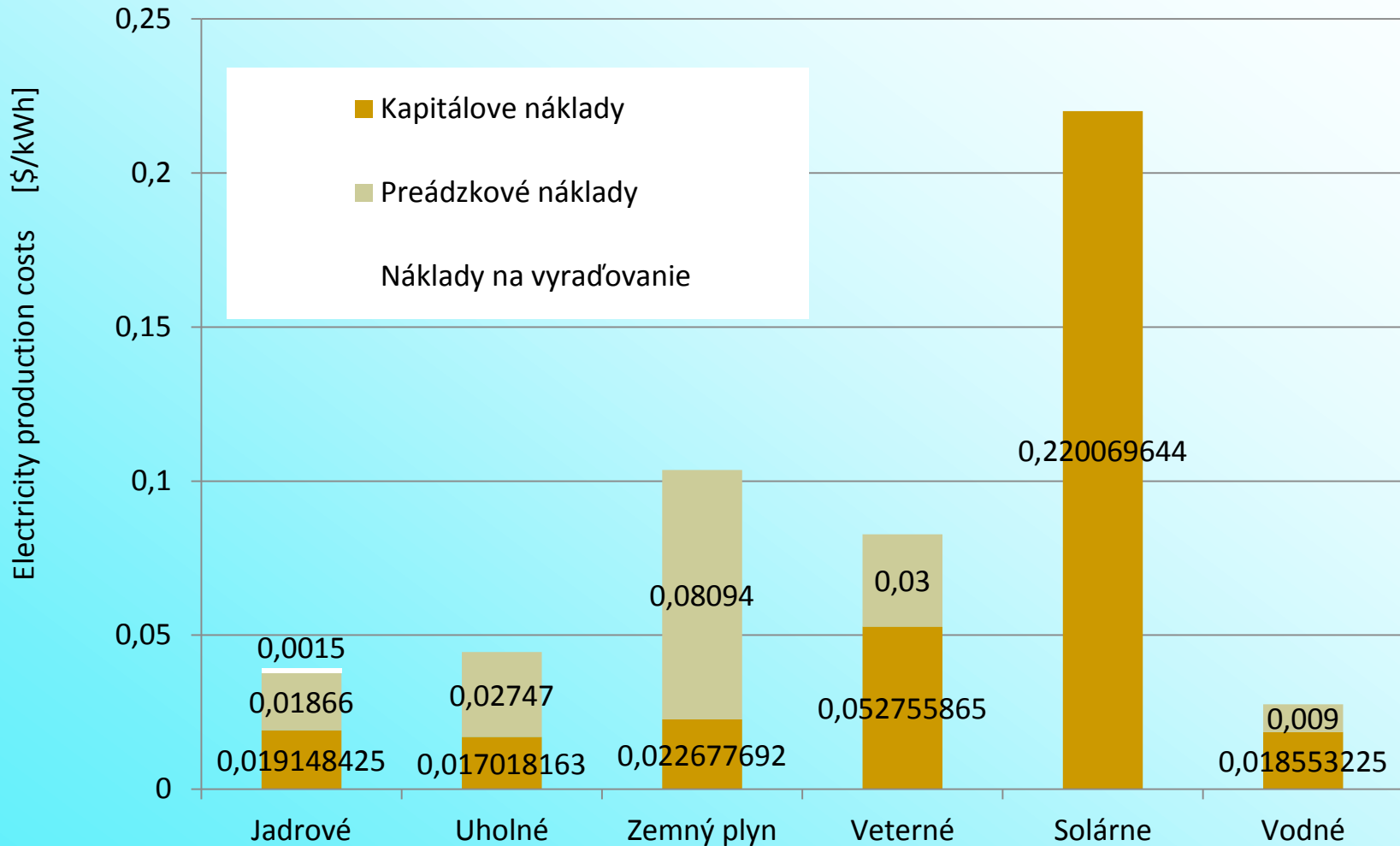
Source: IEA Key World Energy Statistics 2013

Dependence on inport (2014)



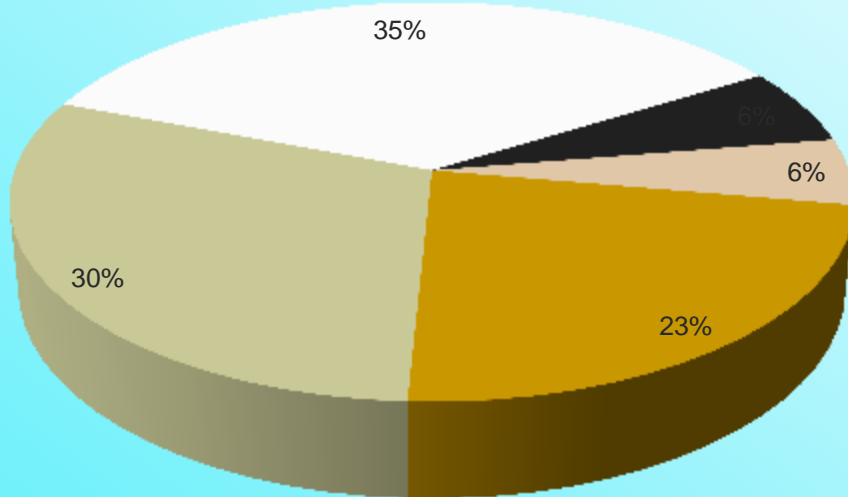
Only 40 countries do not import electricity

Comparison of energy sources based on electricity production costs



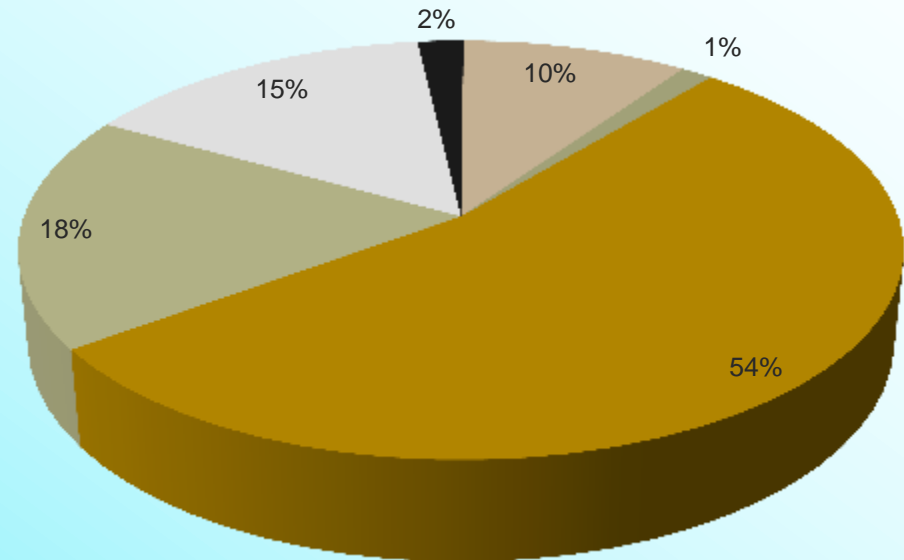
Installed capacity and electricity consumption in Slovakia

Installed capacity



■ JE ■ VE ■ TE ■ FVE ■ Ostatné

Electricity consumption



■ JE ■ TE ■ VE ■ FVE ■ Ostatné ■ Import

NPP in Slovakia

In operation: EMO1,2 (2x VVER440/213)

EBO V2 (2x VVER440/213)

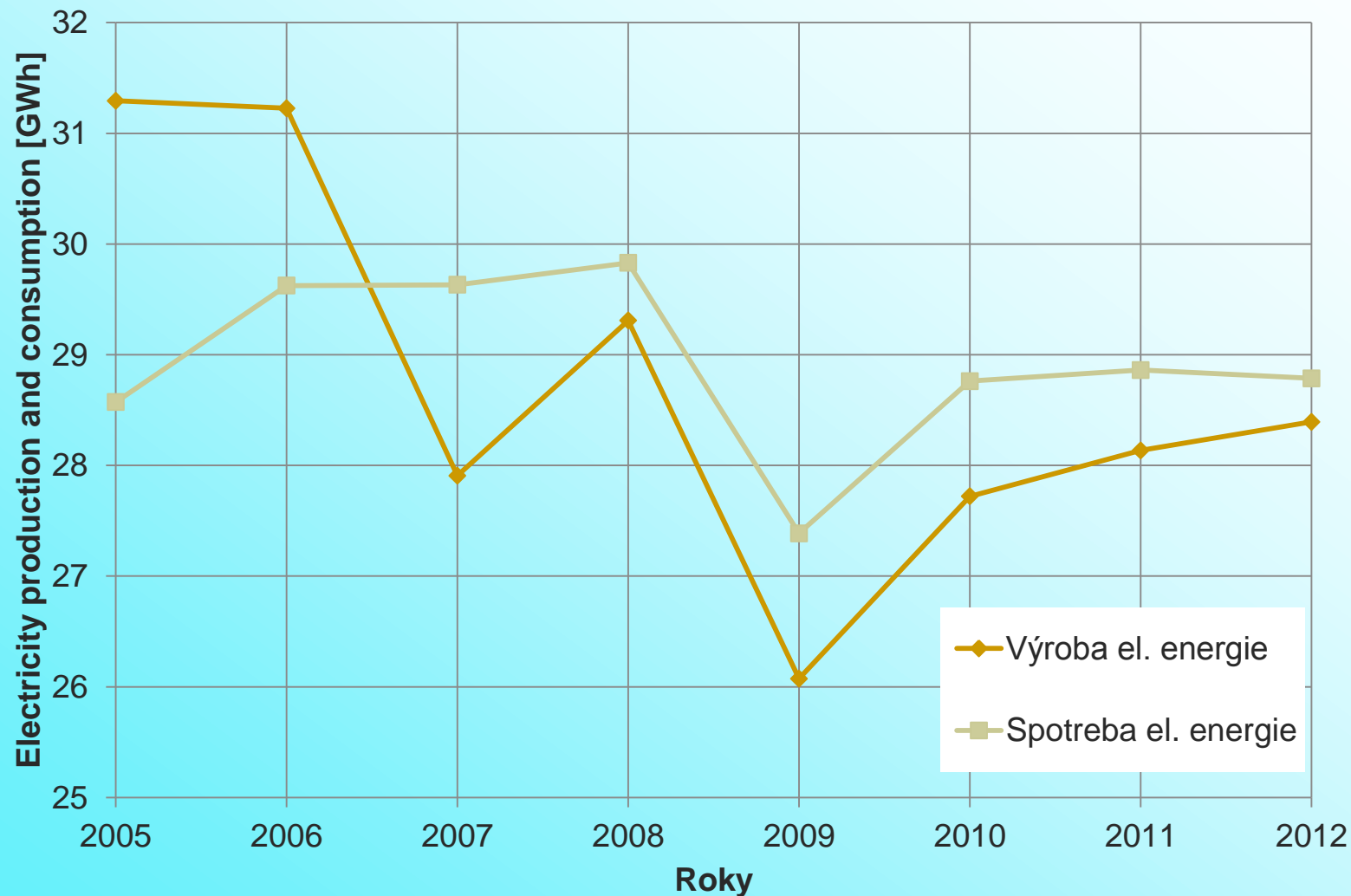
In built: MO3,4 (2x VVER440/213)

In decommissioning: V1 (2x VVER440/230)

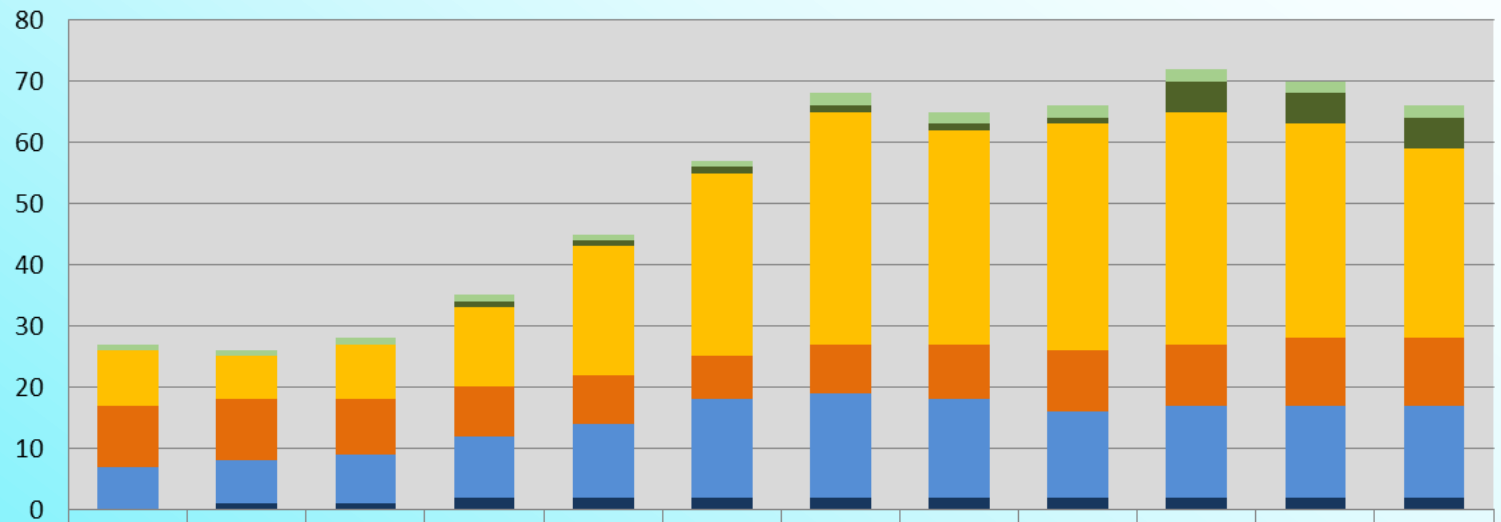
A1 (KS-150)



Electricity production and consumption in Slovakia

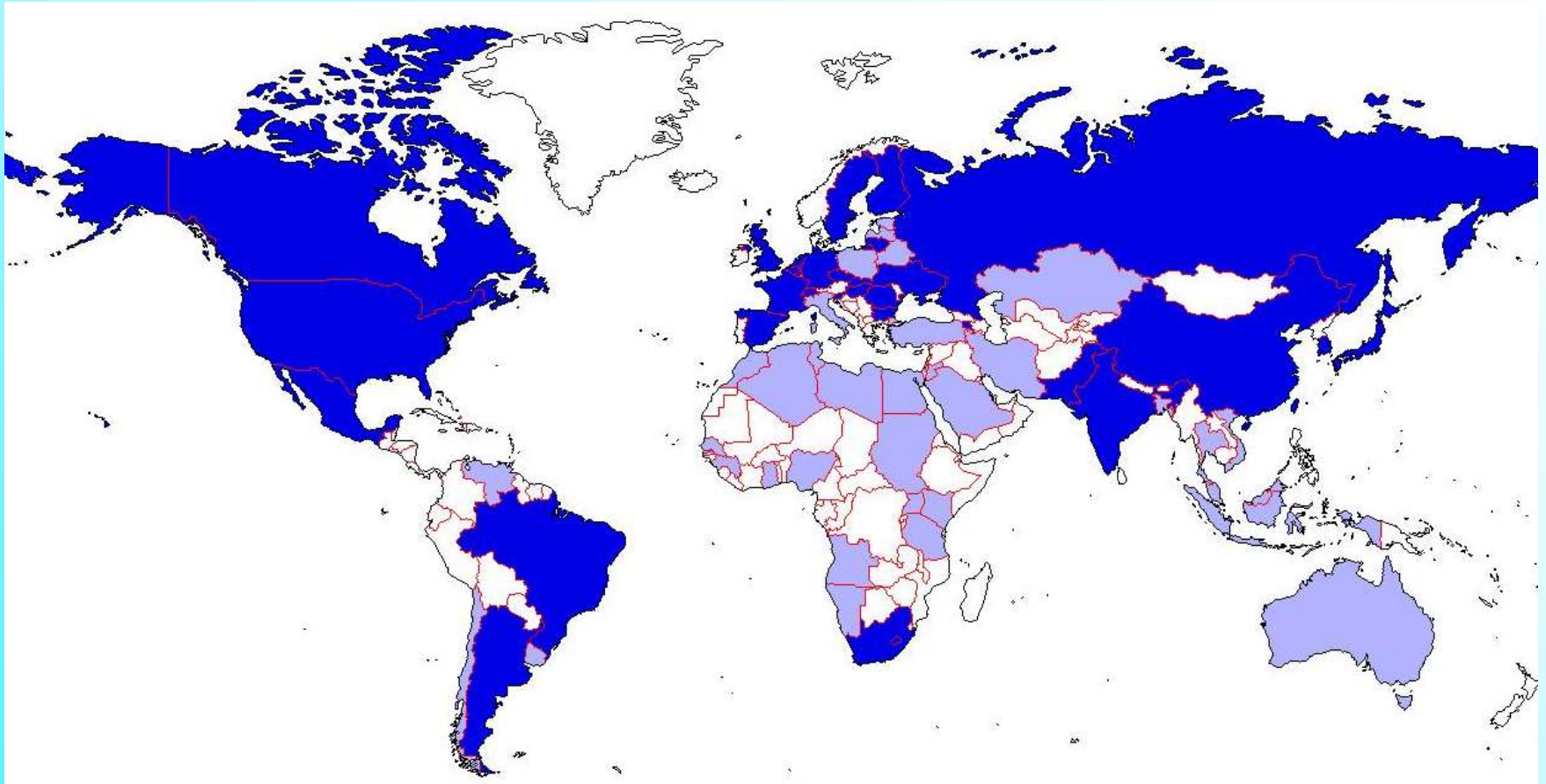


Number of reactors under construction by region

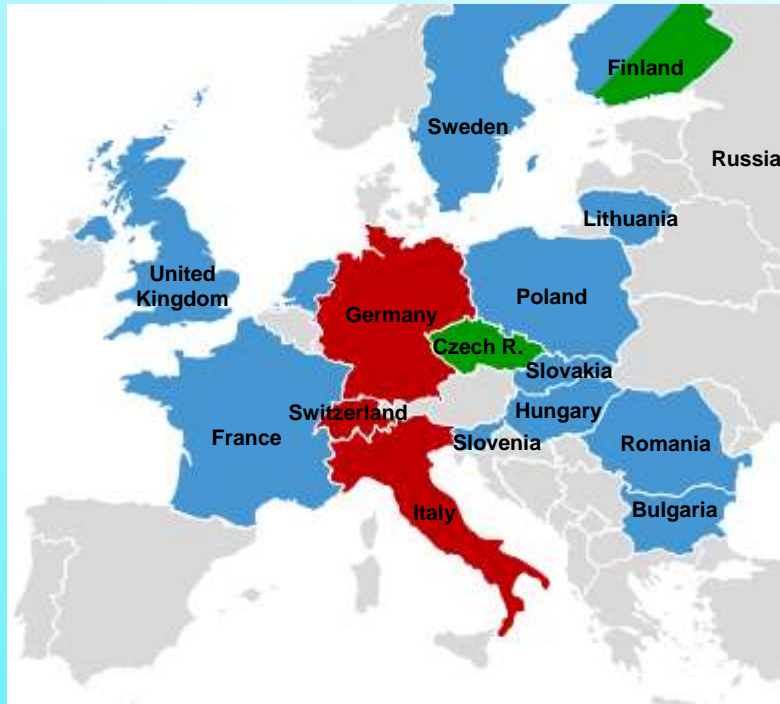


■ America - Latin	1	1	1	1	1	1	2	2	2	2	2	2
■ America - Northern	0	0	0	1	1	1	1	1	1	5	5	5
■ Asia - Far East	9	7	9	13	21	30	38	35	37	38	35	31
■ Asia - Middle East and South	10	10	9	8	8	7	8	9	10	10	11	11
■ Europe - Central and Eastern	7	7	8	10	12	16	17	16	14	15	15	15
■ Europe - Western	0	1	1	2	2	2	2	2	2	2	2	2

Countries with nuclear reactors and countries planning NPPs built.



Planned NPP built in Europe before Fukushima



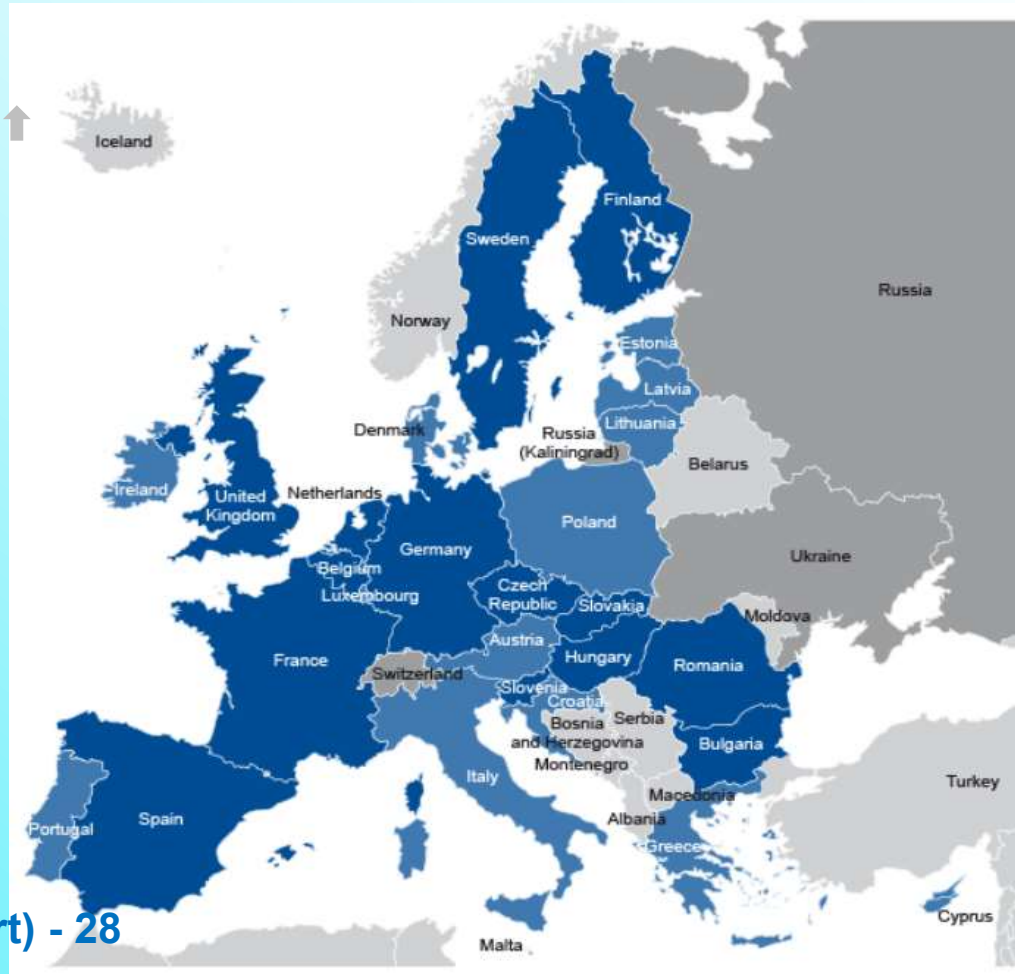
- Planning new build
- Open tender/negotiations
- Ban on new build

Country	Plans for new build
 Bulgaria	1 unit of Kozloduy NPP
 Czech Republic	2 units of Temelin NPP. Bid process is underway.
 France	1 unit of Penly NPP.
 Finland	Bid/negotiation process for 2 new units is underway
 Hungary	2 units of Paks NPP. Tender TBA in 2013-2014
 Lithuania	1 unit of Visaginas NPP
 Poland	6GW. First tender to be announced
 Romania	2 units of Cernavoda NPP
 Slovakia	1 unit of Bohunice NPP
 Slovenia	1 unit Krsko NPP under consideration
 Sweden	New units construction replacing the old ones
 United Kingdom	15-20 GW

Delays and posponing

NPPs in Europe – 2015:

- France - 58
- United Kingdom - 16 ↑
- Sweden - 10 ↓
- Germany - 9 ↓
- Belgium - 7 ↓
- Spain - 8 ↓
- Czech Republic - 6 ↓
- Slovakia - 4 ↑
- Finland - 4 ↑
- Hungary - 4 ↑
- Bulgaria - 2 ↑
- Romania - 2 ↑
- Netherlands - 1 ↑
- Slovenia - 1
- Switzerland - 5
- Ukraine - 15
- Russia (European part) - 28



- EU member states with operating nuclear power plants (as of January 2014)
- EU member states without operating nuclear power plants
- Non-EU countries with operating nuclear power plants
- Non-EU countries without operating nuclear power plants

Total in EU

132

+

CH + UA + RF

48

||

Total in Europe

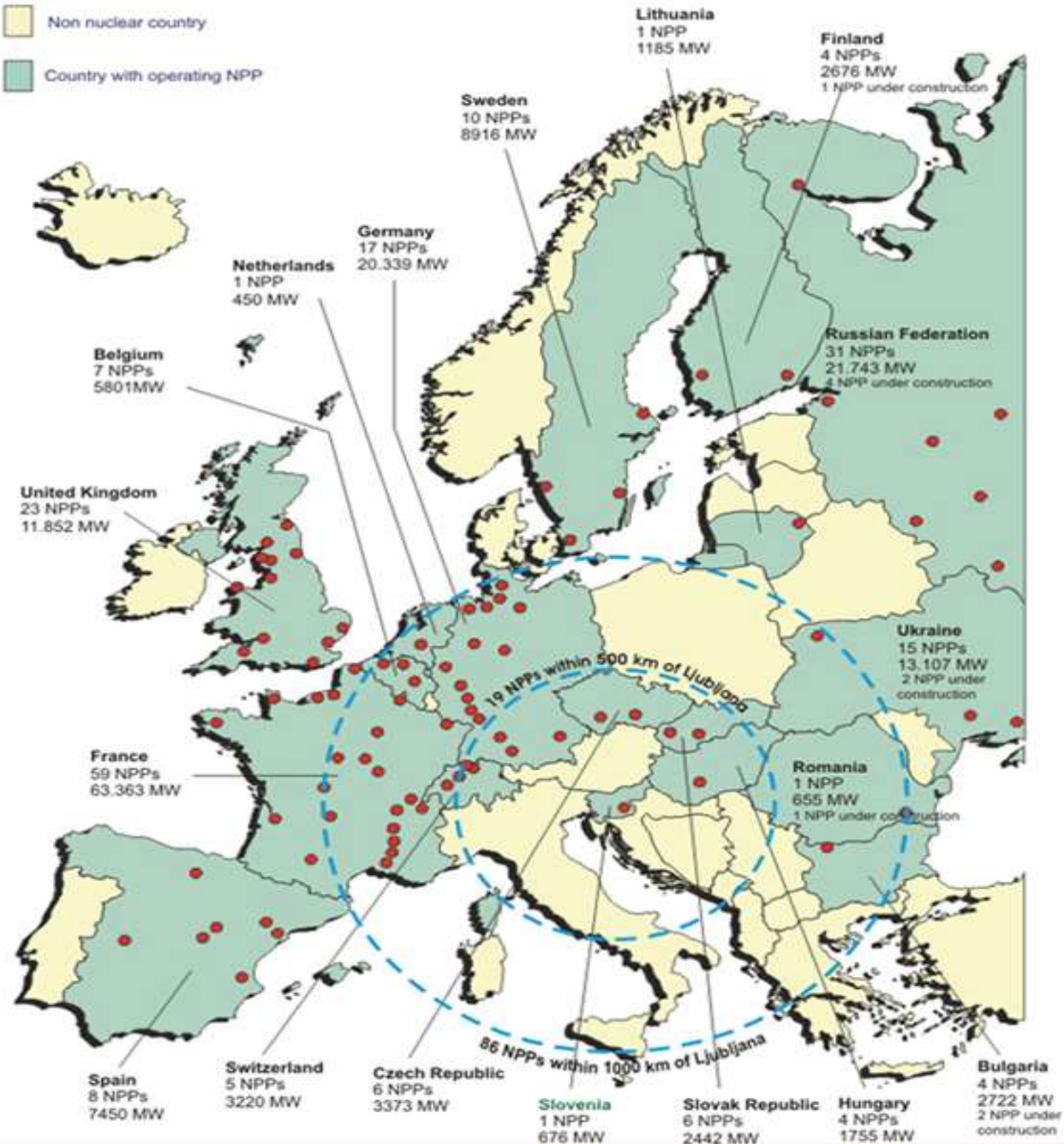
180
reactors

Location of NPPs in Western Europe.

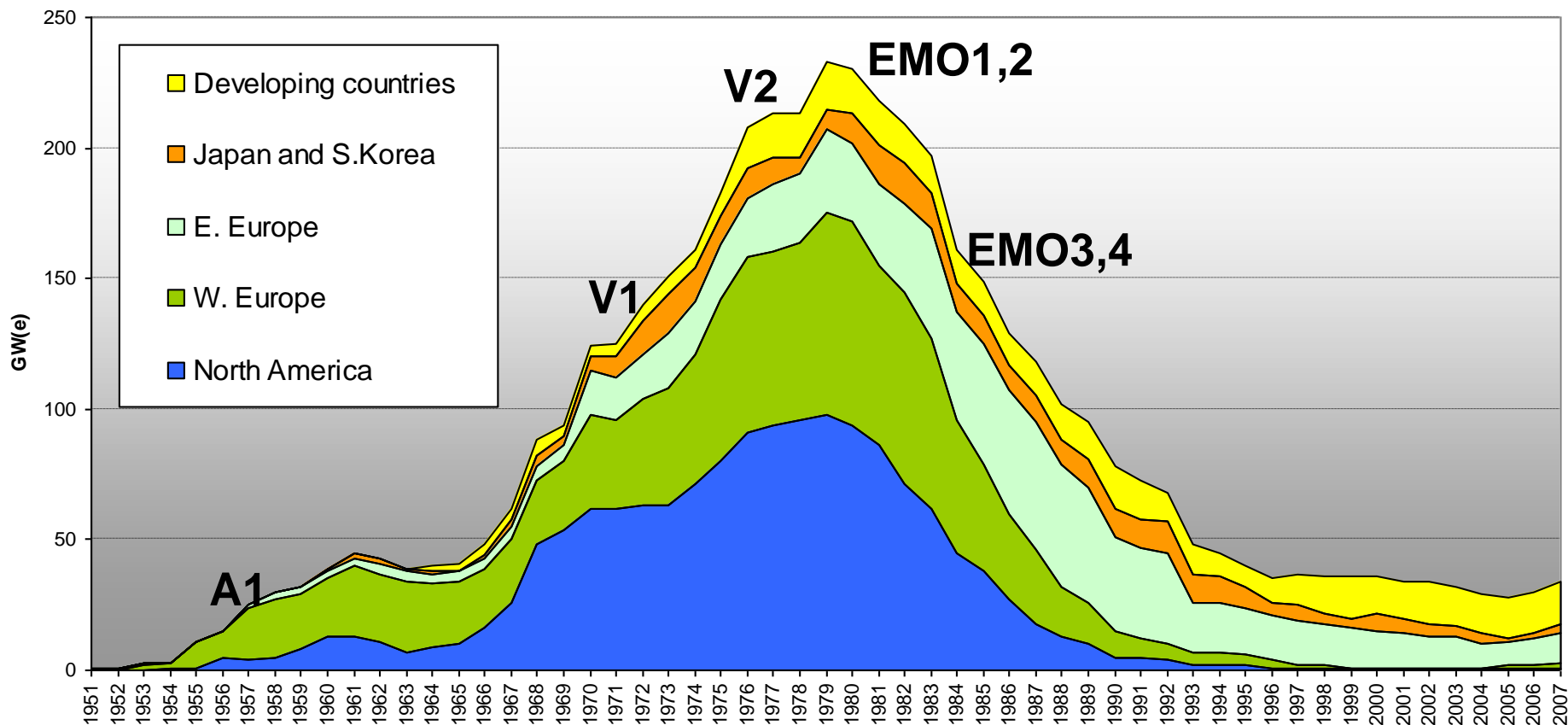
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www.icjt.org

 Non nuclear country

 Country with operating NPP



Number of reactors under construction



Thank you.



E-MAIL

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www.ujfi.feistuba.sk

China Nuclear & Electric Power Data

	Units	MWe (net)	Total Power Generation
Operating	11	8,602	3,316.6 TWh
Under Construction	21	21,221	
Planned / Proposed	~90	~100,000	Total Installed Capacity
Forecast for 2015	40	38,044	
Forecast for 2020	69	70,216	800.0 GWe
Forecast for 2030	~129	~133,216	

Electric Power Generation Mix



2015

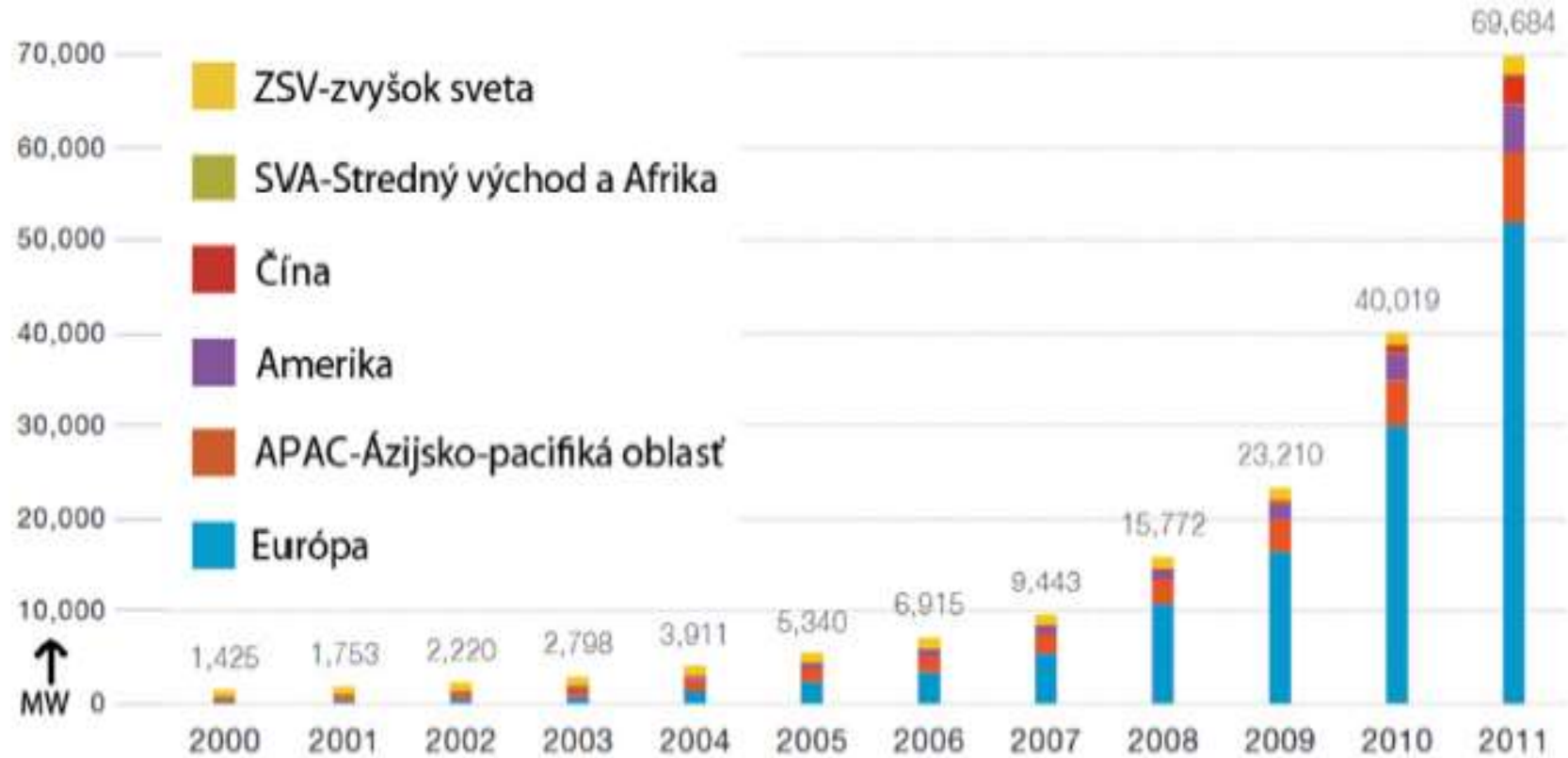
NPPs connected to grid

FANGJIASHAN-2	(1000 MW(e), PWR, CHINA) on 12 January
HONGYANHE-3	(1000 MW(e), PWR, CHINA) on 23 March
NINGDE-3	(1018 MW(e), PWR, CHINA) on 21 March
SHIN-WOLSONG-2	(960 MW(e), PWR, S. KOREA) on 26 February
YANGJIANG-2	(1000 MW(e), PWR, CHINA) on 10 March

New built

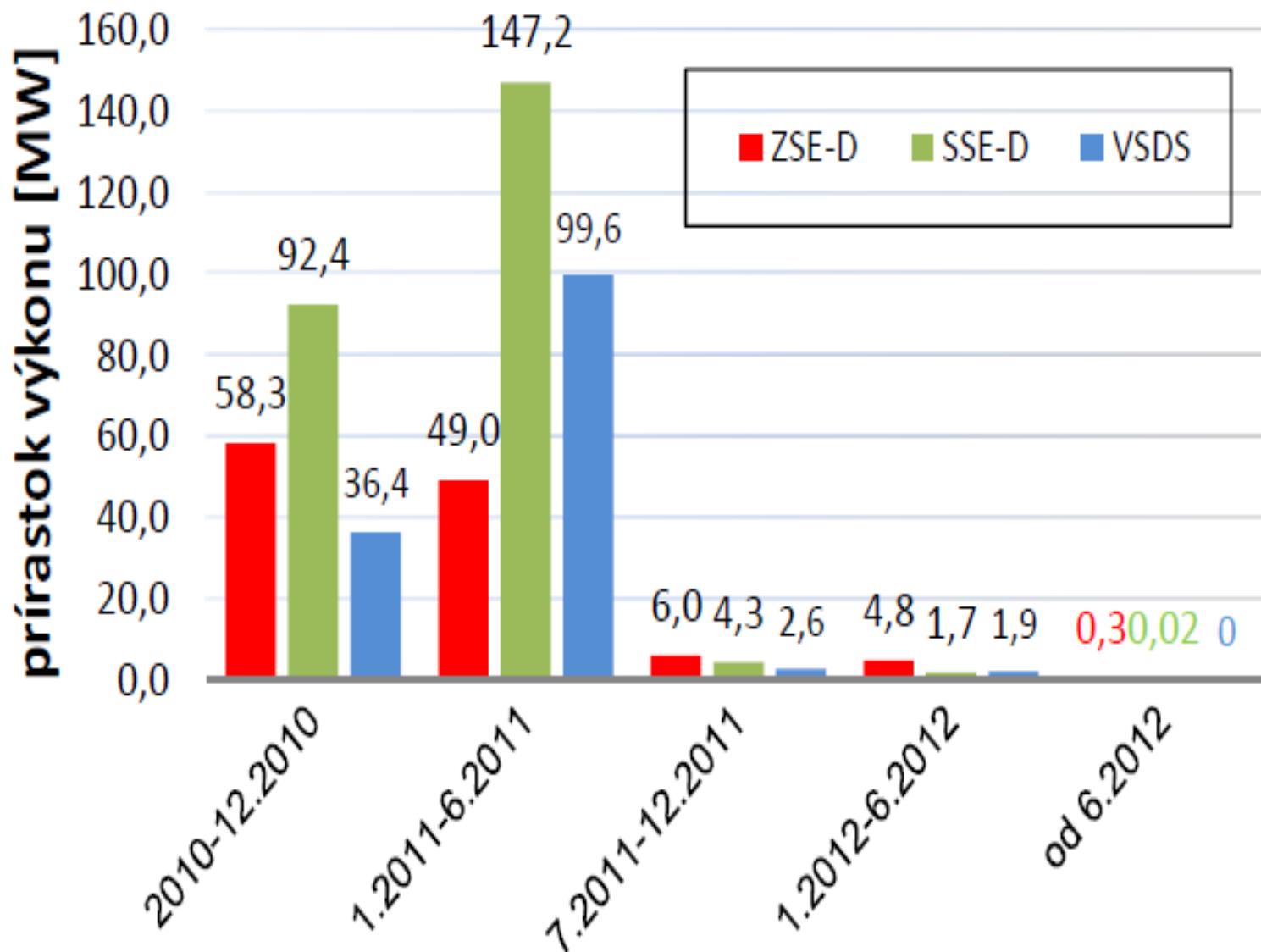
HONGYANHE-5	(1000 MW(e), PWR, CHINA) on 29 March
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Electricity marked deformations

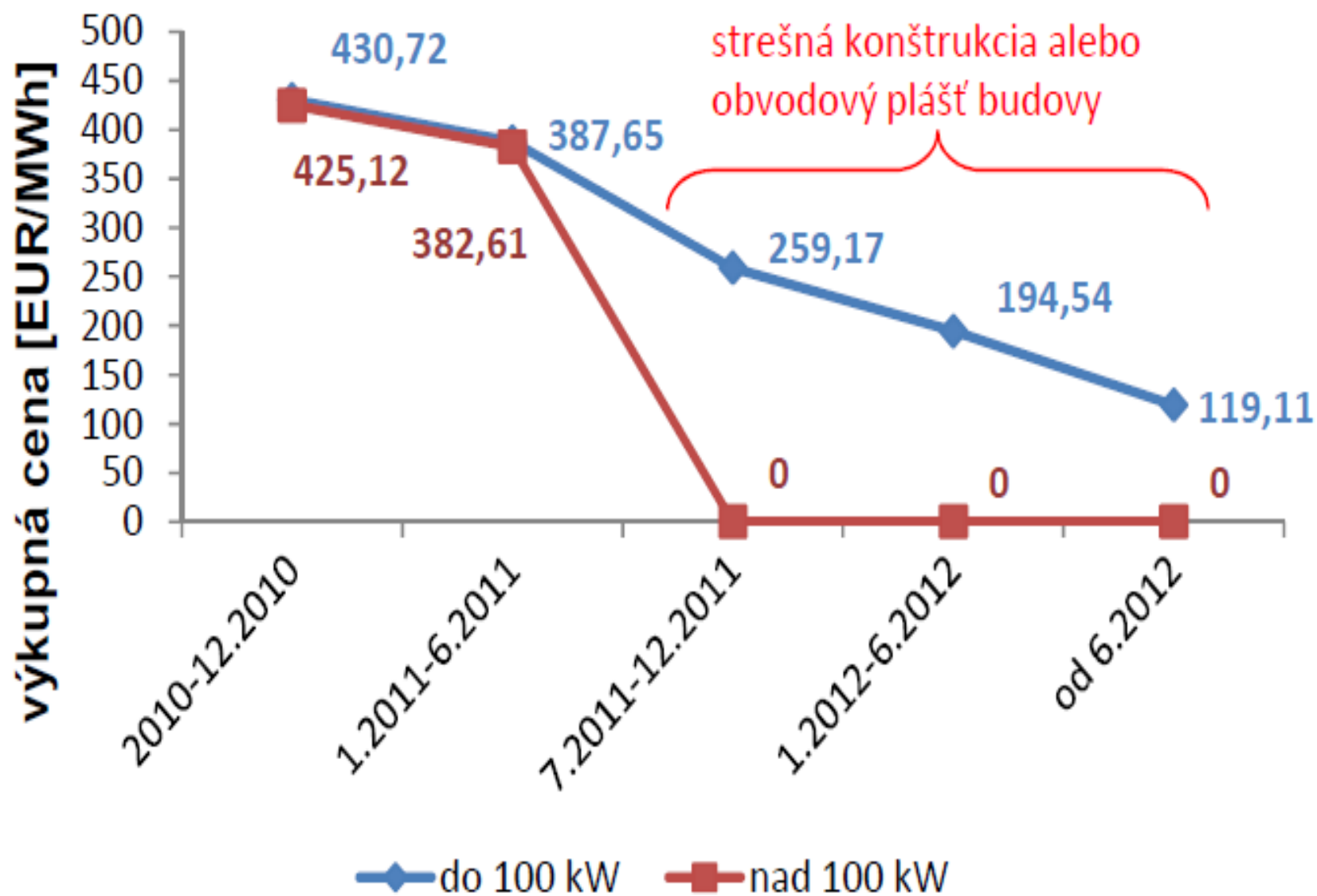


	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
ZSV	751	807	887	964	993	1,003	1,108	1,150	1,226	1,306	1,209	1,717
SVA	—	—	—	—	—	—	—	—	—	21	205	336
Čína	19	30	45	55	64	68	80	100	145	373	803	3,093
Amerika	146	177	222	287	378	496	645	856	1,205	1,744	2,820	5,053
APAC	355	491	677	902	1,178	1,475	1,797	2,080	2,643	3,409	5,116	7,769
Európa	154	248	389	590	1,297	2,299	3,285	5,257	10,554	16,357	29,777	51,716
spolu	1,425	1,753	2,220	2,798	3,911	5,340	6,915	9,443	15,772	23,210	40,019	69,684

Ročné prírastky výkonu vo FV zdrojoch v rokoch 2000-2011 (ROW- zvyšok sveta, MEA- Stredný Východ a Afrika, APAC- Ázijský Pacifik)³⁰



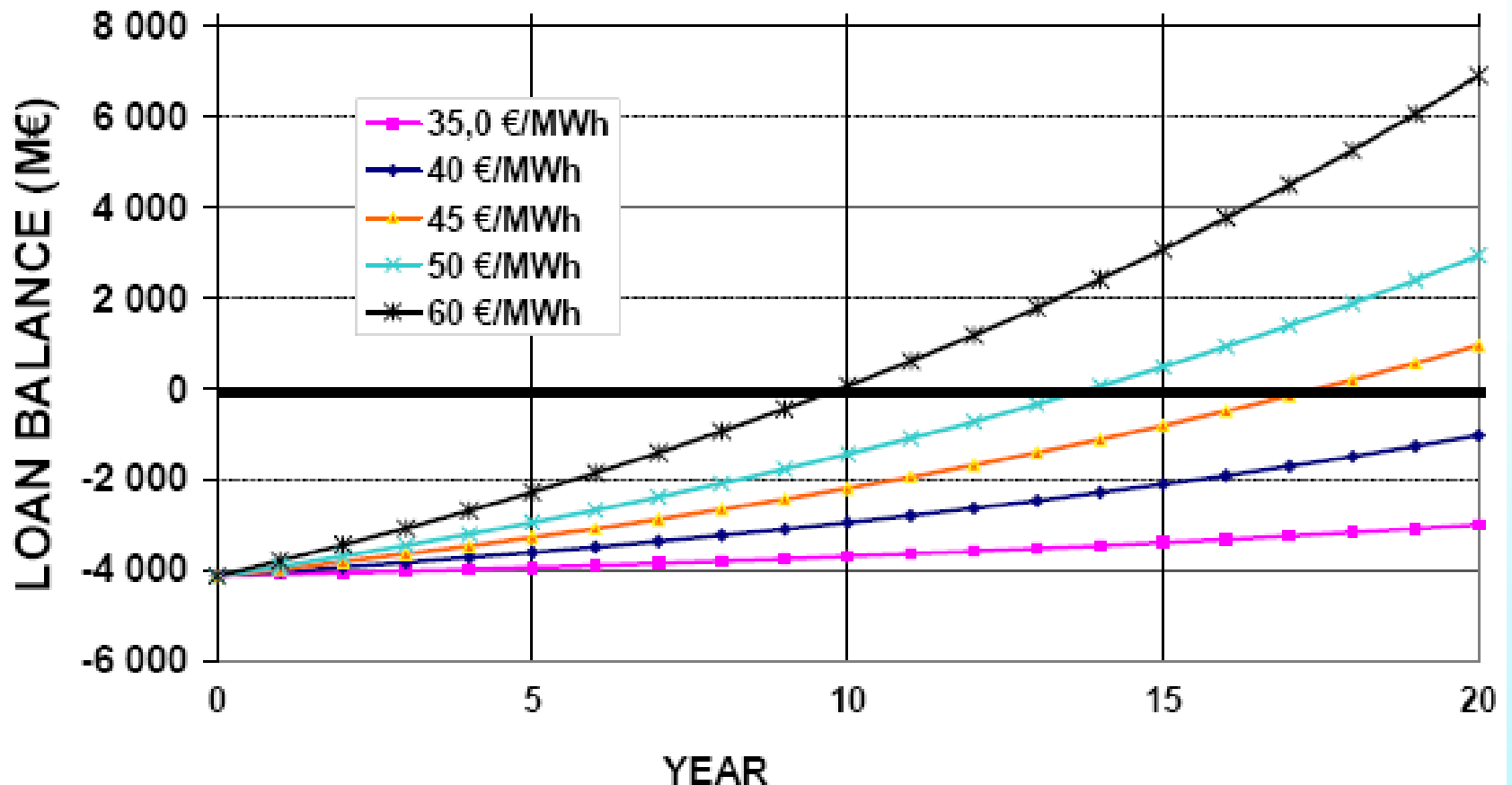
Približný prírastok inštalovaného výkonu v SR v jednotlivých obdobiach trvania výkupných cien podľa RDS (na základe cenových rozhodnutí ÚRSO pre rok 2012)⁴¹

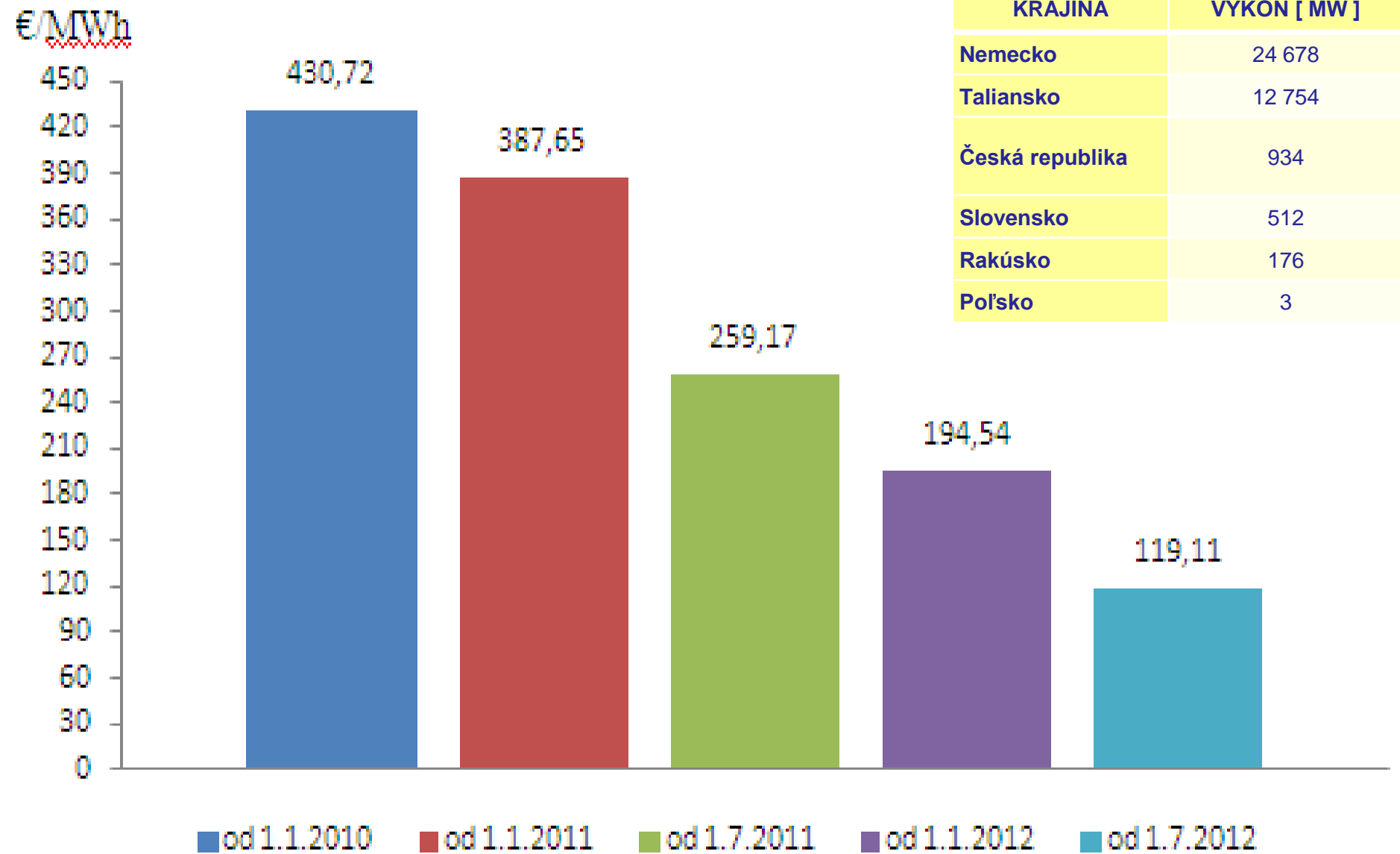


Vývoj výkupných cien za elektrickú energiu (EUR/MWh) vyrobenú vo FV zdrojoch na Slovensku

Diagram návratnosti investícií do jadrového bloku pri meniacich sa cenách el. energie – v 20 ročnom horizonte

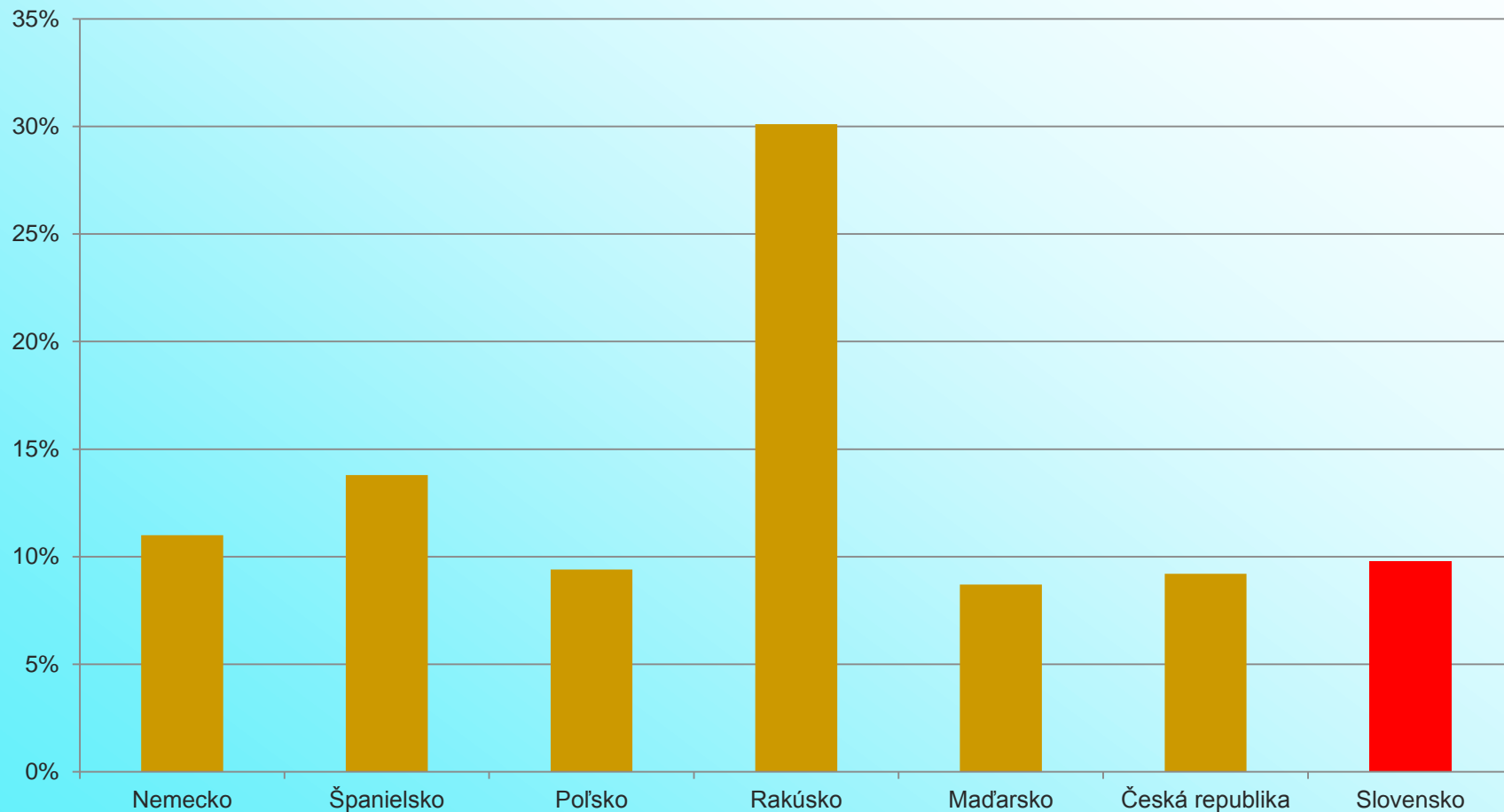
PAYBACK DIAGRAM OF NUCLEAR INVESTMENT WITH VARIOUS MARKET PRICES OF ELECTRICITY (time scale 20 a)





vývoj výkupnej ceny elektriny vyrobenej pomocou slnečnej energie 28

Podiel energie z OZE na hrubej konečnej spotrebe energie (Eurostat, 2013)



Energetické havárie

- V USA ročne 40 000 úmrtí od vdychovania splodín spaľ. uhlia v el.
- r. 1981 bronchitída od spaľovania uhlia v Anglicku - 15 600 úmrtí
- Pri explózii plynu v Mexiko City 1984 bolo zabitých 500 ľudí a zranených 4 248 ľudí
- Plynová havária si v ZSSR v roku 1989 vyžiadala 650 obetí
- Únik metylizokyanátu v Bhópale zabil 2 850 ľudí a vážne zranil 200 000 ľudí
- 26. apríl 1942 v Číne prišlo o život 1 549 ľudí pri explózii uhoľného prachu
- Ropný priemysel zabil tisícky ľudí pri haváriách tankerov, vrtných plošín a pri explóziách. Najťažšia havária v Brazílii v roku 1984 stála 546 životov
- Černobyľ – 38 priamych obetí (do troch mesiacov). Niekoľko 1000 ľudí s možnými následkami.
- Fukushima – nikto nezomrel na následky ožiarenia!!!