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NUKLEARNA ENERGETIKA POSLIJE FUKUŠIME: RENESANSA ILI SAHRANA?

Rad je predat u formi PP prezentacije.

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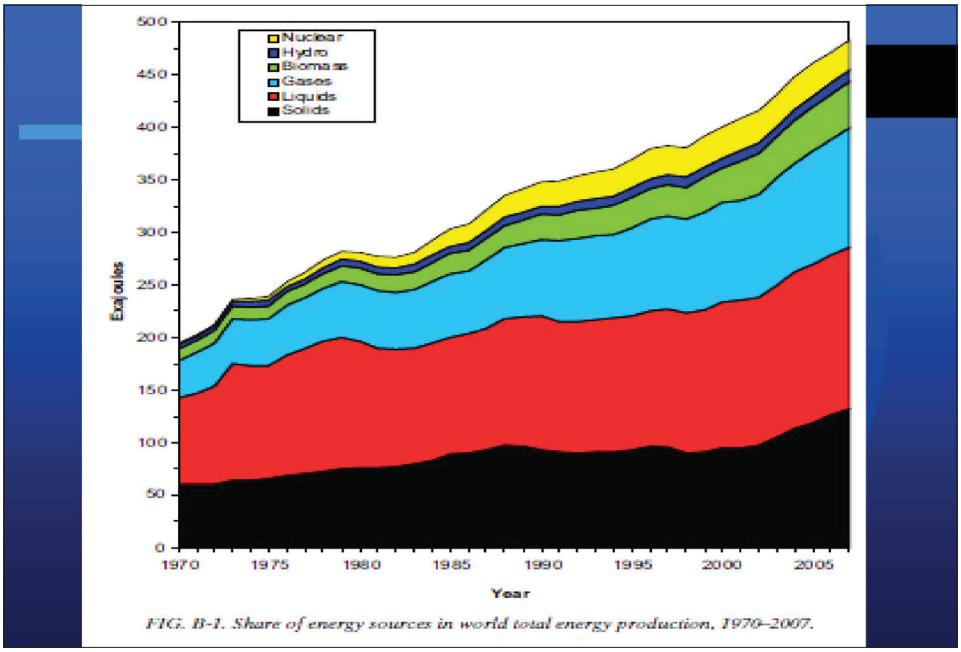
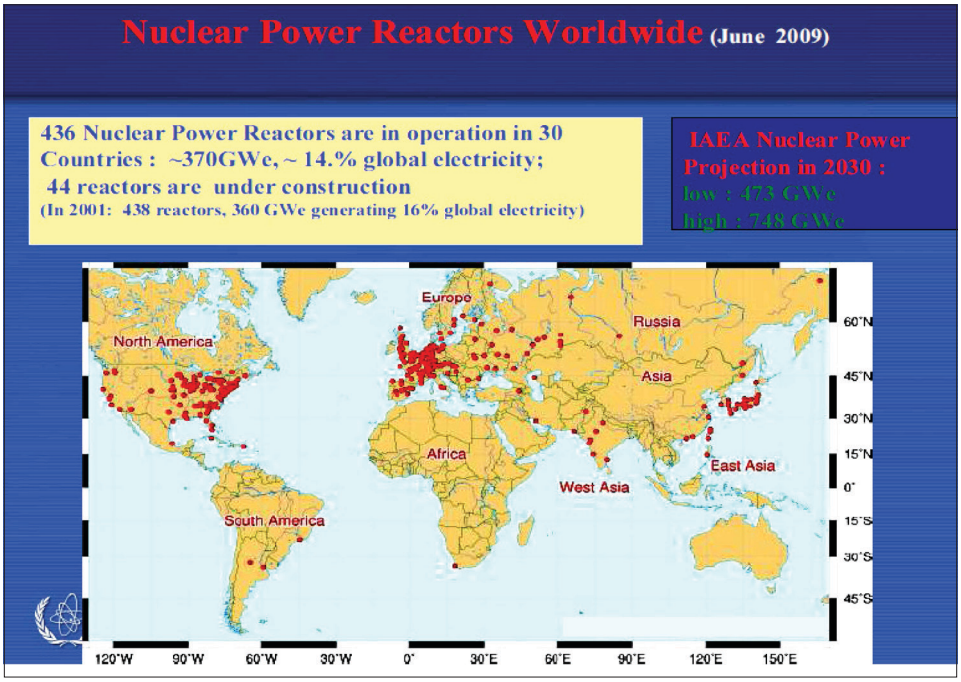


FIG. B-1. Share of energy sources in world total energy production, 1970–2007.



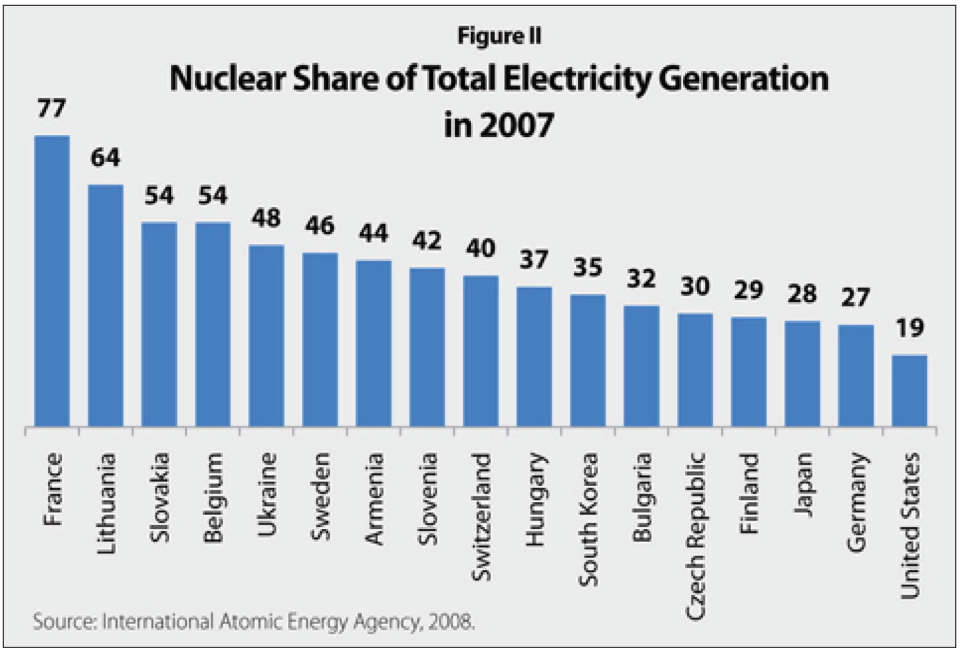
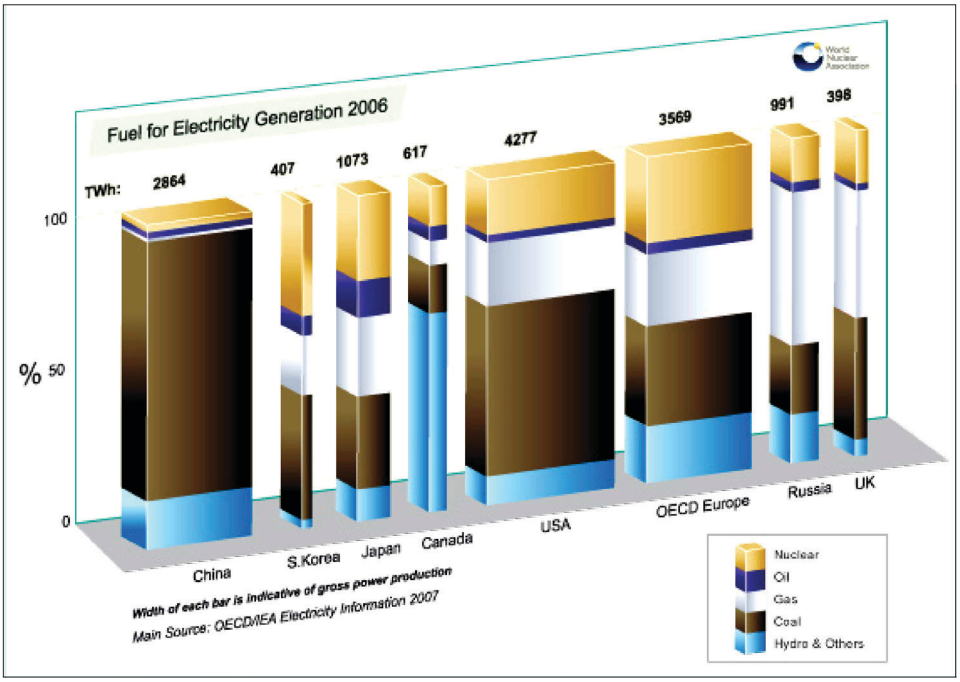
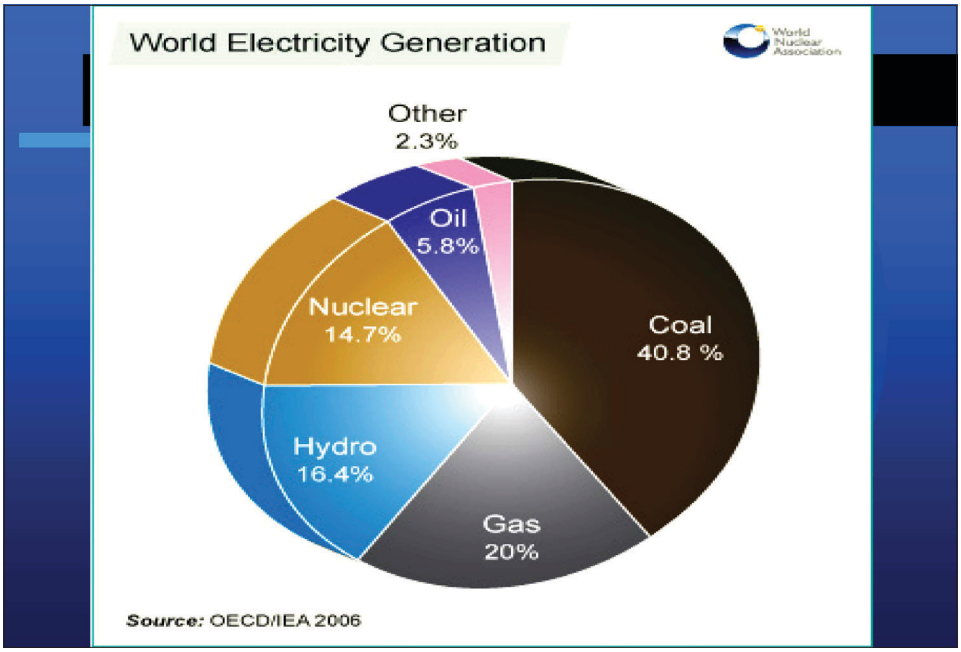
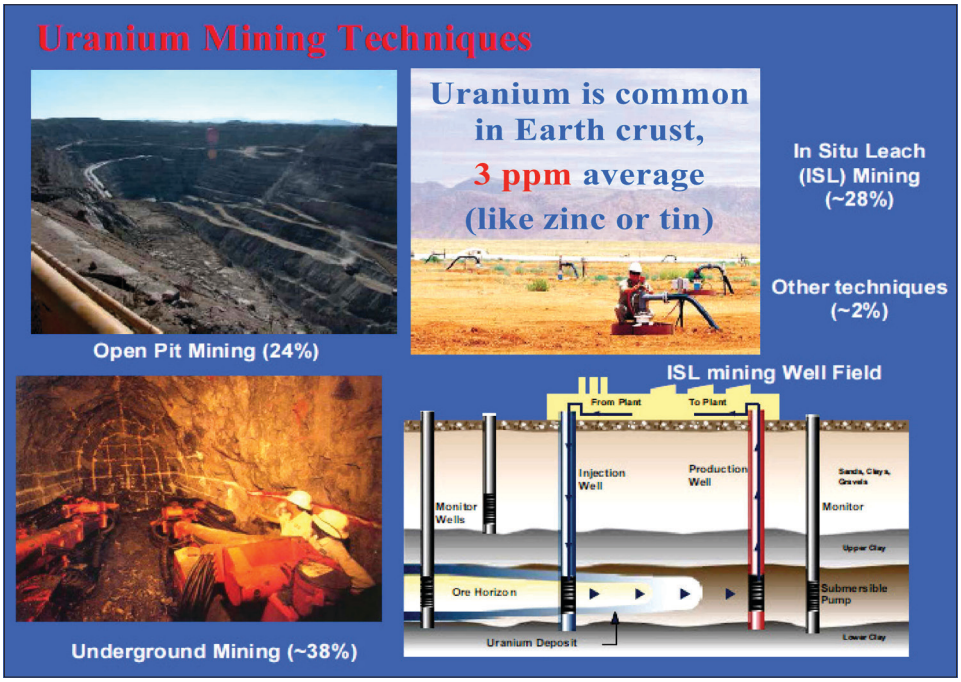


Figure II
Nuclear Share of Total Electricity Generation in 2007
77
64
54
54
48
46
44
42
40
37
35
32
30
29
28
27
19
France
Lithuania
Slovakia
Belgium
Ukraine
Sweden
Armenia
Slovenia
Switzerland
Hungary
South Korea
Bulgaria
Czech Republic
Finland
Japan
Germany
United States
Source: International Atomic Energy Agency, 2008.


Fuel for Electricity Generation 2006
TWh:
2864
407
1073
617
4277
3569
991
398
100
%
50
0
China
S.Korea
Japan
Canada
USA
OECD Europe
Russia
UK
Nuclear
Oil
Gas
Coal
Hydro & Others
Width of each bar is indicative of gross power production
Main Source: OECD/IEA Electricity Information 2007

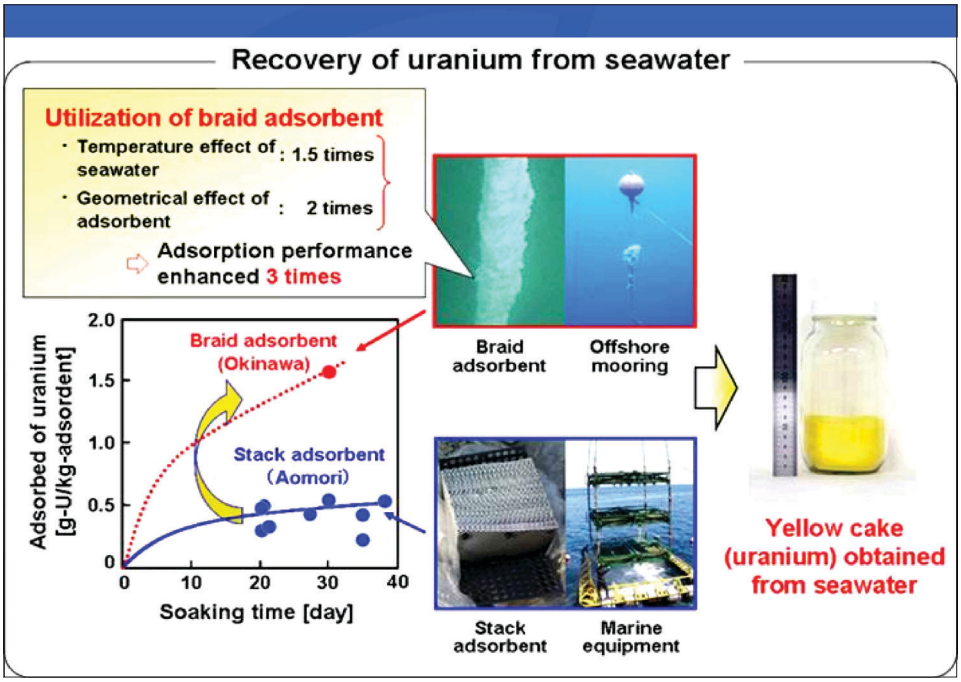

World Electricity Generation
World Nuclear Association
Other
2.3%
Oil
5.8%
Nuclear
14.7%
Coal
40.8 %
Hydro
16.4%
Gas
20%
Source: OECD/IEA 2006


Uranium Mining Techniques
Uranium is common in Earth crust,
3 ppm average
(like zinc or tin)
In Situ Leach (ISL) Mining (~28%)
Other techniques (~2%)
Open Pit Mining (24%)
ISL mining Well Field
From Plant
To Plant
Injection Well
Production Well
Monitor Wells
Monitor
Sands, Clays, Gravels
Upper Clay
Ore Horizon
Submersible Pump
Uranium Deposit
Lower Clay
Underground Mining (~38%)

Very high-grade ore (Canada) - 20% U	200,000 ppm U
High-grade ore - 2% U,	20,000 ppm U
Low-grade ore - 0.1% U,	1,000 ppm U
Very low-grade ore* (Namibia) - 0.01% U	100 ppm U
Granite	4-5 ppm U
Sedimentary rock	2 ppm U
Earth's continental crust (av)	2.8 ppm U
Seawater	0.003 ppm U

Known Recoverable Resources of Uranium 2009

	tonnes U	percentage of world
Australia	1,673,000	31%
Kazakhstan	651,000	12%
Canada	485,000	9%
Russia	480,000	9%
South Africa	295,000	5%
Namibia	284,000	5%
Brazil	279,000	5%
Niger	272,000	5%
USA	207,000	4%
China	171,000	3%
Jordan	112,000	2%
Uzbekistan	111,000	2%
Ukraine	105,000	2%
India	80,000	1.5%
Mongolia	49,000	1%
other	150,000	3%
World total	5,404,000	



Erice seminar 2009

Current status of technology for collection of uranium from seawater

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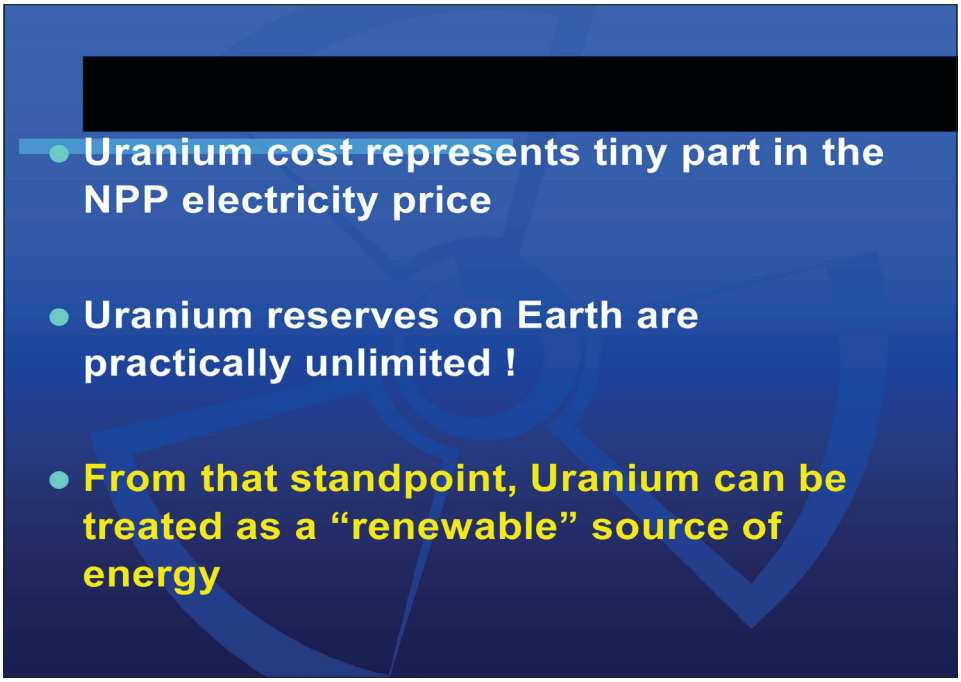
Total amount of uranium resource in seawater is one thousand times of that in terrestrial ores. A polymeric adsorbent being capable of collecting uranium in seawater was developed in early 1980s, since uranium is inevitable resource to operate atomic power plants. This adsorbent fabric was synthesized by radiation-induced graft polymerization which could impart a desired functional group into fibrous trunk polymers. The amidoxime group was selected as a high affinity group for uranium collection from seawater. As a marine experiment, 350kg of the adsorbent stacks was dipped at 7 km offing of Mutsu-Sekine seashore in Aomori prefecture, Japan. In total 9 tests over three years, 1 kg of uranium could be collected successfully as a yellow cake. A new braid type adsorbent has been developed to achieve the practical cost of uranium collection. This braid adsorbent can stand on the bottom of the sea and does not need the heavy adsorbent cage for adsorbent stacks. The adsorption performance in marine experiment indicated 1.5 g-U/kg-ad for 30 day soaking. This value was three times higher than that of adsorbent stacks. The collection cost of uranium was calculated by including processes of adsorbent production, uranium collection, and purification at annual collection scale of 1200 t-U. The uranium collection cost based on the adsorbent durability in the laboratory scale experiment, 32 thousand yen/kg-U. When the braid type is utilized 18 times, the collection cost reaches 25 thousand yen/kg-U which is equivalent to $96/lb-$U_3O_8$.



- **Uranium cost represents tiny part in the NPP electricity price**
- **Uranium reserves on Earth are practically unlimited !**
- **From that standpoint, Uranium can be treated as a “renewable” source of energy**

However...

- Approaching sixty years since the introduction of nuclear power for electricity generation, the spectrum of its various perspectives is broader, hotter and more colorful than ever
- In the midst of maturity, hardly any of its aspects stays undisputable – these are rather subjects of passionate debates, doubts, controversies, denials
- Experts and public are separated by the ever growing abyss of misunderstanding and mistrust

- Why is it so?
- Why is nuclear power not progressing the way it objectively deserves?
- Why is it lingering far behind poorer performing competitors, coal for instance?

- In elaborating some reflections, this presentation is to some extent *deliberately provocative,* in-good-will.

I. From hero to outlaw

- Nuclear power (NP) started as a brilliant/amazing new technology from the fifties (first NPP: 1954)
- Emerging as culmination from the series of brightest scientific ideas and greatest fundamental discoveries ever
- NP was initially welcomed with huge enthusiasm and seen as the solution of energy problems for the mankind

I. From hero to outlaw

- The euphoric belief went that with nuclear power, electricity would become "too cheap to meter"

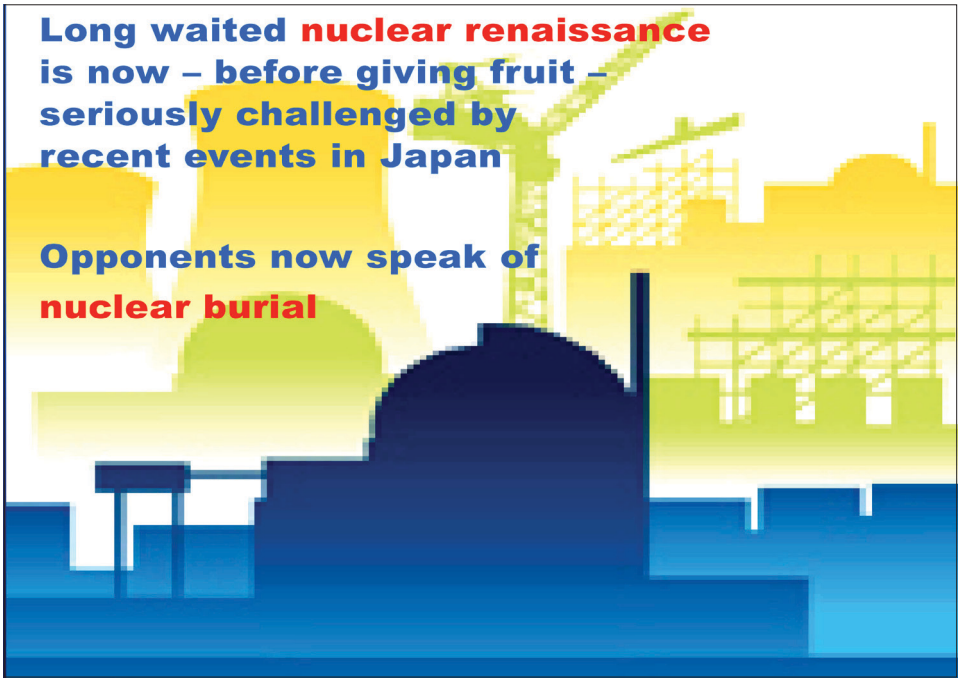
  (Lewis L. Strauss, chairman of the U.S. Atomic Energy Commission, 1953-1958)
- This never came through. However, contrary to NP opponents mocking nowadays with Mr. Strauss' words, it does not mean he was wrong!
- It might be well those who took the nuclear sector over who could be blamed...

I. From hero to outlaw

- After steep growth/expansion in the sixties and seventies, NP witnessed the two-decade stagnation in the aftermath of Three Mile Island and Chernobyl accidents.
- In 2010 NP represented only
  - 13% of global electricity production and
  - 6% of total energy production.

Long waited nuclear renaissance is now – before giving fruit – seriously challenged by recent events in Japan

Opponents now speak of nuclear burial



I. From hero to outlaw

- In the meantime, from initial general acceptance and a hero status, NP became bad guy in the city and subject of strong anti-nuclear sentiments and movements
- This results frequently in political opposing, arbitrary shut-downs, humiliating referendums, legal bans and phase-outs
- In some countries, especially in Europe, where half of the world nuclear electricity is produced, NP is *de facto* and/or *de jure* an outlaw

I. From hero to outlaw

- Was/is the change spontaneous or orchestrated?
- If spontaneous, what triggered/caused it?

  N.B. The change started in organized manner well before major nuclear accidents happened
- If orchestrated, why? Who was/is the conductor?

II. Public perception and its consequences

- It is easy to claim bluntly that public perception about NP is wrong
- it seems obvious from experts' standpoint: the issue is pretty complex for comprehension, indeed
- It is more difficult to say what should be done to "rectify" it
- And to do it eventually will be really cumbersome

II. Public perception and its consequences

- NP is regarded as extremely dangerous
- The only technology which has no right to fail occasionally
- Risks and consequences of NP operation – not to speak of nuclear accidents – are compared to those of other energy generating technologies with
  - bias
  - prejudice
  - disproportion
  - different standards...
- More often, even worse, it is not compared at all !
- NP is apart category on its own

II. Public perception and its consequences

- In a democratic society, poor public acceptance transforms (more or less fluently) into political will and subsequently into hostile legal/regulatory conditions for NP
- Paradoxically enough, a less democratic society might turn out to be a friendlier environment

III. Twin brother shadow

- NP never truly came out of the horrifying shadow of its military twin brother – nuclear weapon – at least not in the perception of common people, which means the majority of people
- Whatever accident or just a problem with NP, Hiroshima is revoked, even compared with (!?). Many still believe nuclear reactor can explode like nuclear bomb
- This absurd fear, like other nonsense beliefs/myths about NP, is a substantial ingredient of anti-nuclear sentiment

III. Twin brother shadow

- Hiroshima–Fukushima rhyme as words
- Twin brother logic will rhyme/connect them as metaphors.

IV. A useful comparison: nuclear industry vs. aviation industry

- When talking of NP to those not familiar with the subject, a comparison with aviation is illustrative, appealing and useful
  - Both industries are based on extremely sophisticated and complex technologies. Investments are huge, affordable only to the biggest/richest
  - Utmost competence, regulation, discipline and long term stability of many parameters are required
  - Safety and security are absolute paramount
  - When properly operated, the output is surpassing by far any competition

IV. A useful comparison: nuclear industry vs. aviation industry

- Yet, accidents happen, likewise in any other technology or human activity
- These are relatively rare, but attract much public attention, even collective horror, disproportional to other disasters with similar consequences
- Learning from accidents is painful, but most efficient learning

IV. A useful comparison: nuclear industry vs. aviation industry

- Aviation owes much of its current excellence to such lessons; these happened much more in its hundred years of history than those of NP
- A surprising conclusion, hard to say, may be that NP has not had enough bitter opportunities to learn

V. Mature, yet shy

- When four blocks at Kozloduy (Bulgaria) NP plant were shut down couple of years ago, as a part of Bulgarian accession to EU deal, prices of electricity in the region nearly doubled within months. Nobody was willing to openly connect these two facts
- In 1987 Italians voted at a referendum for immediate closure of their four NP plants. Chernobyl was still smoking. Again, nobody said they were about to be paying the most expensive electricity in Europe afterwards; In 2011 there was another referendum, while Fukushima was smoking...

V. Mature, yet shy

- Negative implications (even direct/explicit as the above ones) of nuclear bans/closures are rarely exposed to public the same way as NP risk/drawback
- In general, nuclear sector is shy – surely not agile enough, not to speak of being aggressive – in promoting advantages of NP and disadvantages of competing modalities of energy production.

V. Mature, yet shy

- The simplest, but worst supporting argument is eventually being exploited more and more:

"NP will progress, because there is no other viable alternative to meet growing energy demands!"

- This may be true;

  However, it actually approves anti-nuclear reasoning – implicitly admitting that NP has nothing better to show/offer

VI. Expensive but cheap

- NP electricity is reliable and very cheap to produce in abundance
- fuel costs are close to insignificancy
- However, plants are extremely expensive to build
- This cheap-expensive balance proved to be quite unstable and fragile, hence treacherous

VI. Expensive but cheap

- Consequently, despite undeniable profitability and economic benefits of NP, nuclear build became the investor's nightmare, as well as his banker's "stay-away" suspicion
- Planned front end capital (already in billions) easily grows twofold or threefold, the same as construction time, for reasons out of investor's control
- Investor bares the risk of the devastating impact of
  - political and social volatility
  - legal and regulatory pitfalls
  - one-affects-all effect (e.g. in case of major NP accidents)

VII. Waiting for the new generation

- Progress on introducing new generation of nuclear reactors is surprisingly slow

  featuring intrinsic passive safety, high fuel efficiency and small remaining nuclear waste – goals set decades ago

- 40 or more years were not enough, for instance, for fast breeders to break through

VII. Waiting for the new generation

- Investments in NP research are far below e.g. those for prospecting new oil/gas fields or coal mines
- Governmental incentives/subsidies go regularly to "friendlier" or "more promising" technologies
- Legal and regulatory requirements, understandably/justly becoming more stringent towards protecting people and environment, are not paralleled with analogue ones for other (competing) sources of energy (!?)

VII. Waiting for the new generation

- In order to prosper, NP must be accepted by the society and governments
- It cannot progress being regarded as an outlaw, however affirmative nuclear sector might be thinking autistically of its own
- New, 4th generation of reactors, clearing the drawbacks and suspicion about the current ones – particularly about safety and waste – should be brought to light as a matter of urgency

VIII. Highs and lows of nuclear wisdom

- NP is heavily a knowledge-based technology. Immense nuclear knowledge and expertise are accumulated over decades of research, development and experience
- However, this wisdom is remaining pretty enclosed within nuclear community
- Nuclear community hardly ever succeeded in really convincing general public about NP benefits largely outweighing risks and drawbacks

VIII. Highs and lows of nuclear wisdom

- Nuclear industry is highly demanding in various kinds of knowledge and expertise, embracing not only nuclear experts (e.g. scientists and engineers), but many, many others, too
- However, it seems that nuclear wisdom retains somehow in technological phase, thus declining (sometimes sharply) towards higher deciding levels – managerial and political
- This fact is largely overlooked, dismissed or just reluctantly admitted... and ignored. It means, in effect, that the fate of NP is dominantly not in hands of NP experts

VIII. Highs and lows of nuclear wisdom

- This might have something to do with possible **shortages** in nuclear sector of:

Initiative
Momentum
Innovation
Daringness
Openness
Confidence
Self-confidence
Vision
Charismatic leadership
Etc.

IX. Contemplation on missed opportunity and back to reality

- **What the world could have looked like** if only NP had switched its place with coal?
- I.e. if NP had reached 50% of global electricity production – as it seemed imminent and quickly approaching back in 1975 – with coal dropping to 10-15%?
- The answer to this hypothetical (but not ridiculous) question, together with an additional small step in deriving subsequent conclusions, may shed some light on **why it never happened**

IX. Contemplation on missed opportunity and back to reality

- Opponents will firstly think of more Chernobyls
- However, far more important/impressive …

  … a drastic reduction in air pollution, with tens of millions human lives spared (at least one million people worldwide die every year due to consequences of coal burning) …

  … CO_2, green house effect and changed climate

IX. Contemplation on missed opportunity and back to reality

- Plentiful and cheap nuclear electricity could have boosted global economy and reduced its dependence on oil and gas – resulting in different geopolitical map of the world
- Some of the biggest contemporary structural monopolies might have been dissolved, global power redistributed, oil wars avoided…
- If we scratch on sensitivity, reluctance, opposition to NP …

  may we find sensitivity, reluctance, opposition to such changes?.

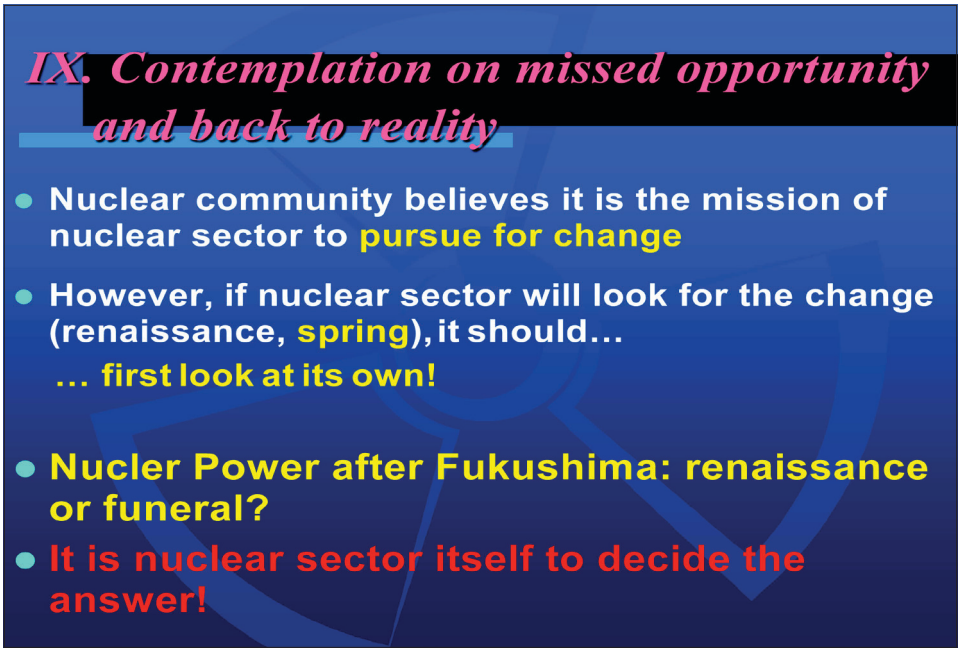
IX. Contemplation on missed opportunity and back to reality

- **Back to reality:**
  Whatever former, current and future pros and cons about NP were…

  …the fact is that dirty old black coal…

  keeps firmly:
  - **current dominant position**
  - **the brightest perspective as the main energy source in XXI century**

- **This is bad news for human kind**


IX. Contemplation on missed opportunity and back to reality
Nuclear community believes it is the mission of nuclear sector to pursue for change
However, if nuclear sector will look for the change (renaissance, spring), it should...
... first look at its own!
Nucler Power after Fukushima: renaissance or funeral?
It is nuclear sector itself to decide the answer!