The Social Construction of Chernobyl: Plans, Politics, and Reactor Design Choices in the Soviet Union

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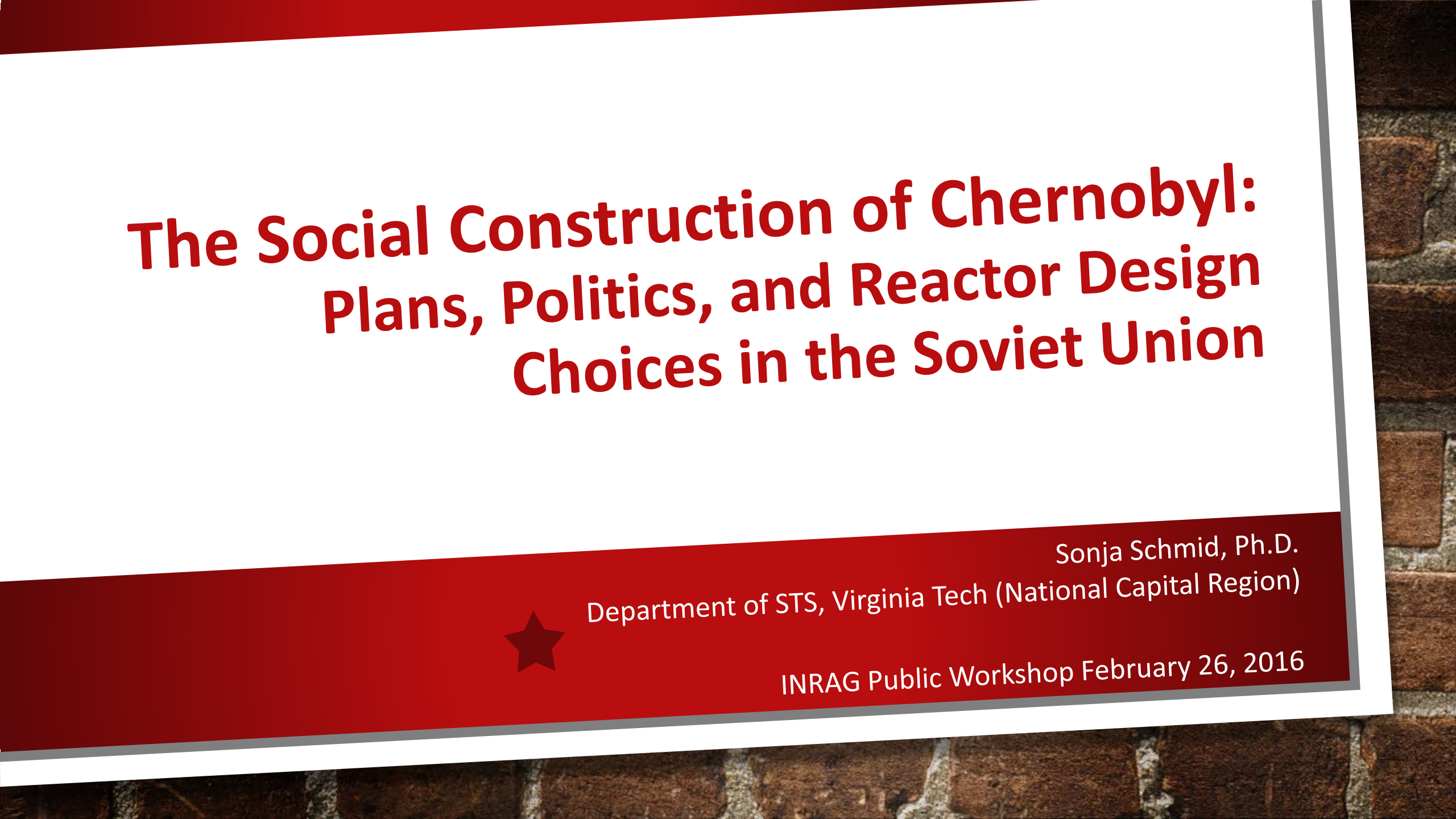
INRAG Public Workshop February 26, 2016



Chernobyl timeline

- Saturday, April 26, 1986, at ca. 1:24 a.m.: Reactor number 4 explodes
- April 27, 1986: Satellite town of Pripyat evacuated, 30km zone created
- April 28, 1986: Scandinavians measure elevated levels of radiation; Soviets admit “incident” and broadcast short announcement on Soviet TV
- Over the next weeks, a radioactive plume wafts across Europe and the world
- August 25-29, 1986: Soviet delegation presents an official report to the IAEA in Vienna
- November 1986: Concrete entombment of the reactor (the “sarcophagus”) completed
- July 1987: Chernobyl trial
- 1991: Publication of “Shteinberg Report”

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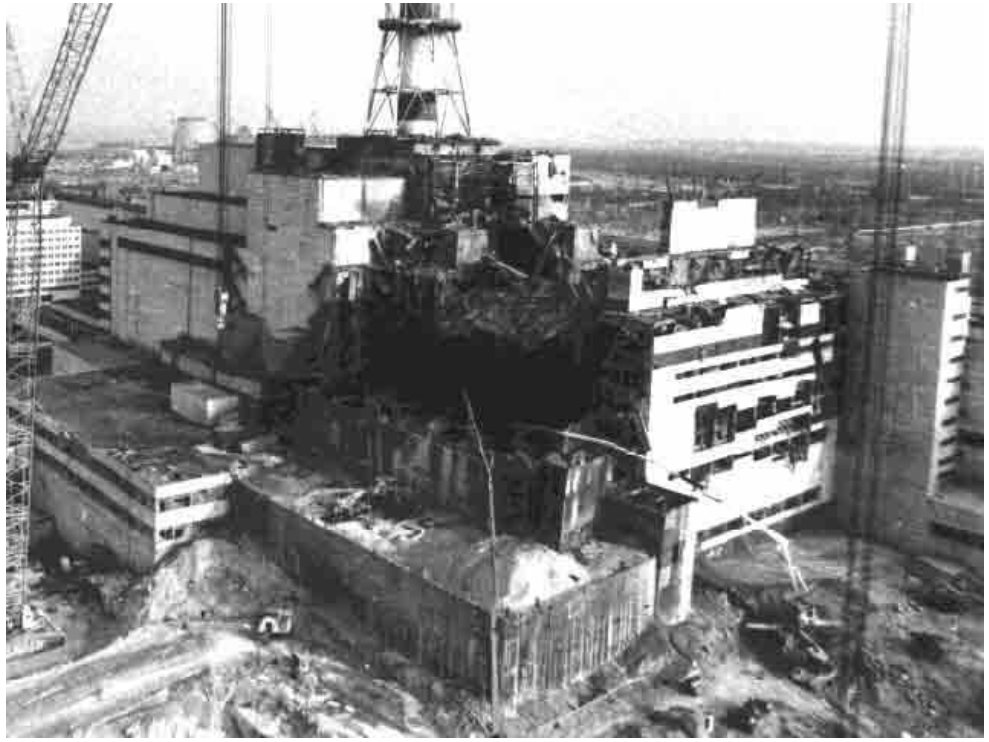
Three Explanations

- Human error
- Design flaw
- System failure



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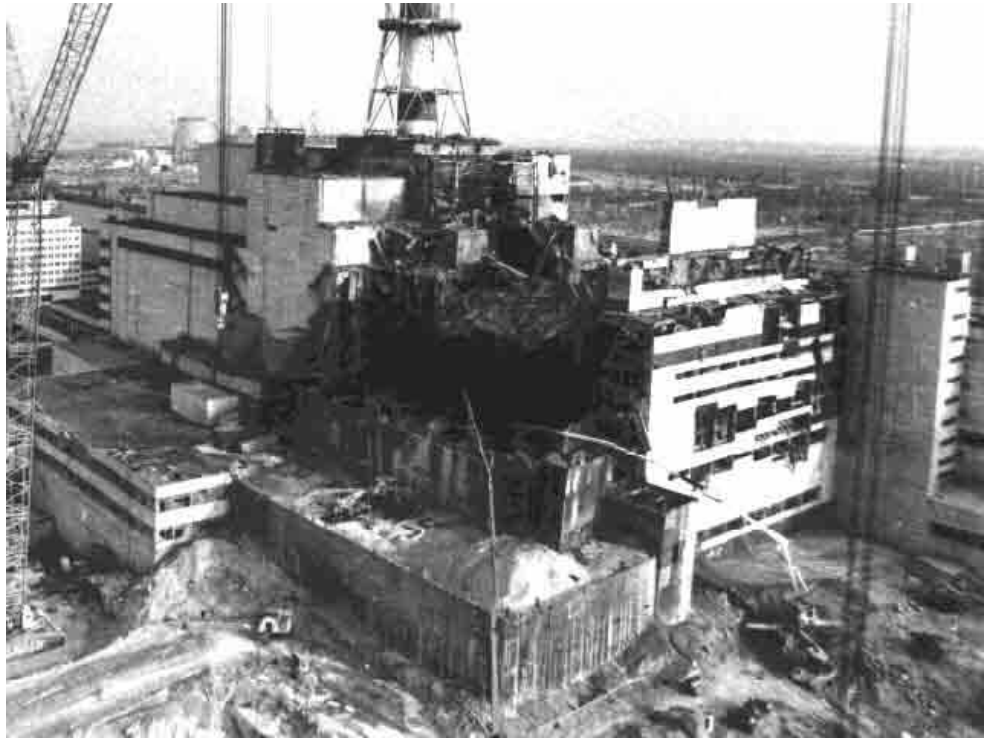
The Argument

- Not any of these explanations *alone* can fully account for the disaster; rather, we need to understand them as interlocking factors.
- Focusing only on the events immediately preceding the explosion will leave us at best with an incomplete, at worst with an incorrect account.



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“The Social Construction of Chernobyl”

To understand Chernobyl, we need to open the “black boxes” of human error, design flaws, and systemic failure, and consider more fully:

- **Plans,** How the Soviet planned-administrative economy worked;
- **Politics,** How scientific and technical knowledge within Soviet science and industry was taught, learned, managed, maintained, required, disputed, and concealed;
- **Design Choices,** Why some reactor designs made sense in very specific geopolitical, economic, and organizational contexts.

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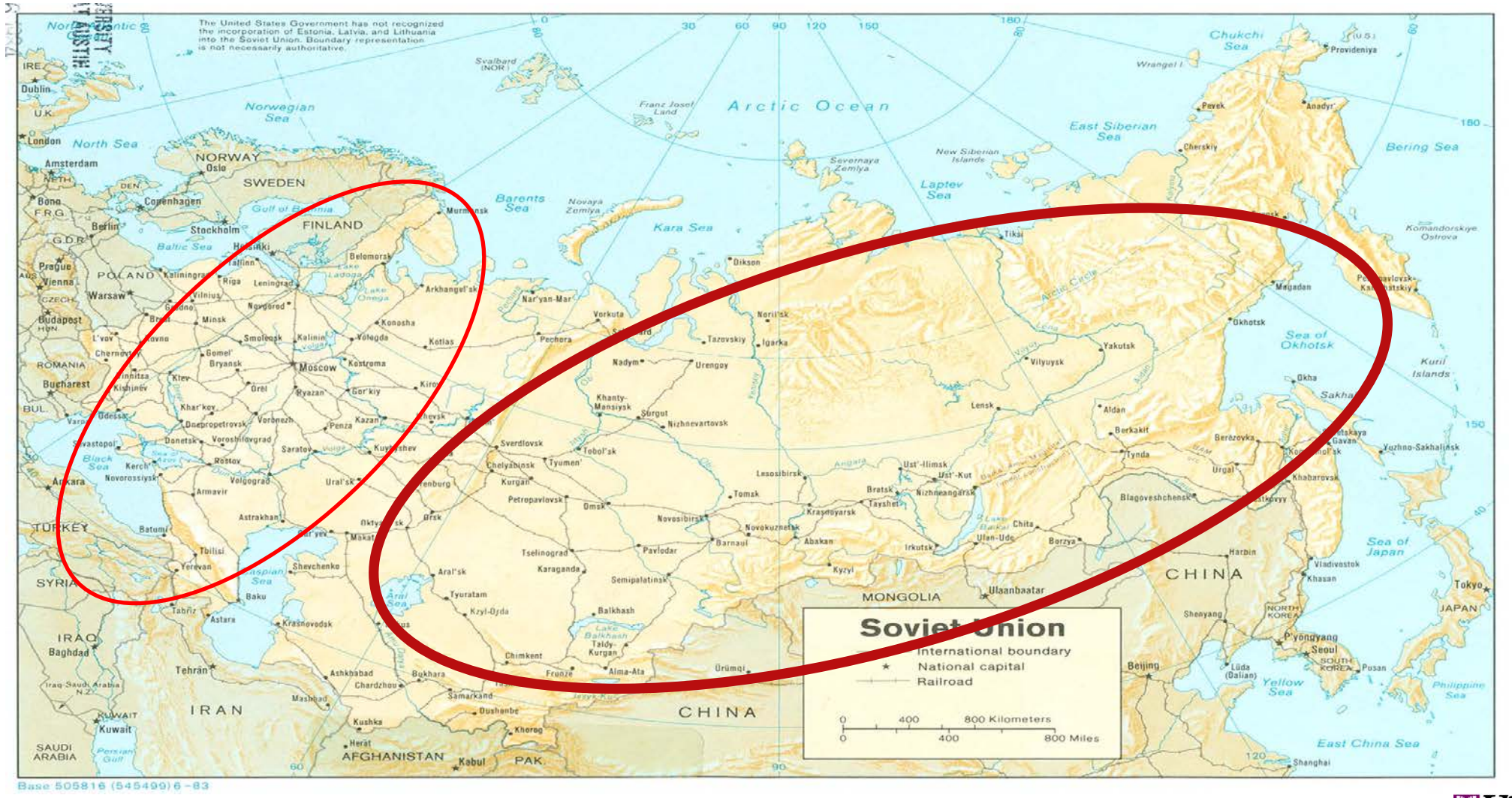
1. Plans: How the Soviet Economy Worked

- Nuclear energy not inevitable in resource-rich country, but uneven distribution



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1. Plans: How the Soviet Economy Worked

- Nuclear energy not inevitable in resource-rich country, but uneven distribution
- Soviet scientists and engineers develop nuclear weapons in crash program post-1945; they start advocating civilian nuclear power *before* first Soviet A-bomb explodes in 1949
- Obninsk ("World's First Nuclear Power Plant") starts up in July 1954

“The World’s First Nuclear Power Plant,” Obninsk. Control room (picture by the author, May 2003)

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1. Plans: How the Soviet Economy Worked

- Nuclear energy not inevitable in resource-rich country, but uneven distribution
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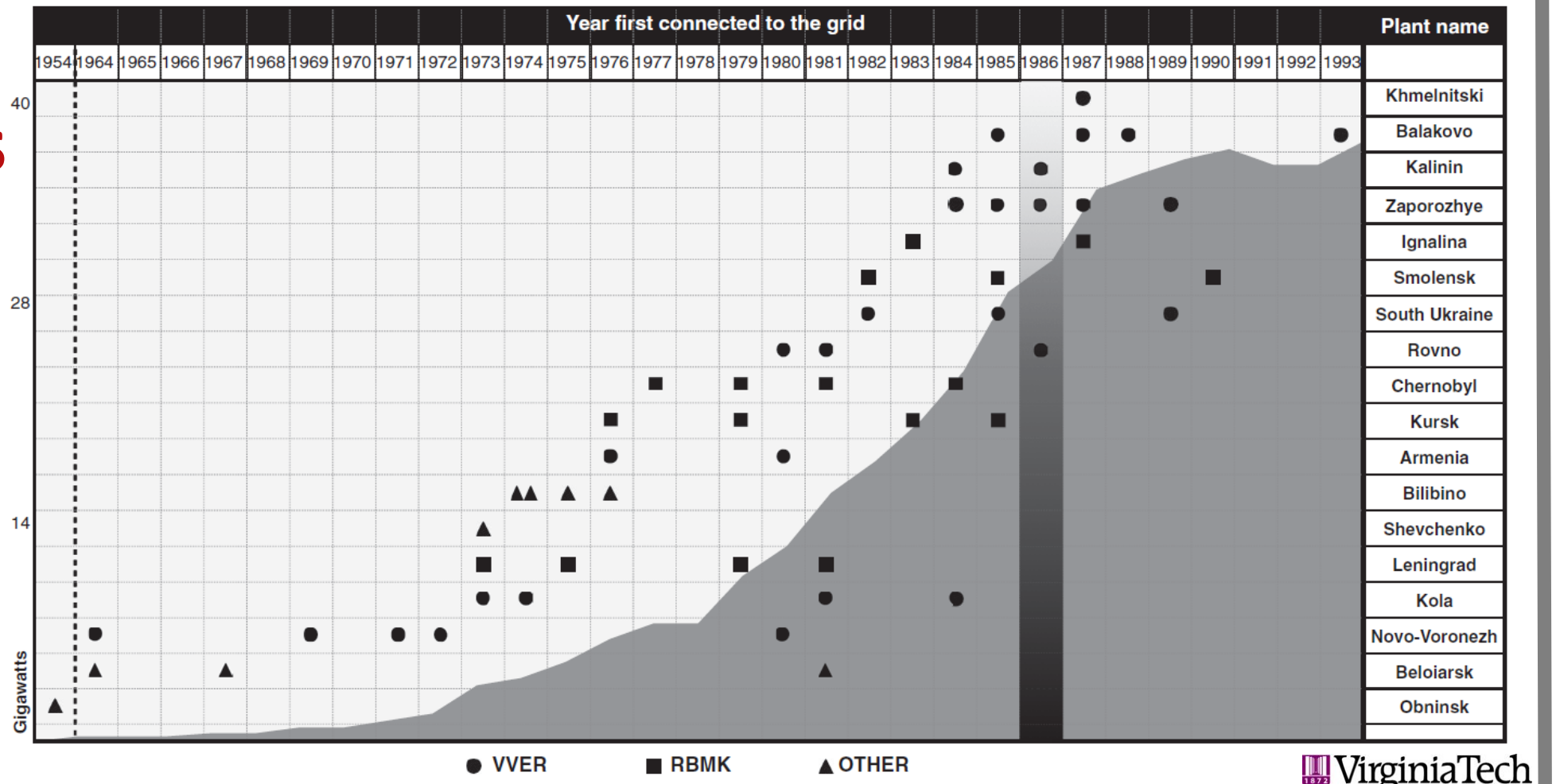
- Obninsk ("World's First Nuclear Power Plant") starts up in July 1954
- Civilian program gets funded, defunded, depending on whether planners find scientists' claims persuasive or not
- 1962: Civilian nuclear program re-starts, *because it gets written into "the plan"*
- 1964: Two nuclear *power* reactors start up (Beloiarsk, Novo-Voronezh)

Reactor Startups



Graphic design: Dane Webster

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1. Plans: Taking Stock

By the mid-1960s, nuclear power industry has been included in long-term plans, but the realization of these plans is *not secured!*

- Domestic supply and manufacturing industry can't handle ambitious expansion relying *only* on VVERs (PWRs)
- East European allies want Soviet "Atoms for Peace" (research and power reactors)

2. Politics: Training for the Nuclear Industry

Training a nuclear power workforce (on the job versus formalized):

- By the late 1960s, broad base of trained engineers available to recruit from
- Comprehensive nuclear engineering curricula start in 1956, spread across the Soviet Union
- Expertise and experience are critical in the face of notoriously unreliable instrumentation

Kuzma V. Vladimirov, Moscow 1967

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2. Politics: Managing the Nuclear Industry

Igor V. Kurchatov (1903-1960), “Father” of the Soviet Atomic Bomb

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2. Politics: Managing the Nuclear Industry

I.V. Kurchatov

Anatolii P. Aleksandrov (1903-1994), Kurchatov's deputy and eventual successor (1960-1988); President, Soviet Academy of Sciences (1975-1986)

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2. Politics: Managing the Nuclear Industry

I.V. Kurchatov

A.P.Aleksandrov

Efim P. Slavskii (1898-1991), Minister of Medium Machine Building (*Sredmash,* 1957-1986)

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2. Politics: Managing the Nuclear Industry

I.V. Kurchatov

A.P. Aleksandrov

E.P. Slavskii

***Sredmash* vs. *Minenergo*:**
different programmatic roots,
different organizational cultures

Petr S. Neporozhnii (1910-1999),
Minister of Energy and Electrification
(*Minenergo*, 1962-1985)

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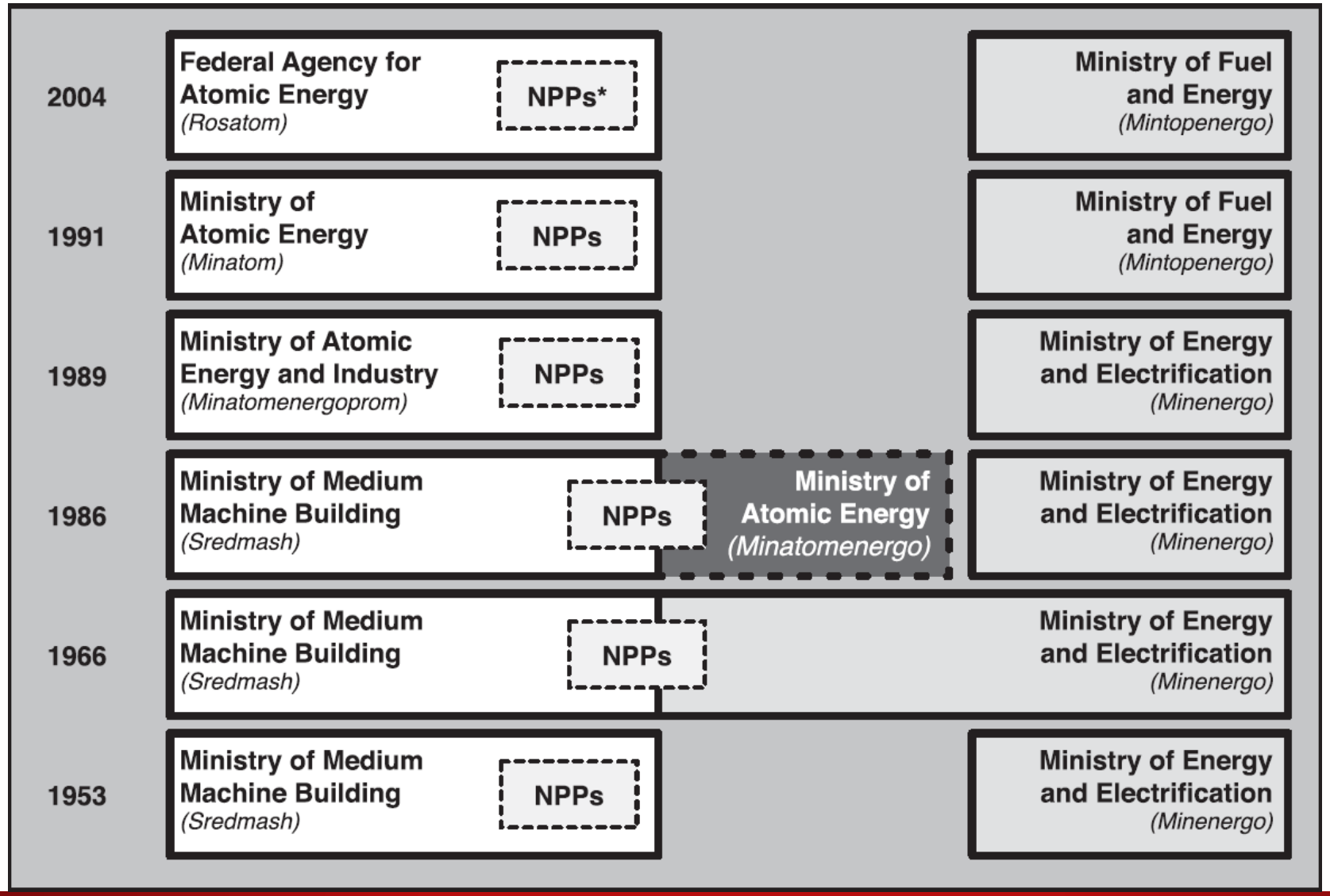
2. Politics: Decision-Making

- 1966: Council of Ministers issues a decree that mandates the transfer of responsibility for operating nuclear power plants (two) and those under construction from *Sredmash* to *Minenergo*
- However: reactor design, fuel delivery, and other sensitive tasks remain under the aegis of *Sredmash*, as well as some prototypes
- This leads to conflicts and some stereotyping: *atomshchiki* versus *energetiki*
- *First* matter to get addressed after Chernobyl (*before* technical revisions)



Graphic design:
Dane Webster

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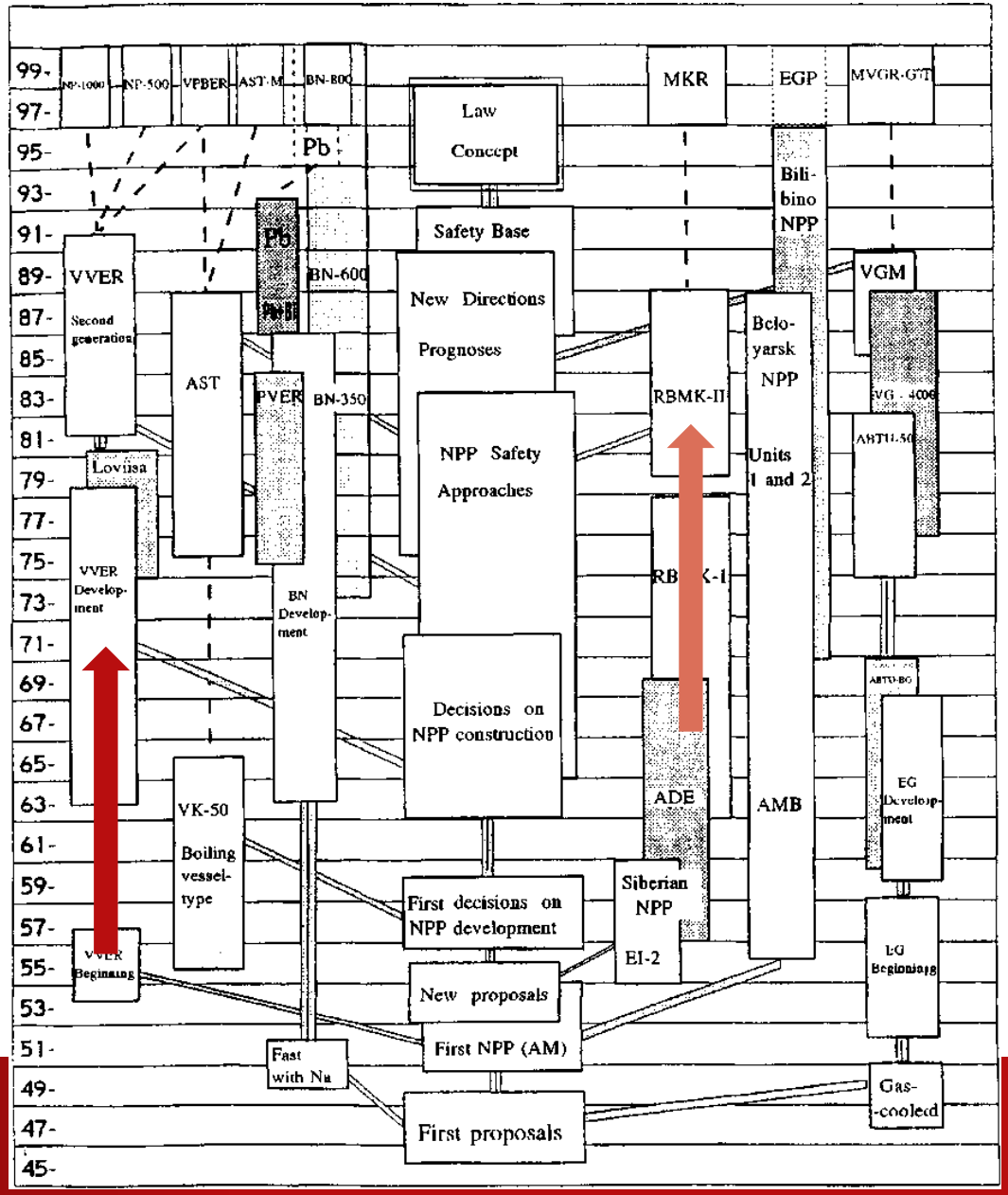
2. Politics: Taking Stock

- Workforce
- Managing the industry: programmatic roots, organizations, leaders
- Transfer of nuclear power plants exacerbates differences between *atomshchiki* and *energetiki*

3. Reactor Design Choices

- Obninsk design based on military reactors (AM – “naval atom”: attempt to miniaturize for submarine propulsion)
- Other designs (“up to ten”) in the works in the late 1950s
- Very long period of multiple design development, state-funded (curious in the “country of the plan”)



Source:
Sidorenko 1997

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3. Reactor Design Choices: the VVER

- Beloiarsk: Design based on Obninsk
- Novo-Voronezh: VVER (PWR)
  - ✓Design based on submarine propulsion
  - ✓Support from top scientific institutes
  - ✓International argument (most popular design worldwide)
- Soviet government designates VVER as future design for Soviet nuclear industry
- But: VVER alone could not carry projected growth of nuclear industry

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3. Reactor Design Choices: the RBMK

- Decorated engineers present a different design:
  - ✓Support from top scientific institutes and construction bureaus
  - ✓International argument (uniquely Soviet)
  - ✓Design based on military and dual-use reactors (Pu production!)
  - ✓Existing cohort of trained operators familiar with similar reactors
  - ✓1,000 MW prototype, online refueling, on-site assembly, existing, independent supply industry
- 1965: Government approves design, 1973: LAES RBMK-1000 starts up

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3. Reactor Design Choices: Taking Stock

- Convincing technical, economic, and political arguments for both designs
- Two designs meant two paths, two independent supply industries, and *faster growth*
- Note: some scientists considered the RBMK safer than the VVER because of its modular design and low pressure
- Note: both designs were “standardized” *and* continuously improved

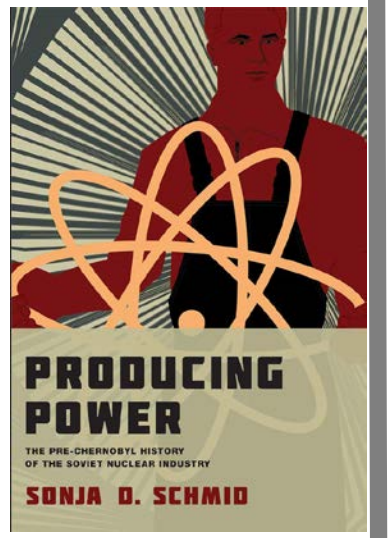
RBMK Generations

Generations	1	2	3	4	5	6	7
Leningrad	Units 1&2		Units 3&4				
Kursk		Units 1&2		Units 3&4			Unit 5
Chernobyl		Units 1&2		Units 3&4			
Smolensk				Units 1&2	Unit 3		
Ignalina						Units 1&2	

Conclusions: Could Chernobyl Happen Elsewhere?

- Chernobyl was Soviet through and through (people, reactor design, system), but:
  a) "Operator error" needs to be specified by what an operator was supposed to be, to know, to do
  b) "Design flaw" needs to take into account why the RBMK design made good sense at the time
  c) "System failure" needs to acknowledge that Soviet system mostly worked, and that other systems are vulnerable, too.
- Chernobyl was the result of a specific, unfortunate combination of multiple factors that led to disaster: we cannot know, let alone anticipate, all these combinations
- By dismissing the disaster as caused by operator error, a design flaw, or general system failure, we miss (and indeed, did miss) an opportunity to learn.

Producing Power: The Pre-Chernobyl History of the Soviet Nuclear Industry (MIT Press 2015)



Introduction
Envisioning a Nuclear-Powered State
Between Atomic Bombs and Power Plants: Sharing Organizational Responsibilities
Training Nuclear Experts: A Workforce for the Nuclear Industry
"May the Atom Be a Worker, Not a Soldier!": A New History of Soviet Reactor Design Choices
Chernobyl: From Accident to Sarcophagus
Conclusion
Epilogue: Writing about Chernobyl after Fukushima

http://mitpress.mit.edu/books/producing-power

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Thank you!

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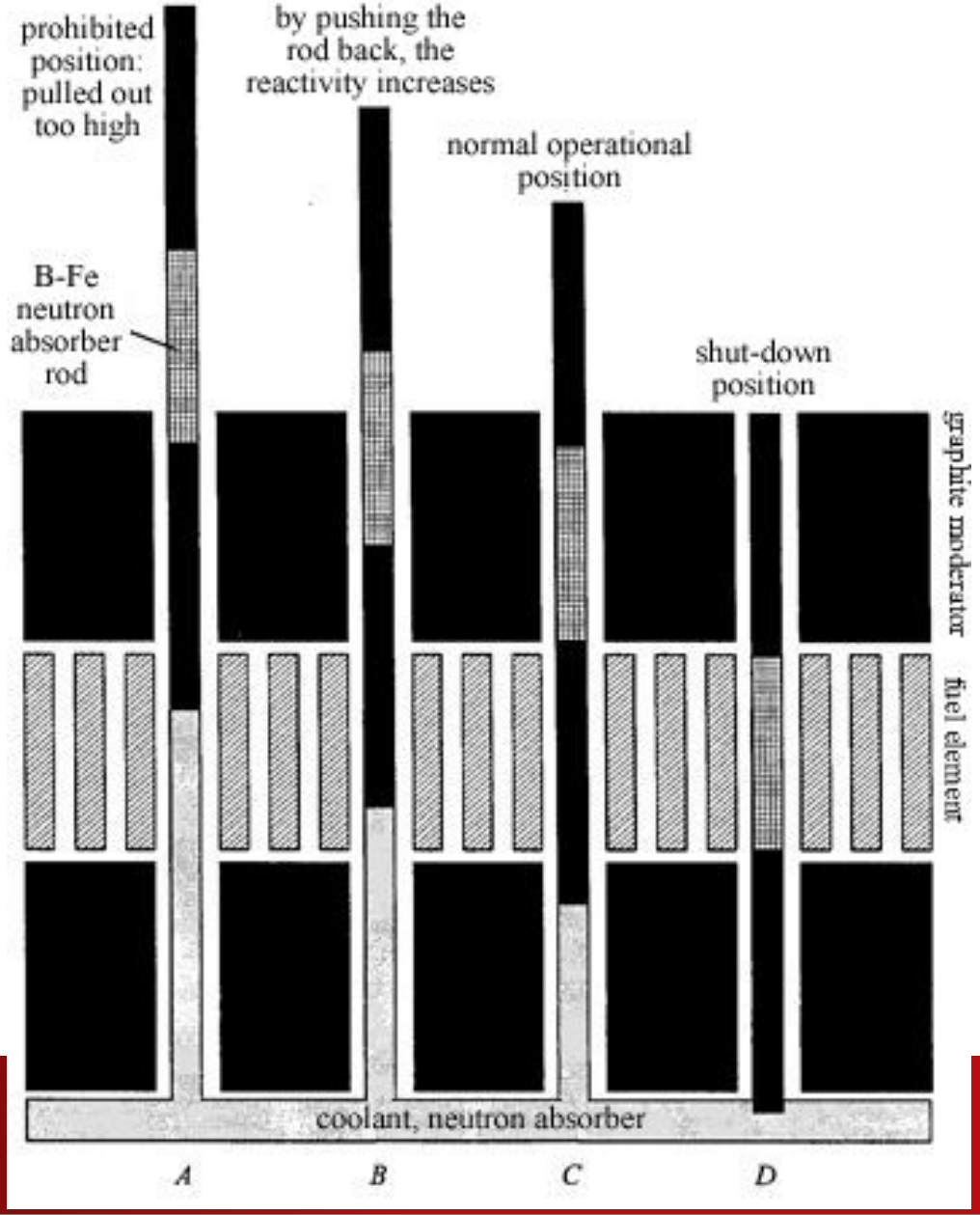
Soviet Nuclear Regulation

- 1946 “State Service for Radiation Safety Control”
- 1958-1970, Sredmash (then plus Health Ministry and Mining Safety Authority)
- 1966, *Gosgorenergotekhnadzor* (*Minenergo)*
- 1972, *Gosatomnadzor* (*Sredmash)*
- 1974, OPB-73: first legally binding nuclear safety rules (updated OPB-82)
- **1983, *Gosatomenergonadzor*: first independent nuclear safety oversight committee** (based on international models)
- 1989, *Gospromatomnadzor* (of *Gosatomenergonadzor* and *Gosgortekhnadzor*); transition to regulation



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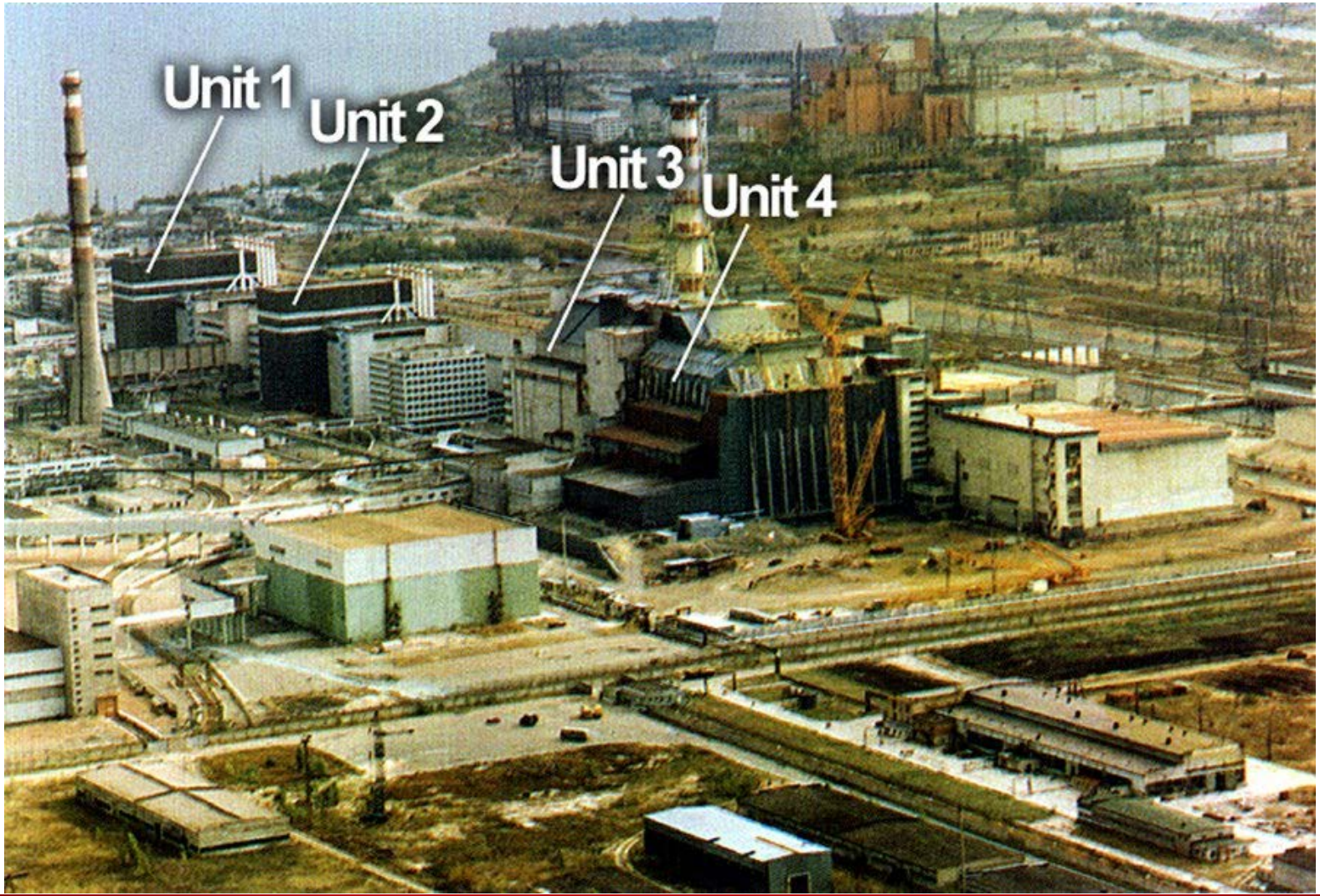

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Kola
Ignalina
Leningrad
Rovno
Khmelnitski
Chernobyl
Smolensk
Obninsk
South Ukraine
Kursk
Zaporozhye
Novo-Voronezh
Kalinin
Balakovo
Beloiarsk
Armenia
Shevchenko
Bilibino
Graphic design:
Dane Webster
VVER
RBMK
Other

“Second Ivan” (EI-2)

Source: Alekhin & Kiselev 2003